Alton Natural Gas Storage LP: Review of the Conestoga-Rovers & Associates Third Party Review Findings

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EXECUTIVE SUMMARY

An independent review of the environmental assessment registration document and associated documentation for the Alton Natural Gas Project was undertaken by Conestoga Rovers and Associates in 2015 (CRA). CRA was retained by the Kwilmu'kw Maw-klusuaqn Negotiation Office (KMKNO) on behalf of the Assembly of Nova Scotia Mi'kmaq Chiefs in the negotiations and consultations among the Mi'kmaq of Nova Scotia, the Province of Nova Scotia and the Government of Canada re: the Project.

CRA focused its review on assessing potential impacts of the proposed project on fish and fish habitat of the Shubenacadie Estuary. The CRA report was released publicly on Thursday July 23, 2015. Following the release of the report, Alton Natural Gas Ltd participated in a government-led multiparty working group which included representation from Alton, the Mi'kmaq of Nova Scotia, and federal and provincial governments. Alton believes this process led to an improved understanding by the company of the values and interests of those around the table. As a result of these discussions, the company's previously proposed monitoring plan was improved by making changes, including:

- increasing the shut-down period during striped bass spawning from two weeks to 24 days
- more frequent sampling when brining begins
- increased focus on intake and outfall sampling

The CRA report made five recommendations which Alton Natural Gas Storage (Alton) is committed to implementing, including:

1. The Alton monitoring plan should include how natural variances in striped bass recruitment in the river will be monitored and correlated to evaluate potential negative effects related to the project, and to clearly define when brine discharge will be discontinued through the striped bass spawning season.

2. The planned monitoring of striped bass eggs and larvae be conducted to validate the EA predictions for the numbers that will pass through the constructed channel.

3. Modelling and ongoing monitoring to ensure the level of sand and small debris in the water does not interfere with mixing of the brine prior to release into the river.

4. Describe in greater detail what is in the brine, including its major ion composition.

5. Explain any potential toxic effects on striped bass eggs and young fish.

The following report is the company's response to the recommendations in the CRA Report. Information in this report was shared with those involved in the working group and is now being made available.

All five recommendations have been carefully integrated in the long-term monitoring program. As a result of the government-led multiparty working group, Alton has updated the monitoring program to reflect natural variances in striped bass recruitment in the river and clearly define when brine discharge will be discontinued through the striped bass spawning season. As a result, Alton will discontinue discharging brine through the period when striped bass eggs and larvae are most abundant following spawning. Alton will implement a detailed monitoring program in the Shubenacadie River, the mixing channel and the water intake system. To ensure small debris in the water does not interfere with brine mixing prior to release into the river, Alton has established careful engineering and operational protocols. Ongoing monitoring and close salinity monitoring will circumvent potential impacts from sedimentation interfering with mixing of the brine prior to release. Further information has been collected about what is in the brine and its major ion composition. Further analysis of various sections of salt core and river water was undertaken. The sections of the salt core, taken at varying depths, were very similar in content and determined to be benign. Finally, the study to determine any potential toxic effects on striped bass eggs and young fish was designed in consultation with DFO and will commence once brine from the Alton project is available and in the months from May to September when young striped bass are available for study.

Alton Natural Gas Storage is pleased to implement the five CRA recommendations and confident that the third party review confirmed the EA document was complete and in accordance with requirements. The Alton project has been planned, engineered and constructed to safeguard the river and its ecosystem from potential negative impacts by direct in river monitoring of the water quality and biota, during construction and operations over the life of the project. We look forward to continuing to work with the Mi'kmaq of Nova Scotia, governments, and members of the community as the project progresses.

INTRODUCTION

1.1 Background

On behalf of the Assembly of Nova Scotia Mi'kmaq Chiefs in the negotiations and consultations between the Mi'kmaq of Nova Scotia, the Province of Nova Scotia and the Government of Canada, the Kwilmu'kw Maw-klusuaqn Negotiation Office (KMKNO) retained Conestoga-Rovers & Associates (CRA) to review the Environmental Assessment (EA) Registration report and associated documentation for the Alton Natural Gas Storage LP project. In this report (see Appendix D), CRA focused the review on the assessment of potential impacts of the proposed project on fish and fish habitat of the Shubenacadie Estuary. The purpose of the review was to:

a) Complete a literature review of existing information for similar operations around the world, specifically, on solution mining, brine discharge requirements, and the associated environmental impacts.

b) Review the existing information to evaluate the scientific and technical information for completeness and for comparison to documented and validated scientific methods including the interpretation of the information with generally accepted standards of good scientific practice.

c) Identify any information gaps and, if warranted, recommendations on how to address the information gaps.

The CRA report was made available to the public and Alton Natural Gas Storage LP (Alton) on Thursday, July 23, 2015.

1.2 Alton's Overview of the Conestoga-Rovers Report

Alton is satisfied with the conclusions of the third party review by Conestoga-Rovers & Associates. The report has provided five recommendations that the company is committed to implement for the project. As part of this process, the company is committed to ongoing engagement with the Mi'kmaq of Nova Scotia, including environmental monitoring.

The report has also provided a number of observations on key issues including the preparation of the EA, effects of salinity on the estuary, scientific practices and eight years of monitoring.

Regarding the Alton EA Conestoga-Rovers states:

> *"The EA registration document was completed in general accordance with NSDEL requirements"* (CRA report, section 4.0, page 12)

Regarding added brine to the tidal river Conestoga-Rovers states:

> *"Other issues considered, and then quickly dismissed, were significant effects on salinity of the Estuary and the thermal regime of the Estuary."* (CRA report, section 3.2, page 5)

Regarding accepted standards of good scientific practice for the eight years of research and studies Conestoga-Rovers states:

> *"These additional studies were generally completed using defensible scientific methods, and the data obtained used to develop mitigation strategies to minimize potential effects to the environment."* (CRA report, section 4.0, page 12)

> *"Subsequent fish stock studies completed for the Shubenacadie Estuary and River provided additional information on the ecosystem to meet DFO requirements"* (CRA report, section 4.0, page 12)

> *"Over the course of the planning and approval process, starting in 2007, the project has received extensive review from a variety of government sources, especially DFO."* (CRA report, section 3.2, page 5)

ADDRESSING CONESTOGA-ROVERS FIVE RECOMENDATIONS

2.1 Understanding Critical Factors Causing Yearly Success or Failure of Striped Bass Recruitment

CRA Statement:

"*… filling other data gaps and results of during-project monitoring will reduce the uncertainty associated with this data gap. Thus, for example, a better understanding of brine ionic composition, its potential toxicity, and success of mixing of brine/estuary water in the mixing channel could help dismiss brine discharges as a significant cause of bass mortality. Similarly, <u>the ichthyoplankton will be monitored at several locations during project operation, and these data can also be useful in determining whether the project could cause significant effects</u>."* (CRA report, section 3.4, pages 9-10)

CRA Recommendation:

"The recruitment of Striped bass within the Shubenacadie River and Estuary are not well understood and current factors causing success or failure of this fish species present limitations in its use as an indicator species for assessing potential effects related to the Project. Recommend that the proposed monitoring plan clearly define "peak spawning events" for discontinuing brine discharge and include a contingency to reduce lag times between sampling and analysis of eggs in the river. In addition, the plan needs to detail how natural variances in Striped bass recruitment in the river will be monitored and correlated to evaluate potential negative recruitment effects related to Project activities." (CRA report, section 4, page 13)

Alton Proposed Action:

Clarify how the natural variances in striped bass recruitment will be monitored and correlated to evaluate potential negative recruitment effects related to Project activities. The knowledge gained over the past eight years of study have been used to refine the monitoring program. Additional studies will be performed during operations by Dr. Jim Duston (Dalhousie University, Department of Plant and Animal Sciences, Faculty of Agriculture). The analyses will include detailed study of the Alton mixing channel and the main river channel. The 2016 monitoring plan, which is a condition of the Industrial approval, states:

- "When eggs are detected at the Alton site on the flood tide sampling, brine discharge will be stopped and Nova Scotia Environment will be notified. This will trigger operational measures to further protect the eggs."
- "From the date that Stripped bass eggs are detected the brine discharge will be stopped for 24 days. From start-up following the no brine release period until July 5th, the discharge will be regulated as above to maintain salinities at or below 7 parts per thousand (ppt) above background and at or below 20ppt."

- "If Striped Bass eggs are detected in the intake well or river at the site after the 24 day period, both Nova Scotia Environment (NSE) and DFO will be contacted to determine if further action is necessary."

River Wide Species Monitoring

1. Plankton net tows at the Alton Site during the flood tide

Objective: At the Alton site, determine ichthyoplankton, particularly, striped bass eggs and larvae density per cubic meter of water filtered in the main channel and their stage of development and condition and larvae mean body size and condition.
Methods: Day time flood tide (30 second long 250uM mesh net) plankton net sampling in the main river channel at the river site will be conducted every 10 minutes on the 90 minute flood-tide when the mean daily water temperatures reach 11^{0}C, sampling will be daily on the daytime flood tide seven days a week until live Bass eggs are detected. Detection of the Bass eggs will trigger the 24 day shutdown of brine release. Tow frequency: single tow (30 seconds; 250µM mesh net) every 10-15 minutes for 9 tows total, over 90 minute flood tide 3 days/week. Timing: Post initial spawning to July 15. Location: main channel. Evaluating the condition of ichthyoplankton will include: physical appearance, primary assessment to evaluate if they are dead or alive followed by looking for any signs of physical damage.
Rationale: This sampling protocol was developed and tested 2010-2012 and adopted as a 'standard' from 2013 onwards. Flood tide sampling in less than 2 hours provides rapid means to assess the abundance of striped bass eggs and larvae. It provides similar information to ebb tide sampling but can be completed in less than 2 hours, as opposed to up to 11 hours over the protracted ebb tide.

2. Plankton net tows up-estuary between the salt front at high tide and the Alton Site

Objective: Map the location of salt front at high tide and quantify the density of striped bass eggs and larvae density and their copepod prey relative to salinity, and egg stage of development and larvae mean body size.
Methods: Two replicate tows (every 30 secs) about every 1 km working down-estuary on the main channel during early ebb tide back to Alton site if the confluence is navigable, otherwise terminate at breakwater opposite golf course (rkm 29). Sampling will occur every 7 days from May to July at high slack water on the Shubenacadie branch of estuary.
Rationale: The salt front at high tide marks the up-estuary boundary of the nursery habitat for striped bass. Striped bass eggs and larvae are absent from freshwater. They are distributed down-estuary of the salt front over several kilometers over a wide salinity gradient from around 0.3 to 15ppt. Above 15ppt eggs and larvae are present but their relative abundance is lower. This up-estuary sampling complements the flood tide sampling by providing data on the abundance of young striped bass and their copepod prey. Mapping the location of the salt-front provides an indicator of advection risk. Following heavy rain, increased runoff forces the salt front down- estuary increasing risk of eggs and larvae being flushed (advected) into Cobequid Bay, which we believe is unsuitable habitat for these early life stages.

3. Beach-seine netting

Objective: Determine striped bass larvae and juvenile mean body size, condition and catch per unit effort. Additionally, other species of fish and invertebrates will be identified and counted but will not be measured for size/length.
Methods: Seine net sampling on the West sand bank of the Alton site and upstream on the Shubenacadie River at the Highway 102 Bridge. Work plan will include sites in Cobequid Bay if DFO cannot maintain their striped bass young-of-the-year survey that was conducted annually from 1999 onwards, but ceased at the end of 2014. Beach seining typically catches a variety of species of fish and invertebrates, all of which are identified and counted. Sampling will take place every 7 days from June to October.
Rationale: Beach seine hauls become the sole means to catch young striped bass from early July onwards. The plankton net is no longer effective. The survey yields valuable data on abundance (catch per unit effort) and the change in the body size and diet of the young bass through the summer. Also body size at the end of growing season is a good indicator of over winter survival and recruitment. The study will also provide quantitative data on other species that are within the estuary and the study area.

Alton Site Monitoring

> **Important**: The detection of striped bass eggs in the river will result in the cessation of brine discharge for a **24 day period**. Detection of eggs in the intake is not expected but if they are seen it will result in the incident being reported to and consultation with both the DFO and NSE to determine if further action is needed.

Ichthyoplankton sampling at Water Intake

Objective: Determine the density per cubic meter and physical condition of ichthyoplankton, including striped bass eggs and larvae, at both the face of the intake and within the intake/intake well compared to the main channel of the Shubenacadie River. Evaluating the condition of ichthyoplankton will include the physical appearance, primary assessment to evaluate if they are dead or alive, followed by looking for any signs of physical damage. Velocities at the intake face will also be measured during low flow, mid flood tide, slack tide, and mid ebb tide along transects along the face to obtain a picture of the current patterns and to allow for adjustments, if necessary, of water intake levels during operations.
Methods: A portable pump will be used to sample water both at the water intake face and in the intake well inside of the gabion wall. Each water sample will be filtered through 500µM mesh plankton nets. Abundance and appearance of striped bass eggs will be visually assessed immediately since they are large (3.5mm diameter) and easy to see. The rest of the sample will be preserved in 10% buffered formalin for examination under dissecting microscopes. The water quantity filtered will be determined by the time for each sample and pumping flow rate. Sampling will take place 3x/week starting when the intake is operational in May1st through to July 15th. Subsequent sampling will be 1x/week through September 30th.
Rationale: Comparing the number and condition of striped bass eggs and larvae between the main channel of the estuary and the intake channel is an important indicator of the effect of brining operation.

Ichthyoplankton sampling at Brine Discharge

Objective: At the brine discharge site determine the number and condition of ichthyoplankton, including eggs and larvae going past the brine discharge compared to the main channel of the estuary.
Methods: Pump tests/plankton net sampling for species, numbers, life stage and mortalities based on the cubic meters of water sampled. Samples will be taken 5 meters upstream and downstream of the brine discharge at low / mid flood and ebb / high tide. Sampling will take place three times a week from May 1st through July 15th followed by once a week through to late fall.
Rationale: Comparing the number and condition of striped bass eggs and larvae between the main channel of the estuary and the intake channel is an important indicator of the effect of brining operation on the aquatic ecosystem. Monitoring of early life stage striped bass and comparing results to the knowledge gained over the past eight years (see following information) will be an important component of the effects monitoring plan.

Salinity Monitoring

Salinity monitoring and criteria for adjusting the brine discharge rate

Objective: Salinity monitoring will be the most comprehensive way to mitigate against any possible project effects. The objective is to ensure the average salinity over each 10 minute period of the brine discharge five meters from the outfall structure is no greater than 7ppt above background, and does not exceed 28ppt.
Methods: At a distance of five meters either side of the toe of the outfall structure deploy an array of four salinity meters, set at vertical spacing; bottom, 1.5, 3.0 and 4.5m (Image 1). Both arrays are tied into an computer interface that computes the difference in mean salinity each minute between the up flow background salinity meters and the down flow salinity meters . These meters will record salinity every minute. The meters not receiving brine discharge flow in their direction will be used as the background salinity readings. At any time point, the number of meters immersed in water will depend on the state of the tide. Meters exposed to air and reading zero will be ignored. Salinity data from the meters immersed in water column will be averaged (meters either side of the brine discharge separately). If average salinity over a 10 minute period is 7ppt above background or above 28ppt, the discharge flow will be reduced by 20%. The discharge flow will continue to be reduced by 20% every 10 minutes until the average salinity is within 7ppt of background. If the average salinity falls below 7ppt of background the brine flow will be increased accordingly. Operational experience may allow the system to be programed more precisely. This in-river monitoring and control of the brine release will ensure the protection of the ecosystem as the release rate is determined by real time conditions in the river flow. Typically, releases into watercourses are measured at the end of the discharge pipe and environmental conditions in the river are based on dilution models. This can result in adverse conditions. To avoid this risk, brine releases will be real time monitored and automatically corrected as above. Failures in the system like power outages or any problem with the monitoring equipment result in automatic shutdown of brine release.
Rationale: All organisms within the estuary can tolerate salinities within and higher than this salinity range.

Water salinity monitoring at the Channel Ends

Objective: To ensure that the salinity of the brine discharge at the channel ends does not exceed 7ppt above background or a maximum of 28ppt.

Methods: A pair of salinity loggers will be deployed at the floor of each of the channel ends and record salinity every 10 minutes (Image 1). Data will be down loaded daily during the first week of start-up and then three times a week until full brining is achieved then continued for 1 month. Ongoing operation download schedule will be once a week.
Rationale: All organisms within the estuary are naturally adapted to salinities within this range.

Water salinity monitoring in the Main Channel of the Shubenacadie River

Objective: To detect the natural background salinity of the estuary and ensure that the brine is fully mixed and not influencing background readings.
Methods: A minimum of three salinity data logging meters reading every 10 minutes will be positioned in the Shubenacadie estuary and Stewiacke River. One salinity meter will be located 100 meters downstream of the constructed channel. One meter will be up-estuary in the Shubenacadie River, near the Highway 102 Bridge. One salinity meter will be in the Stewiacke River, near the CN train bridge. Data from salinity meters will be downloaded bi-weekly, except during shutdown.
Rationale: The Alton monitoring project has seven years of salinity recording in the Shubenacadie River. Researchers will be able to detect if salinity readings are deviating from normal.

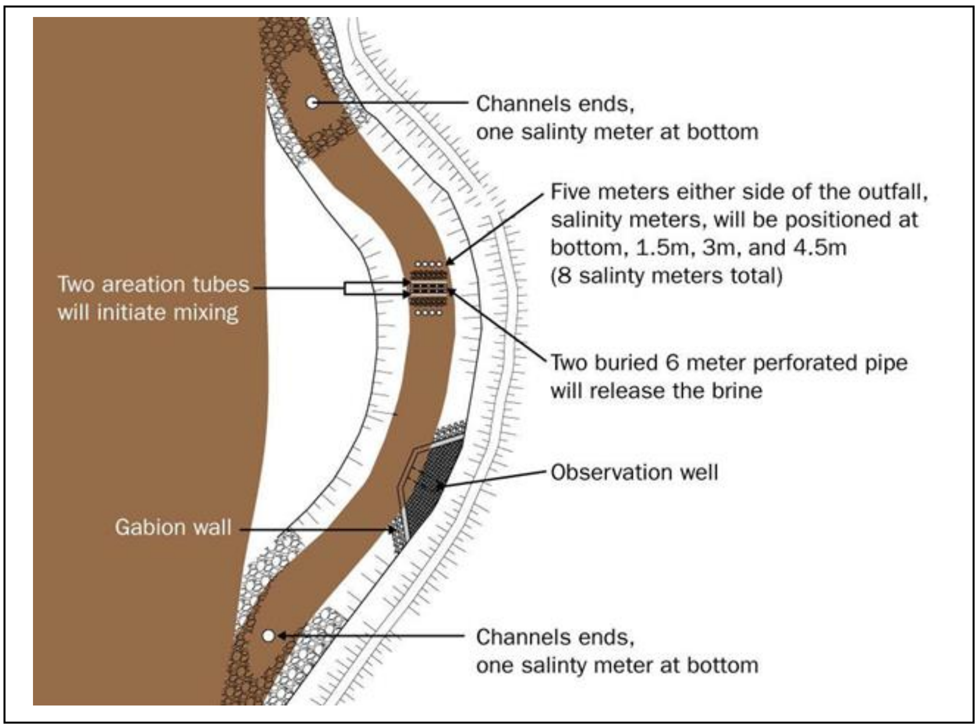


Image 1: Schematic of the placement of the ten salinity meters within the constructed mixing channel.

Knowledge Gained on Factors Influencing Striped Bass Recruitment

Recruitment is when a fish survives their first winter and is added to the population the following year. The factors affecting year class strength of striped bass are of similar complexity to other marine fish, “the outcome of complex trophodynamic and physical processes acting over many temporal and spatial scales and throughout the first year of life” wrote Houde (2008). Even in the highly studied Chesapeake Bay, the understanding of interaction between environmental and biological factors that dictate striped bass recruitment remain limited despite over 25 years of research (Martino and Houde, 2010). Like most highly fecund organisms where there is no parental care, mortality among striped bass is very high in early life stages (Houde 1989). However, once striped bass survive their first year their chances of surviving to maturity are greatly increased (Mraz and Threinen, 1957; Green, 1982; Houde 1987). In stratified estuaries such as Chesapeake Bay, the hydrodynamics associated with the estuarine turbidity maximum (ETM) define the nursery habitat for the early life stages, associated with high densities of suitable prey (Martino and Houde 2010). The macrotidal Shubenacadie estuary, by contrast, is shallow, fully mixed with no ETM. The Shubenacadie-Stewiacke watershed is the only estuary across striped bass species range dominated by a tidal bore (Rulifson and Dadswell, 1995). Research up to 2008 was restricted to basic adult stock status reports published by the Department of Fisheries and Oceans (DFO), and some pioneer early life stage research by North Carolina researchers, mostly in 1994 (Tull 1997; Paramore, 1998; Rulifson and Tull, 1999). The factors affecting the survival and growth of early life stage in the Shubenacadie-Stewiacke estuary were largely speculative prior to the current study (Rulifson and Tull, 1999). To highlight the limited knowledge on the subject of early life stage striped bass in the Shubenacadie prior to 2007, in Alton's 2007 EA, Jacques Whitford (2007a) stated "…..eggs and larvae were reported as being potentially present at high numbers during the spawning season (R. Bradford, pers. comm. 2007 cited in Jacques Whitford, 2007)."

Over the past eight years we have identified a number of factors affecting survival and growth during the critical early developmental stages. The main findings are summarized below.

a) The Shubenacadie estuary can serve as a nursery habitat because it is relatively long compared to other estuaries in the inner Bay of Fundy. The Shubenacadie/Stewiacke estuary is the sole striped bass nursery habitat in the area because it is long enough (>40 km) to retain eggs and larvae within the estuary despite the ebb tide lasting many hours more than the flood.
b) The salt front is the upper boundary of the striped bass nursery habitat. Striped bass larvae have an absolute requirement for brackish water and hence are absent from the freshwater. Moreover, up-estuary of the salt-front in tidal freshwater there is very little food for first feeding striped bass. Copepod prey is broadly distributed down-estuary of the salt front over a wide range of salinities.
c) Large rainfall events following spawning forces the salt-front down-estuary, up to 20 km, increasing the risk of advection of the eggs and larvae out of the nursery habitat and into Cobequid Bay.
d) A cold May can delay spawning to June 1st and below average temperatures in summer shortens the growing season, reducing the chances of juvenile striped bass achieving a body length of 10 cm by the end of the growing season. Evidence from other striped bass populations indicate juveniles less than 10 cm do not survive winter (Hurst and Conover 1998).
e) Food supply in the estuary is a limiting factor during May and June, resulting in striped bass larvae not growing, remaining 6 mm long into July (Fig. 1). The two most abundant copepods in June, and prey for the striped bass is *Pseudodiaptomus pelagicus* and *Scottolana canadensis.* By comparison in other striped bass nursery habitats *Eurytemora affinis* is the principal prey. The genus *Pseudodiaptomus* are known to inhabit waters of high turbidity and turbulence.
f) High survival through the egg and larvae stage and likely high recruitment is associated with low rainfall and high temperatures through May and June. The large numbers of

adult striped bass in the Shubenacadie River are due to exceptional recruitment of the1999 and 2000 year classes (Bradford et al. 2012). May and June of these two years were the warmest and driest in past 90 years.

Other discoveries since the Alton EA (Jacques Whitford 2007a and b) are briefly outlined below:

a) Over eight years, 2008 to 2015, striped bass spawning occurred from mid-May to late-June in several episodes in the Stewiacke River, associated with a warming trend above 12ºC (see next section for more detail). The density of eggs in front of the Alton site progressively rose and fell through the long ebb tide (ca. 10h) over salinities ranging from < 1 to 25 ppt. Egg densities were >15,000 eggs/m³ following the largest spawning episode in 2012, and averaged >1,000 eggs/m³ at least once every year. Larvae numbers were much lower than eggs and exhibited greater inter-annual variation. Mean daily density of larvae ranged from <1/m³ in 2009 to >1,000/m³ in 2012.

b) The thermal spawning range for Shubenacadie striped bass is 12 to 20 °C. The suggestion by Rulifson and Tull (1999) following observations made in 1994 that 18 ºC is 'critical' for spawning is not supported by our 8 years of data. The final stages of gonadal maturation are dictated by temperature. Spawning is inhibited by <12ºC (see next section). The effect of the 28 day lunar cycle on spawning is negligible. However the daily tidal is important, spawning typically occurring around high tide.

c) The duration of the spawning season ranged from 31 to 49 days over 8 years. Each year 90% of the eggs were collected over a continuous 6 – 13 day stretch. The shorter spawning seasons are associated with prolonged warm spells.

d) Eggs and larvae are transported up river on the brief, high energy, flood tide with density decreasing abruptly close to the salt front, and none were found in the tidal freshwater. Risk of advection from the estuary nursery habitat into Cobequid Bay during the ebb tide was highest during large freshets (rainfall events) which forced the salt front up to 20 km down river.

e) The spatial and temporal distribution of striped bass eggs and first feeding stage larvae are similar, and are aligned with salinity. Eggs and larvae at or up-estuary of the Alton site at river kilometer (rkm) 25 are broadly distributed between 0.2ppt and 15ppt salinity. This broad 'phalanx' of eggs and larvae covering several rkm usually drifts past the Alton site on both the flood and ebb tide. When freshwater runoff is high this entire column ends up down-estuary of the Alton site during the ebb tide, a portion returning on the next flood tide. The mechanism for retention of eggs and larvae in the estuarine nursery habitat differs markedly between the fully mixed macrotidal Shubenacadie estuary and stratified coastal plain estuaries such as those draining into Chesapeake Bay.

f) On the ebb tide, the distance suspended particles or bass eggs and larvae travel down-river depends on whether they remain in the main channel or drift into the margins where the flow is slower and complicated by back-eddies. Either path poses a threat to survival of striped bass early life stages. Striped bass eggs can commonly be seen stranded on the many sand banks along the Shubenacadie estuary, particularly when the wind is onshore (Image 2). These stranded eggs would not survive exposure over the long ebb tide.

Image 2: Striped bass eggs stranded on the sand bank of the Shubenacadie River. Stop watch is positioned in the image for scale.

g) Early post-hatch larvae are equally at risk of getting beached since they are vertically orientated. By about 5 days post hatch (dph) (ca. 5 mm TL), they are horizontally orientated and can swim at about 0.02 m/s (Meng 1993), potentially transforming the margins from a threat to a refuge since they can swim to avoid getting beached.

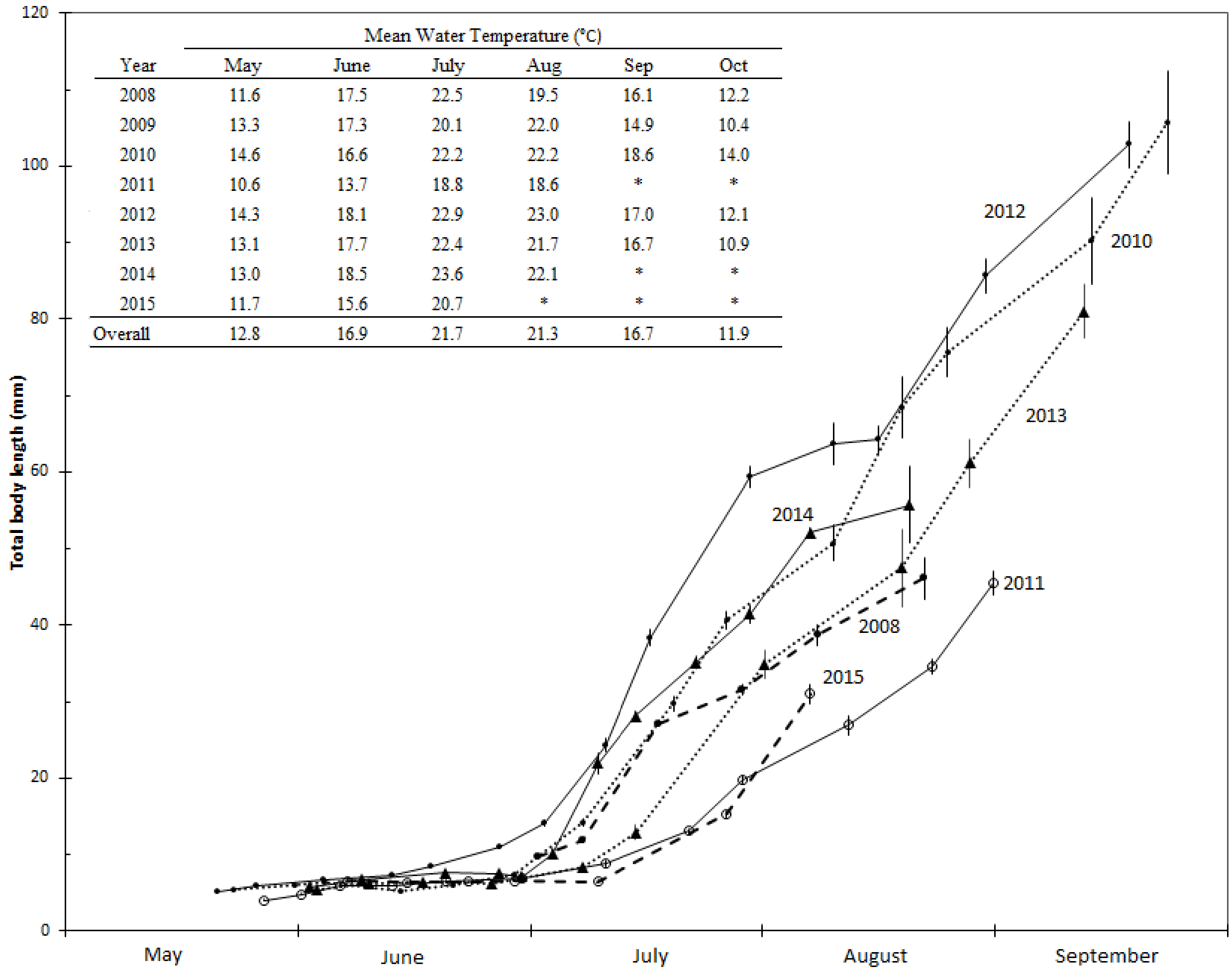
h) Eggs and larvae in the main channel are safe from beaching but risk advection into Cobequid Bay, particularly during freshets. Risk of advection is inversely dependent on the length of an estuary. Since the Shubenacadie River is >40 km long, particles can take several hours to reach the estuary mouth, during which time the next tidal bore can sweep in, sealing off the estuary. Advection was confirmed on May 30, 2011, following a spawning episode May 29 when freshwater discharge was high. Eggs were retrieved in the Cobequid Bay at five sites over 6 km between Noel Shore and Noel Head. Eggs were still exiting the estuary at the end of the ebb tide, their density was 739/m³.

i) The largest spawning event recorded was on May 17, 2012 (ebb tide 0015 h to 1112h), with an estimated 14.3 billion eggs in the main channel alone, from about 18,500 females with a mean fecundity of 777,790. This estimate was considered highly conservative since only eggs in the main channel (30% of the cross-section) were quantified. Nevertheless, egg production in 2012 was >100 times more than the estimated 106 million in 1994 (Rulifson and Tull 1999).

j) Daily egg densities exceeding 1,000/m³ were common in the Shubenacadie River during the study period, which were orders of magnitude higher than numbers reported for the Miramichi River, Chesapeake Bay tributaries and the Savannah River.

k) Feeding rate and growth of larvae in May and June are poor each year. Growth improved as the estuary warmed above 20 ºC. In the warm dry summers of 2010 and 2012, juveniles were >9 cm TL by late-August, indicating good recruitment in those years. By contrast, in the cooler summers of 2008 and 2011, juveniles were only ~ 4 cm TL by September (Figure. 1).

l) Striped bass over-winter survival and recruitment is dependent on underyearlings reaching a body size of ~10 cm fork length by the end of the growing season (Hurst and Conover 1998). Mean body size of the bass in late-summer suggests recruitment among the Shubenacadie population was better in 2010, 2012 and 2013, compared to 2008, 2009, and 2011(Figure 1).



Year	Mean Water Temperature (°C) May	June	July	Aug	Sep	Oct
2008	11.6	17.5	22.5	19.5	16.1	12.2
2009	13.3	17.3	20.1	22.0	14.9	10.4
2010	14.6	16.6	22.2	22.2	18.6	14.0
2011	10.6	13.7	18.8	18.6	*	*
2012	14.3	18.1	22.9	23.0	17.0	12.1
2013	13.1	17.7	22.4	21.7	16.7	10.9
2014	13.0	18.5	23.6	22.1	*	*
2015	11.7	15.6	20.7	*	*	*
Overall	12.8	16.9	21.7	21.3	16.7	11.9

Figure 1: Mean total body length (+/- one standard error) of age-0 striped bass in the Shubenacadie River over seven years. In 2009, too few fish were caught to plot. Mean monthly water temperatures are from the Stewiacke River at rkm 0.6. * indicates missing value

m) The poor feeding success and growth of striped bass 5-7 mm TL in the Shubenacadie River appears to be due to a shortage of food. The ability to survive in a limited food situation through yolk-sac absorption can explain the persistence of 5-7 mm TL larvae in the Shubenacadie River through May and June.

n) The Stewiacke and Shubenacadie River watersheds are nutrient-poor habitat. These oligotrophic conditions, compounded by the high turbidity that limits primary production, can explain why the tidal freshwater portion of the Shubenacadie and Stewiacke branches of the estuaries produce insufficient zooplankton to serve as nursery habitat for striped bass. The salt-front marks the up-estuary limit of a productive heterotrophic food web that is based on suspended organic carbon imported from the Inner Bay of Fundy on the flood tide (Dalrymple *et al*. 1991).
o) The density of copepods in the upper Shubenacadie River was <100/m³ in both June 2012 and 2013, much lower than other rivers at the first feeding stage for striped bass larvae. A different copepod species (*Pseudodiaptomus pelagicus*) from those other rivers was common in the Shubenacadie River in June and is the main prey item for first-feeding striped bass. *Pseudodiaptomus spp*. are epibenthic calanoid copepods that can maintain their position in estuaries with high water currents by clinging onto surfaces, and in culture tolerate high turbulence and turbidity, characteristics suited to the highly turbid Shubenacadie River.
p) Improvements in feeding and growth were associated with the estuary warming above 18 ºC between mid-June (2012) and early-July (2011). Mysids (*Neomysis americana*), were a common prey among striped bass >10 mm TL, as well as sand shrimp (*Crangon septemspinosa*).
q) The nursery habitat expands through July as the striped bass grow. Decreased catches of underyearling striped bass in the estuary through July-August is associated with migration into Cobequid Bay as summer progresses.

Since the EA approval in 2007, Alton supported an annual monitoring program to serve as a baseline against which future monitoring data could be compared and for the refinement of future monitoring program requirements. This baseline information collection program was completed in consultation and collaboration with expert scientists in academia and government. The monitoring program revealed considerable inter-annual variability in environmental conditions that affected the timing of spawning and survival and growth of young striped bass. The knowledge gained will be used in conjunction with the more predictable salinity monitoring to assess potential effects related to the project. Continuous salinity monitoring, monitoring a variety of other species in the estuary and monitoring for ichthyoplankton within the wider river, within the constructed channel and the water intake, will be used to ensure the project does not affect the ecosystem.

2.2 'Stop brining' decision relative to striped bass spawning

CRA Recommendation:

> *"Recommend that the proposed monitoring plan clearly define "peak spawning events" for discontinuing brine discharge and include a contingency to reduce lag times between sampling and analysis of eggs in the river."* (CRA report, section 4, page 13)

Alton Proposed Action:

Alton proposes to take a precautionary approach and stop brining operations during a 24 day from the first detection of bass eggs at the Alton site. The need to define the period of peak egg and larvae abundance in the river is no longer relevant. The exact timing of this period will be determined through precise monitoring of temperature beginning May 1st of each year, and according to specifications in the Industrial Approval monitoring plan. During this shutdown, Alton will conduct annual facilities maintenance.

Through the river monitoring process, researchers at Dalhousie University quantified the number of striped bass eggs passing by the site on both the ebb and flood tide during May and June. Although not required in an EA condition, Alton decided to commit to a precautionary approach and stop introducing brine into the channel when striped bass eggs and larvae are at their highest abundance.

The initial large spawning event by striped bass has occurred between May 15 and June 1 in each of the past 8 years. Moreover, in 6 of 8 years the initial large spawning was associated with an accumulation of between 11 and 20 degree days above 12ºC (Table 1). The striped bass spawning season typically consists of two to four large episodes where over 100 eggs/m³ are detected, with several smaller events <10 eggs/m³. When 12ºC is exceeded and the weather forecast indicates further warming, the Alton operation will go to 'yellow alert' and be ready to stop discharging brine when Bass eggs are detected at the Alton site.

Additional Actions

1. To predict the onset of spawning, the following actions will be taken:

a) Starting on May 1st of each year, water temperature will be monitored continuously and degree days above 11°C calculated. There is less than a 1ºC difference in water temperature between the Alton site and the spawning grounds (Figure 2). Degree days are a measure of how much warming (in degrees) and for how long (in days) the water temperature is above a certain level.

b) Weather forecasts will be closely monitored in anticipation of reaching temperatures above 12˚C and the number of degree days that trigger spawning events.

c) Gaspereau fishers congregating at the 'Fish Shack' (a hub for the local fishing community, Main St. W in Stewiacke) will be consulted at least twice weekly. Through their handling of striped bass by-catch and word-of-mouth they know the state of sexual maturation of the striped bass.

d) Daily plankton net tows will be conducted in the main channel of the Shubenacadie estuary at the Alton site beginning May 1st. Net tows will be every ten minutes through the 90 minute flood tide occurring during daylight hours, following established protocols. Samples will be visually examined at the Alton site within 2 hours of collection for presence/absence of striped bass eggs, and a GO/STOP decision made. Definition of STOP: Brining ceases within 1 hour. GO: Brining continues for another 24 hours until assessment following the next flood tide sampling.

e) Known striped bass spawning locations will be visually monitored for indication of spawning events.

f) Annual facilities maintenance will be scheduled to start following the initiation of the shutdown period and typically last two weeks. However, brining can be halted earlier if water temperatures indicate a spawning event is imminent.

During this maintenance shutdown, monitoring will continue to assess the progress of the *spawning season and abundance of eggs and larvae. Plankton net tows will be conducted every 2-3 days during the flood tide and up-estuary to the salt-front at high tide.*

2. Variability through the spawning season and adaptive management for determining when to re- start the water withdrawal and brine discharge:

a) Each year following the first big spawn, newly fertilized eggs were detected almost daily if the estuary remained >14 ºC, different cohorts were mixed together by the ebb and flow of the tide. The 2012 spawning season was compressed between May 17 and June 5, associated with warm dry weather kept the estuary stable at 16-18 ºC (Figure 3). By contrast, a cessation of spawning was associated with the estuary cooling from >16 ºC to 11 ºC in both 2010 (May 25 to June 2) and 2011 (June 10 to 16; Figure 3).

b) The predictability of the first spawning event is dependable and shut down will be tailored around that. However, given the variability in the length of the spawning season, eggs >10/m³ were detected for 9 to 31 days from 2008 to 2015, adaptive management will be an essential part of re-start.

c) Following the 24 days of shut down, the progression of the spawning season will be assessed, taking into consideration how many spawning episodes have taken place, the size of the spawning, and the water temperature variability. Daily plankton net tows, water temperature and visual up-stream monitoring will take place for the subsequent two weeks. From start-up following the no brine release period until July 5th, the discharge will be regulated as above to maintain salinities at or below 7ppt above background and at or below 20ppt. If an additional spawning episode is detected, after start up DFO and NSE the incident will be reported and the need for remedial action will be determined in consultation with the departments. When very low numbers of striped bass eggs are present in the estuary the authors of the EA considered the possibility of entrainment is near zero. The Biological Impact Statement, within Alton's supplemental EA (Appendix C), estimated "*Out of 100 drifting eggs and larvae, based on water flow, 86 will pass in the river, and 14 will enter the mixing channel and potentially 0.01 to 0.15 will enter the intake. The faster flow and turbulence pattern at right angles to the intake will reduce the potential entrapment of eggs and larvae to near zero."* (Jacques Whitford. 2007b). This estimate was for a single pass and the eggs and larvae may make several passes by the intake. This has been revised as a result of design updates to further mitigate the impacts of the project.

3. Evaluation of striped bass larvae near the Alton site

The density of striped bass larvae at the Alton Site was much lower than eggs, and varied considerably between years. Most notably, in 2009 a total of only 458 larvae were collected at the Alton Site during the ebb tide and mean daily density <1/m³, 0.03% of the number of eggs counted (Figure 3). By contrast, in 2012, the mean daily density of larvae was >1000/m³ for several days in late-May, 6.25% of the number of eggs caught (Figure 3). The presence of larvae at the Alton Site was largely dependent on salinity; they were absent if the ebb tide water was fresh, and their concentration highest at 1 to 4 ppt salinity. By early July, striped bass were rarely caught in plankton net tows in the main channel, associated with their transition from larvae to juvenile and their increased swimming ability and broader distribution throughout the estuary.

Year	Initial big spawn	Degree Days >12˚C	Duration warming trend (days)	Mean daily temperature at spawning (˚C)
2008	1-Jun	11.3	5	12.8
2009	24-May	13	3	16.1
2010	17-May	16.2	13	12.4
2011	22-May	5.6	4	12.2
2012	17-May	19	7	16.5
2013	27-May	5.5	6	13.9
2014	20-May	17.2	6	14.6
2015	30-May	20.5	5	19

Table 1. Striped bass initial large spawning episode over eight years in the Stewiacke River as judged by egg collections down-estuary on the Shubenacadie River (rkm 25) relative to degree days (ºD) accumulated above 12 ºC and duration of warming trend.

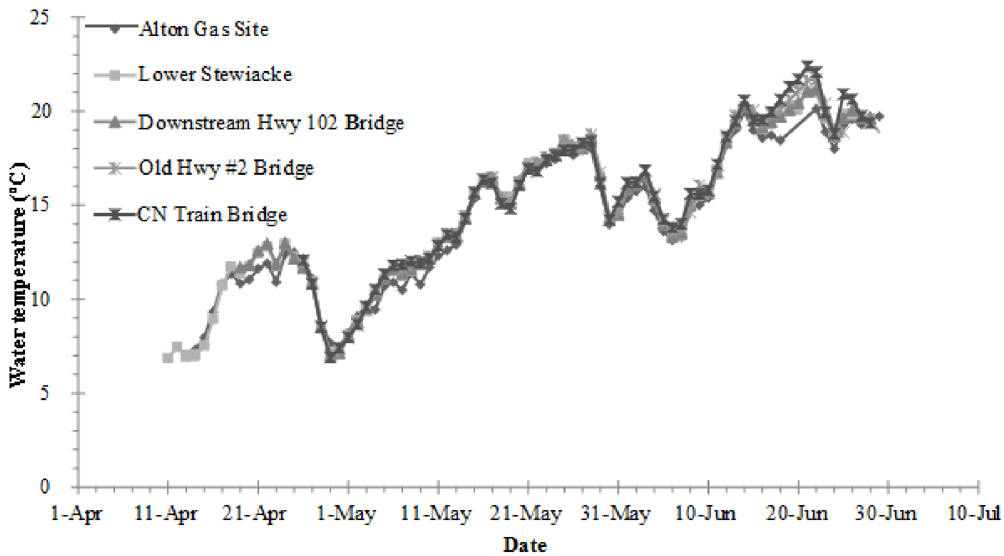
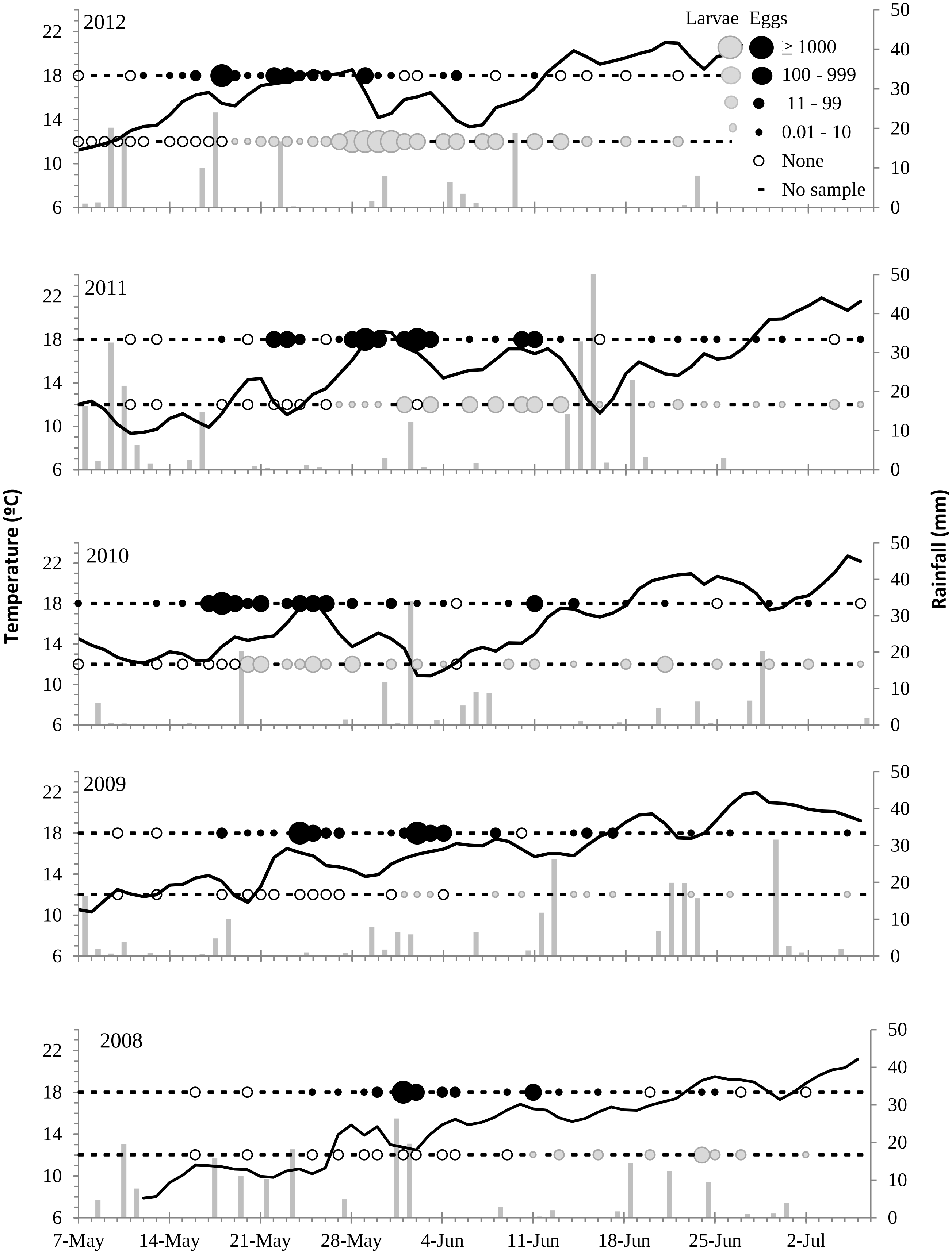


Figure 2. Daily mean water temperature (ºC) from April 11 to June 29, 2012 collected from five conductivity-temperature-depth loggers on the Shubenacadie and Stewiacke Rivers. Loggers were positioned at the Alton Gas Site (river km 25 Shubenacadie), Lower Stewiacke River (rkm 0.7 Stewiacke), downstream of the Highway 102 Bridge (rkm 2 Stewiacke), old Highway #2 Bridge (rkm 4 Stewiacke) and the Canadian National Train Bridge (rkm 8.7 Stewiacke).

Figure 3 (see page 16). Daily mean density per cubic meter of water filtered of striped bass eggs (black circles) and larvae (grey circles) over eight years in the Shubenacadie River estuary at the Alton Site (rkm 25). Each coordinate is a mean of between 3 and 10 plankton net tows in the main channel over several hours through the ebb tide. Daily mean water temperature (solid line) and daily rainfall (grey bars) are also shown. Note the large May 30th 2015 spawning event shown in a black hatch line circle was detected on the Stewiacke River.



2012
2011
2010
2009
2008
Larvae Eggs
≥ 1000
100 - 999
11 - 99
0.01 - 10
None
No sample
Temperature (ºC)
Rainfall (mm)
7-May
14-May
21-May
28-May
4-Jun
11-Jun
18-Jun
25-Jun
2-Jul

2.3 Potential Effects of Entrainment and Impingement on Ichthyoplankton

CRA Statement

"However, effects of entrainment and impingement for water taken to the caverns is very likely negligible since the volumes of water are also very small." (CRA report, section 3.4, page 8)

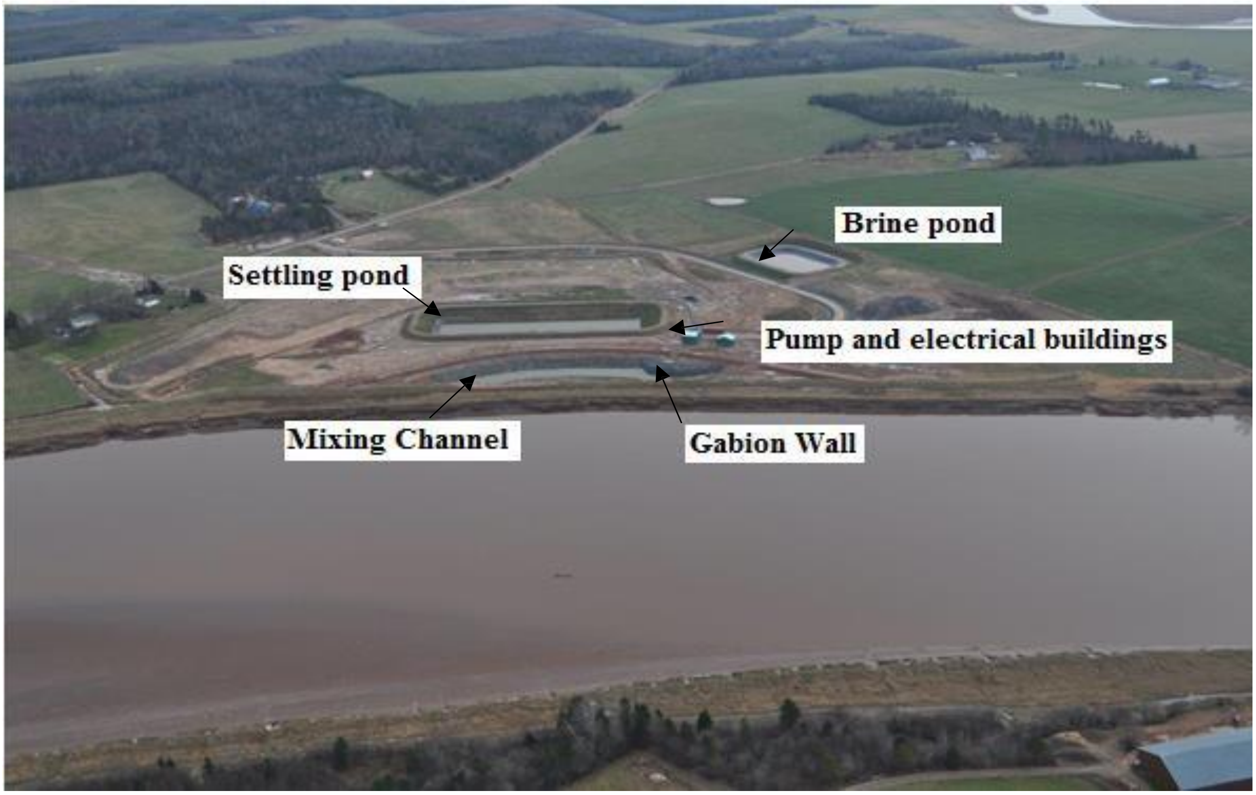


Image 3: Aerial photo of the Alton Natural Gas river site adjacent to the Shubenacadie River in the fall of 2014. Visible components of the facility include the mixing channel and gabion wall, the settling and brine ponds, and the pump and electrical buildings.

CRA Recommendation

"The EA supporting document estimated 14% of Striped bass eggs and fry passing the Site would be entrained in the intake channel. This estimate of entrainment is based primarily on water flows during a single ebb/flow. It does not take into account the potential for eggs and larvae to repetitively pass into the channel during ebb flow conditions resulting in an underestimate of potential entrainment and exposure of eggs and fry to the diluted brine discharge. ***Recommend that the planned monitoring of eggs and fry entrainment in the channel be conducted to validate the EA predictions using ichthyoplankton which will account for potential for repetitive entrainment****."* (CRA report, section 4, page 12)

Clarification: The definition of "entrainment" and "impingement"

> *"The EA supporting document estimated 14% of Striped bass eggs and fry passing the Site would be <u>entrained in the intake channel</u>."* (CRA report, section 4, page 12)

Alton's environmental and engineering consultants have been using the DFO definition for entrainment and impingement and the channel design and water intake system were designed to significantly reduce both Entrainment and Impingement as defined by DFO:

> *"**Entrainment** occurs when a fish is drawn into a water intake and cannot escape."*
>
> *"**Impingement** occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself" (DFO 1995).*

It appears that CRA was using another definition for entrained, possibly meaning "to draw in and transport by flow of a fluid". Going forward within this report, we will continue to use the DFO definition for entrainment and impingement. <u>Clarification of these definitions is essential as the entire intake structure was designed to let free floating organisms pass by the system, free from both being entrained and impinged.</u>

"The channel design and water intake system were design so the faster water flow and turbulence flow pattern at right angles to the intake will reduce the potential entrapment (Entrainment) of eggs and larvae to near zero." (Jacques Whitford. 2007b)."

Alton Proposed Actions

The project will consider the potential effects of entrainment and impingement on ichthyoplankton and implement planned monitoring. This has been addressed through project design, operational protocol and monitoring plans discussed below.

Project Design. Alton's tidal water intake design significantly surpasses DFO standards (DFO 1995). Typically, a water intake structure consists of a pipe with an end of pipe screen that varies in size and area depending on the water flow and organism present in the area (Image 4).
In addition, Alton's elaborate mixing channel and gabion wall intake structure (Images 5 and 6) have been designed and constructed to further avoid entrainment and impingement of organisms. The projection of the gabion wall and its alignment into the mixing channel is designed to ensure an increased velocity of water past the face of the gabion wall structure, which velocity is much greater than the velocity percolating into the gabion structure. The velocity into the intake, via the cobbles in the gabions and surrounding the intake lines, will range from 0.0012 m/s (at the highest observed high-tide water level and assuming a maximum withdrawal rate of 10,000 cubic meters of water per day) to 0.0056 m/s (at the lowest observed low-tide water level). In comparison, the water velocities within the mixing channel and along the face of the gabion wall will range from 0.72 m/s to 0.91 m/s. Thus, the velocity of the water passing along the gabion wall is approximately 130 to 750 times faster than the velocity of the flow into the gabion wall structure depending on the tidal cycle, and the potential for free floating organisms, such as eggs and early stage larvae, being transported into the intake is near zero. Nonetheless, a wet well was incorporated into the design in order to provide a monitoring mechanism (see page 22).

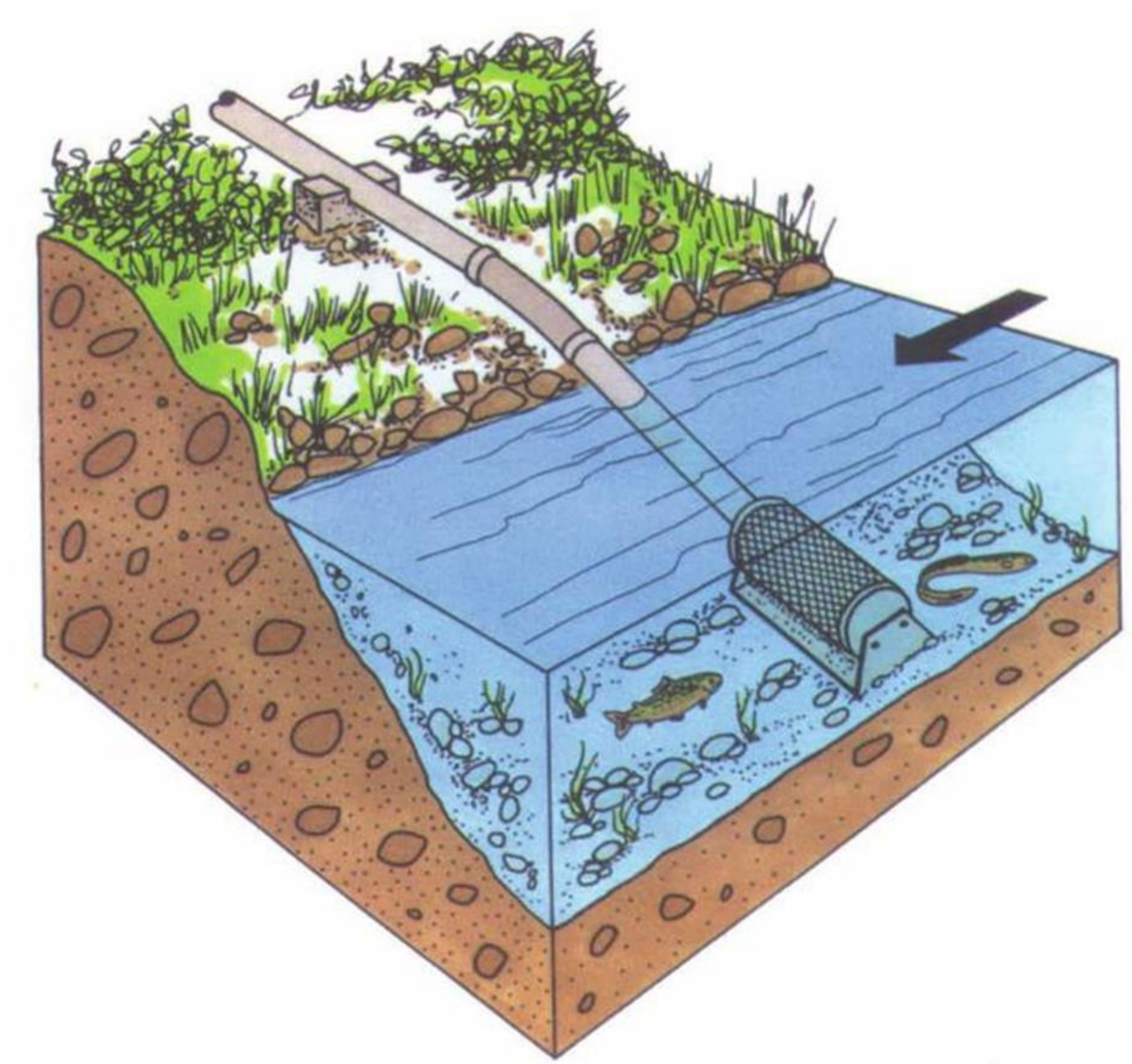


Image 4: Example of a typical installation of end-of-pipe screen to reduce the chance of entrainment and impingement (DFO 1995).

Image 5: Various stages of construction of the mixing channel and gabion wall.

Image 6: Top photo, looking West, existing mixing channel parallel to the Shubenacadie River. Bottom photo, looking East, existing gabion wall within the mixing channel.

Intake Details. The cross-sectional area of the mixing channel was developed from hydraulic modelling and geotechnical slope stability considerations. The size and projection of the vertical gabion wall structure at the intake was selected as follows:

- optimizing the height to accommodate the range of water levels on the river
- providing an adequate permeable medium for the water withdrawal into the intake pipe situated behind the wall. The gabions are infilled with 100 to 200 mm river cobbles and thus have a well-defined permeability (Figure 4).
- projection of the wall and its alignment into the channel was designed to ensure an increased and smooth velocity past the toe of the structure, thus minimizing the potential for entrainment of eggs and larvae and sediment deposition in front of the intake.

The "Johnson" screen intake pipe design was selected considering:

- water withdrawal demand from the river
- water characteristics of the river – special material designed for salt water conditions was selected
- loading from the cobble fill above the pipe

Wet Well. A wet well was incorporated into the design in order to provide an additional monitoring mechanism (Image 7) , in particular to monitor aquatic life that may have been drawn in with the intake water. Features of the system include:

- The well is perforated to provide infiltration capacity in addition to the Johnson screen pipe (Figure 4). Piping and valves have been incorporated in order to periodically back flush, using the available pump head (1,150 KPa) in the Intake Pump

Building, any sediment that might accumulate in the intake pipe and in the permeable fill around the intake line.

- Twin, screened 15 m-long intake lines surrounded by select 100 mm to 200 mm rock. The intake lines feed into a 3.6 m x 3.6 m square perforated pre-cast concrete wet well. Two lines run from the wet well to the pump house. The ends of the intake lines are setback from the face of the intake and are closed off (Figure 4). The attracting velocity into the intake will thus correspond to the velocities through the gabion cobbles and the cobbles around the intake lines, as discussed in the paragraphs above.

The mixing channel and gabion wall were constructed in the summer of 2014 (Image 5 and 6). The final construction phase needed to become operational is to break through the existing dike and finish the armoring in that area.

Image 7: The wet well within the gabion wall and mixing channel.

Operation. In spite of the elaborate design of the gabion wall and intake, which were designed and built to avoid entrainment and impingement of organisms as defined by DFO, Alton recognizes the importance of the significant striped bass spawning in the area. Shubenacadie River water will not be withdrawn when the largest numbers of free floating bass eggs are present (see section 2.1b).

Environmental Assessment (EA) Entrainment Predictions. The Water Intake and Discharge Design (Appendix B), within Alton's supplemental EA, predicted that approximately 14% of the Shubenacadie River flow would travel through the mixing channel. Based on this flow estimate, the Biological Impact Statement, within Alton's supplemental EA (Appendix C), estimated "*Out of 100 drifting eggs and larvae, based on water flow, 86 will pass in the river, and 14 will enter the mixing channel and potentially 0.01 to 0.15 will enter the intake. The faster flow and turbulence pattern at right angles to the intake will reduce the potential entrapment of eggs and* *larvae to near zero."* (Jacques Whitford. 2007b).

CRA highlighted that this estimate did not account for eggs and larvae passing the site several times on the ebb and flood tide. CRA was correct that the estimate did not account for multiple passes through the channel, as this was not known in 2007 and was discovered during the 2008-2015 river monitoring program. Updates to the project design have also been made since 2007 based on knowledge gained from this monitoring, and are intended to further mitigate the impacts on aquatic species. These include a revision of flow estimates resulting in a lower proportion of eggs and larvae potentially being entrained. Additionally, water withdrawal will be minimal during Striped Bass spawning when the largest number of free floating organisms are present. It should be noted that large losses of striped bass eggs may occur naturally, for example by being stranded on sand bars (Image 8) or by discharge out into Cobequid Bay.

Monitoring. There will be regular monitoring in the intake wet well to verify the entrainment prediction. Monitoring for organisms such as eggs and larvae within the wet well, at the face of the gabion wall and within the wider river will occur on a regular basis (greater detail in section 2.1a).

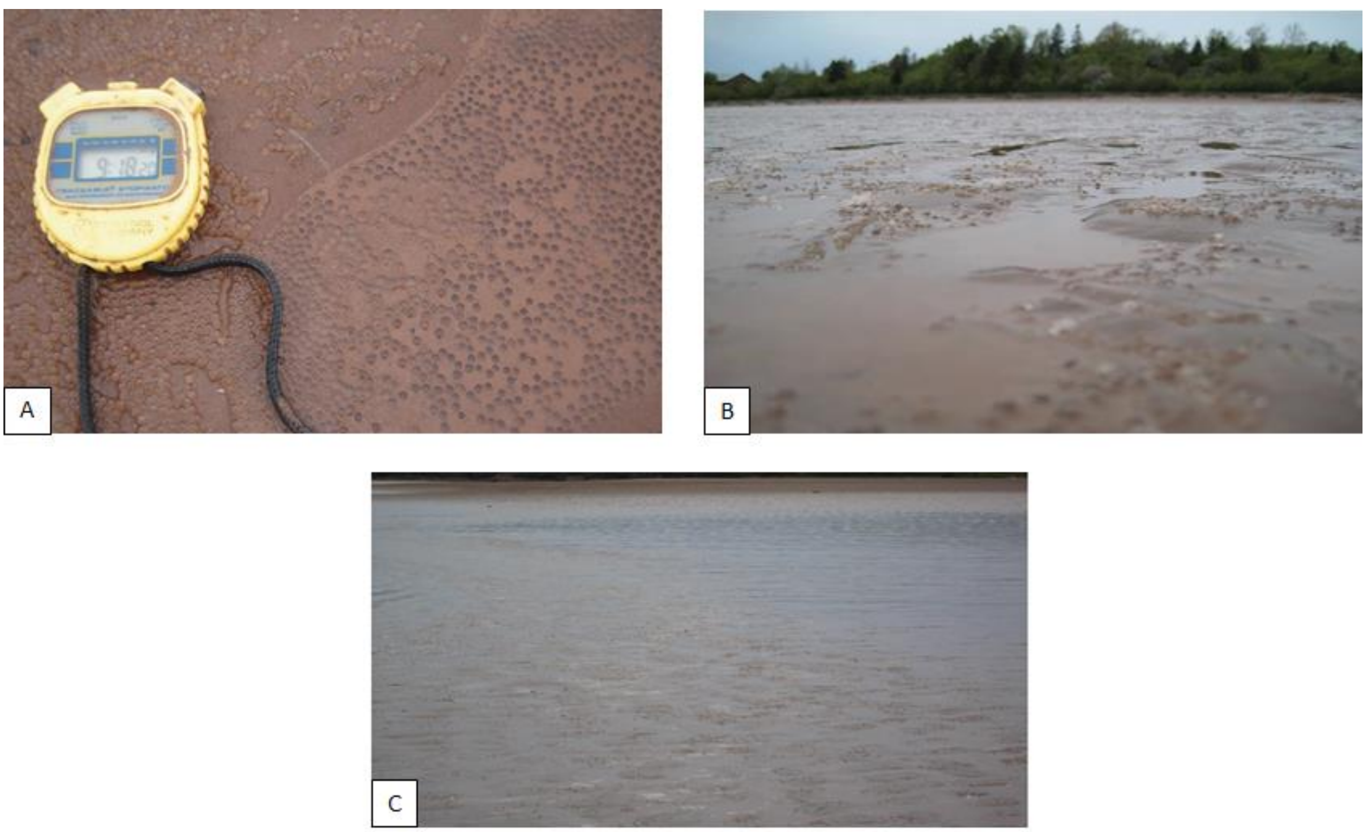


Image 8 (A, B, C). Striped bass eggs stranded on the West sand banks of the Shubenacadie River across from the Alton river site as the tide recedes in 2010. These eggs will die from exposure through the ebb tide. (Stop watch in picture A included to provide relative scale of size of eggs)

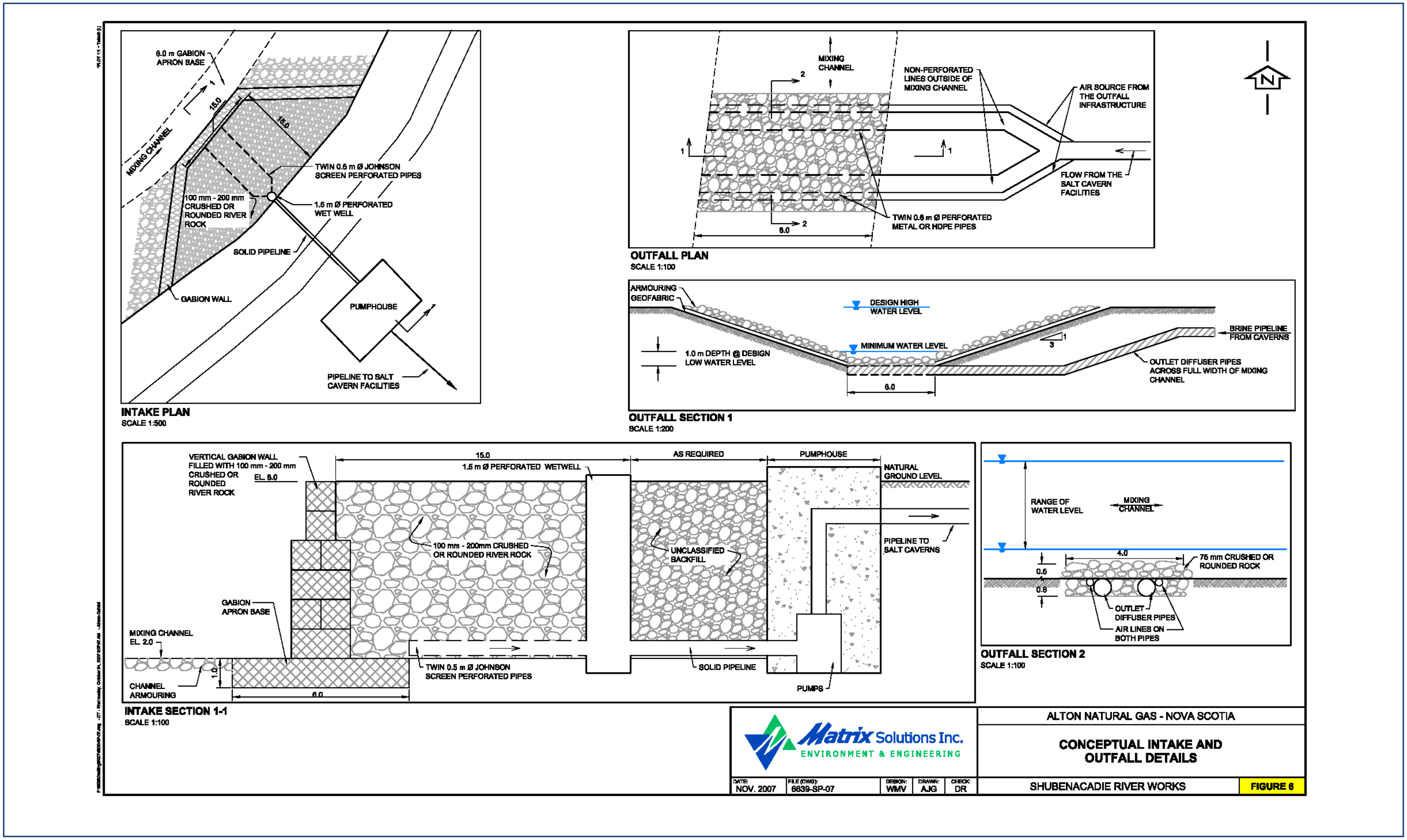


Figure 4: Details of the design of the gabion wall, wet well, water intake line, and brine outfall design.

2.4 Potential for Sediment Fouling of Rock Berm/Diffuser is Unknown

CRA Statement

> *"The current plan is to discharge the brine to a diffuser pipe buried below a coarse rock berm in the middle of the mixing channel. The combination of the diffuser and flow through the coarse rock berm are estimated to dilute the brine by more than an order of magnitude prior to the brine reaching the water column. An airline will also installed in the berm to add additional mixing if monitoring shows insufficient mixing of brine or "to help flush out sediment." In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel's water column. The potential for this to happen is unknown. However, this data gap can potentially be reduced with some sort of modeling prior to construction and ongoing monitoring after construction."* (CRA report, section 3.4, page 11)

CRA Recommendation

> *"In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the mixing channel berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel's water column. The potential for this to happen is unknown. Recommend that modeling prior to construction and ongoing monitoring after construction occur to confirm the issue is not creating unacceptable impacts."* (CRA report, section 4, page 13)

Alton Proposed Action

Careful engineering, operational protocols, ongoing monitoring and close salinity monitoring will circumvent any potential impacts from sedimentation. The CRA review process did not allow for contact with Alton staff or a site visit of the constructed facility. Many design details have been added to the infrastructure to circumvent sedimentation.

Engineering design of the channel is such that we are not expecting sedimentation build up at the brine line outfall area. However, Alton has incorporated the following operational features to the design to help manage any potential sedimentation issues:

Brine Discharge Facilities. Brine flows out of the Brine Pond through two 400 mm HDPE pipes (Image 9). The brine is measured, and controlled to insure the salinity of the river is maintained within permitted values. The brine pipe length between the outlet of the Brine Pond and the brine outfall is approximately 200 meters. The pipe expands into two 400 mm pipes with a WYE TEE. The two pipes downstream of the WYE TEE are perforated with 420, 10 mm diameter holes, installed below the bottom of the mixing channel at an invert of 0.5 m geodetic and extend about 6 meters across the bottom of the channel. A 50 mm perforated air pipe parallels the two 400 mm brine outfall pipes and provides enhanced turbulence to add in both mixing of the brine with the channel water and reduced sedimentation build up by bubbling the air through the lines. (Figure 5).

The Intake/Transfer Pumps in the pump building have the ability to direct water from the River Water settling pond through the brine outfall pipes with positive pressure of 1,150 KPa, which will also flush out any possible sedimentation build up.

Image 9: The two perforated six meter brine discharge pipes and air lines located in the mixing channel during channel construction in the summer of 2014.

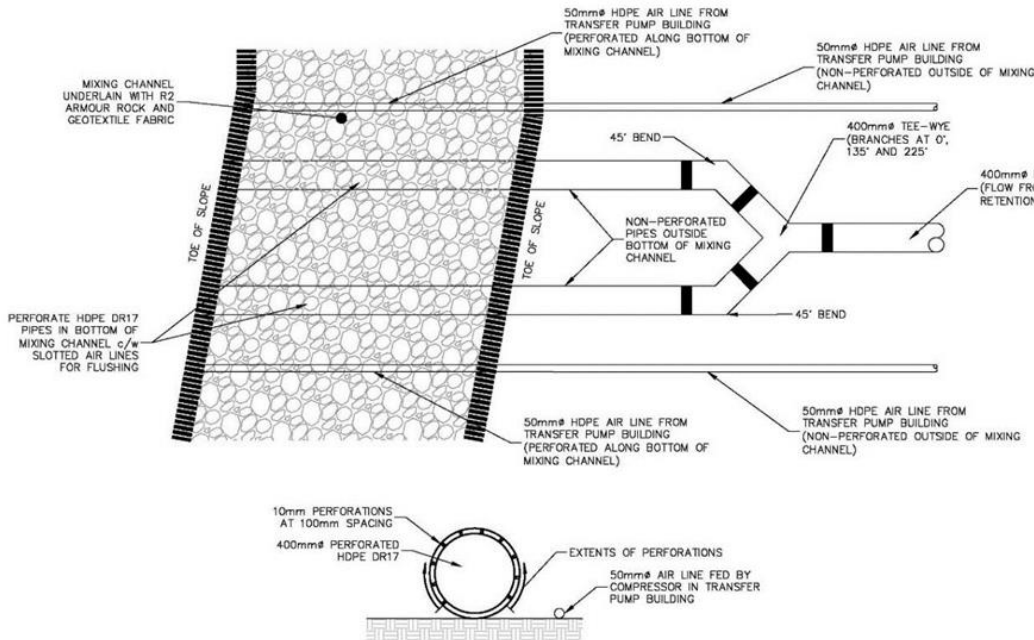


Figure 5: Brine outfall design plan

Brine Pond. An electronic level indicator and transmitter on the Brine Pond that will continually monitor and transmit Brine Pond level data to the computer PLC (programmable logic controller) system. The Brine Pond level data will be read every four seconds and the data will be available for graphing for hourly, daily, and monthly or up to one year with our SCADA system. In the event of a power failure, the brine discharge line has a fail close valve that automatically closes during an outage.

Operating protocols for regular flushing of the brine outfall lines. Details of the brine discharge levels and salinity level will be closely monitored in accordance with environmental approvals. Unexpected increases in salinity levels may be an indication of sedimentation build up at the brine outfall as well as unexpected decreases in brine discharge from the outfall.

i) If conditions require, before the start of each discharge cycle, the brine outfalllines can be flushed with pressurized water from the pumping station (1,150 KPa). As a precautionary measure to ensure the removal of any sedimentation build up, the operators may do this on a periodic basis.
ii) If the conditions require, before the start of each brine discharge cycle the air pipe lines, air pressure and release rate can be increased to help remove sediment build up or periodically as a precautionary measure to ensure the removal of any potential sedimentation build up.
iii) If required, the airlines adjacent to the brine outfall pipes can continually flow to reduce sedimentation build up from around the outfall brine area. Sedimentation level in the river decreases during none tidal flow periods.
iv) If required, from time to time, the area around the brine discharge area can be manually hosed down/washed with river water from above to remove sediment build up.

Brine Discharge Monitoring. Monitoring of salinity within the constructed channel will include:

a. Four (4) salinity meters installed 5m both sides of the brine outfall. These meters are mounted at intervals of 1.5m of water elevation. The eight (8) salinity meters send salinity measurements every two seconds to the process computer that controls the brine pond outlet flow. There are two additional salinity meters installed in the channel, one at either end. (ten salinity meters total in the channel).
b. The four salinity meters 5m from the outfall structure not receiving brine discharge flow in their direction will be used as the background salinity readings. In channel, outflow salinities 5m from the outfall structure:

    - are to be maintained at or below 7ppt above background
    - are to be maintained at or below 28ppt

c. If sedimentation build up does occur around the brine discharge leading to the brine being discharged over a smaller more concentrated areas, it will be detected by the salinity monitoring system. The eight salinity meters positioned at various depths either side of the outfall will detect if the brine is not being instantaneously mixed and diluted. If salinities 7ppt above background or above 28ppt are detected, the system will automatically reduce the brining rate and shut down. Monitoring of salinity within the wider rivers will include salinity meters:

    - Downstream of the constructed channel
    - Upstream on the Shubenacadie River
    - Upstream on the Stewiacke River

The computer controlled salinity monitoring system will not allow for exceedance above the regulated salinities. Any operational problems (e.g. power failure or computer malfunction) results in automatic stop of the brine release. The sedimentation concern then becomes an Alton operational issue, which has been thoroughly addressed through careful engineering, operational protocols, and ongoing monitoring.

2.5 Major Ion Composition of Brine is Unknown

CRA Statement

> *"We believe this to be a **minor data gap**. The brine will be diluted by an order of magnitude or more in the mixing channel, so it is unlikely that ionic differences between brine and Estuary water would be biologically meaningful"* (CRA report, section 3.4, page 8)

CRA Recommendation

> *"The major ion composition of the brine and brine-estuary water mixture is not known. Recommend collecting undiluted brine water as well as the brine water diluted with estuary water under various saline conditions to characterize the ionic composition of water potentially being discharge to the Estuary."* (CRA report, section 4, page 12)

Alton Proposed Action

Action 1: Various sections of the salt core were submitted on July 14, 2015 to AGAT Laboratories (Dartmouth) for analysis of major ions and total metals.
Action 2: Water samples from the Shubenacadie River estuary were taken through the tidal cycle on July 27, 2015 and submitted the same day to AGAT laboratories for analysis of major ions, standard water and total metals.
Action 3: In addition to the Shubenacadie River estuary water samples collected and analyzed for the Alton EA (Jacques Whitford 2007a, Section 5.4.1 pg. 52), five additional samples were collected to establish a more comprehensive baseline. Shubenacadie River estuary water samples were collected from the river bank at the Alton site at the end of the ebb tide and mid-flood tide and submitted to AGAT laboratories by WSP Canada Inc., on November 12 & 26, 2014, December 3, 2014, June 3, 2015, and July 14, 2015 for analysis of major ions, standard water and total metals.

Methods

Salt Core. Four salt core samples were selected from borehole ANGS-14-01, drilled by Alton Natural Gas in August/September of 2014. These samples were selected throughout the proposed cavern depth interval to confirm for this report the homogeneity of the salt within the interval. Two samples were selected near the top of the proposed cavern interval (Sample 1 at 869.5m depth and Sample 2 at 873.9m depth), one from the middle of the cavern (Sample 3 at 891.8m depth) and one near the base of the interval (Sample 4 at 945.7m depth).

AGAT Labs was tasked in preparing these four rock samples into a saturated brine so that they could be analyzed for major ion composition and total metals. AGAT Labs took a sub-sample of approximately 25g from each one of the submitted salt core samples and dissolved it to a salinity of 26ppt. This dilution was necessary to achieve detection limits at or below the Nova Scotia Environment Tier 1 Environmental Quality Standards for Surface Water (NSE 2013) and the Canadian Council of Ministers of the Environment (CCME) interim Canadian Water Quality

Guidelines for the Protection of Aquatic Life (CCME 1996). The United States Environmental Protection Agency (US EPA) Toxicity Reference Values (TRVs) guidelines (ERD 1999) have also been referenced to give context to results for metals for which no guidelines have been identified by NSE or CCME. However, the presence of high levels of sodium chloride (salt) made it unachievable to have detection limits below the guideline limits for Nickel and Selenium. However, the detection limits are significantly lower than those presented in the 2007 Alton EA (Jacques Whitford 2007a, Section 6.1.5 pg. 95). The major ion detection limits are also slightly raised because of the presence of high levels of sodium chloride. These slightly raised detection levels is also true for the estuary water samples.

Shubenacadie River Estuary Water. Nine (9) water samples from the Shubenacadie River estuary were taken through the tidal cycle on July 27, 2015 and submitted the same day for analysis for major ions, standard water and total metals. Shubenacadie River estuary water samples were collected from the river bank at the Alton site at the end of the ebb tide and mid-flood tide and submitted to AGAT laboratories on November 12 & 26 (2014), December 3 (2014), and June 3 and July 14 (2015). AGAT analyzed these samples for major ions, standard water and total metals. Two sets of samples were collected on December 3, 2014 for analysis. The first samples (6151571 and 6151587) were analyzed with the sediment included and the duplicate samples (6151584 and 6151590) were decanted after 24 hours, allowing the sediment to settle and not be included in the analysis. This procedure was done to mimic the Alton operational protocol of taking Shubenacadie River water into the settling pond where the water will settle for a minimum of 24 hours before being pumped to the cavern site. The settled water samples more accurately represent what parameter levels will be returning to the brine pond and subsequently to the river.

Results

Major ion composition. The major ion composition of the four sections of salt core brine consists of varying concentrations of calcium (range 8.8 – 263 mg/L), magnesium (range 0.1 – 2 mg/L), potassium (range 2.2 – 12.4 mg/L), sulphate (range <200 – 368 mg/L), chloride (range 12,600 – 14,900 mg/L) and sodium (range 11,700 – 12,600 mg/L, Table 2). With the exception of sodium, these concentrations are within range of the major ion concentrations found in the Shubenacadie River; calcium (range 8.8 – 307 mg/L), magnesium (range 2.7 – 985 mg/L), potassium (range 1.3–300 mg/L), sulphate (range 18 – 1,750 mg/L), chloride (range 18 – 12,400 mg/L) and sodium (range 9.6 – 7,980 mg/L, Table 3). The settled vs. non-settled river water samples showed very little differences in major ion composition (Table 3).

Within the Shubenacadie River estuary, there are large variations in parameter values between the end of the ebb tide and flood tide. Often the water quality parameter, in order of magnitude, is higher in the flood tide sample vs. the end of ebb tide sample (Table 3). The size of the tide and the amount of fresh water runoff also greatly influences the parameter values of the Shubenacadie River water. The five samples collected on the Shubenacadie River were collected through varying tide sizes and rainfall accumulation (Table 4). Large tides occurred on November 26, 2014, December 3, 2014 and June 3, 2015. However, these tides were all preceded by large rainfall events (>43 mm), the largest tidal influence actually occurred on July 14, 2014 when there was a medium size tide but no rainfall in the three previous days. This led to the highest major ion values recorded on both the ebb and flood tides (Table 3).

Table 2. Major ion composition of four salt core brine samples taken at various depths from borehole ANGS-14-01.

Parameter	Unit	RDL	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Salt Core Samples			
					1	2	3	4
					869.5 m	873.9 m	891.8 m	945.7 m
Total Calcium	mg/L	0.1	-	-	51.4	8.8	263	182
Total Magnesium	mg/L	0.1	-	-	0.1	0.6	2.0	1.0
Total Potassium	mg/L	0.1	-	-	10.3	12.4	2.9	2.2
Sulphate	mg/L	200	-	-	ND	ND	368	343
Chloride	mg/L	1	-	-	13500	14900	12600	13700
Total Sodium	mg/L	0.1	-	-	12400	12600	11700	12400

1. Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)

RDL Reportable detection limit
- No established guideline concentration
ND Not Detected

Table 3. Major ion composition of five Shubenacadie River estuary water samples collected from the west river bank of the Alton river site at the end of the ebb tide and mid-flood tide, samples were collected on November 12th & 26th (2014), December 3rd (2014), June 3rd and July 14th (2015). Following initial analysis the December 3 duplicate samples were decanted after 24 hours, allowing the sediment to settle and not be included in the analysis (*).

Parameter	Units	RDL	NSE Tier 1 EQS Marine Water [1]	CCME Water Quality Guidelines [2]	Shunbenacadie River Water Samples											
					Ebb Tide	Flood Tide	Ebb Tide	Flood Tide	Ebb Tide	Ebb Tide*	Flood Tide	Flood Tide*	Ebb Tide	Flood Tide	Ebb Tide	Flood Tide
					11/12/2014	11/12/2014	11/26/2014	11/26/2014	12/03/2014	12/03/2014	12/03/2014	12/03/2014	06/03/2015	06/03/2015	07/14/2015	07/14/2015
					6071877	6071880	6127094	6127097	6151571	6151584	6151587	6151590	6618011	6618015	6736226	6736231
Total Calcium	mg/L	0.1	-	-	12.4	81.7	11.7	107	12.7	13.8	112	106	8.8	109	93.1	307
Total Magnesium	mg/L	0.1	-	-	5.3	137	3.4	273	2.6	2.7	304	277	2.8	275	208	985
Total Potassium	mg/L	0.1	-	-	1.9	48.7	1.6	86.5	1.5	1.3	90.8	87.7	1.3	87.2	79.3	300
Sulphate	mg/L	2	-	-	25	345	19	466	19	18	955	529	25	569	436	1750
Chloride	mg/L	1	-	-	42	2271	24	4010	19	18	9200	8050	28	3310	2770	12400
Total Sodium	mg/L	0.1	-	-	34.1	1160	14.1	2290	18.7	15.2	2410	2420	9.6	2220	1760	7980

[1] Nova Scotia Environment (NSE) Tier I Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
[2] CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)

RDL	Reportable detection limit
-	No established guideline concentration/not analysed
Ebb Tide	Surface water sample at low tide
Flood Tide	Surface water sample at high tide
*	Allowed sediment to settle prior to analysis
11/12/2014	Sampling date (M/D/Y)
6071877	Laboratory Sample ID

Table 4. Dates, corresponding tide sizes, and rainfall accumulation (mm) in three days prior to the water sample collections at the Alton site on the Shubenacadie River estuary.

Date	Tide Size	Rainfall accumulation within three days (mm)
November 12, 2014	S	0
November 26, 2014		43.4
December 3, 2014	L	45.7
June 3, 2015		64.6
July 14, 2015	L	0

Legend: S=small, M=medium, L=large

The major ion composition of the salt core brine is similar to that of the Shubenacadie estuary river for chloride (~ 52% vs. ~54% respectively) and sodium (~47% vs. ~31% respectively, Table 5). The percent composition of sulfate, magnesium, calcium and potassium is orders of magnitude lower in the salt core brine compared to the Shubenacadie River water (Table 5). However, during cavern creation the salt core will be diluted with river water as opposed to distilled water to create the brine and will then be further diluted, by an order of magnitude or more in the mixing channel. Thus, as CRA stated *"it is unlikely that ionic differences between brine and Estuary water would be biologically meaningful"* (CRA report, section 3.4, page 8).

Table 5. Percent composition of the major ions detected in the Shubenacadie river estuary water (ebb and flood tide) and the four salt core brine samples. Typical sea water major ion composition is also shown for comparison.

Major ions	Percent (%) Composition						
		Shubenacadie River Water[1]		Salt Core Brine			
	Typical Sea Water	Ebb tide	Flood tide	1	2	3	4
Chloride	55	50.7	57.1	51.6	53.7	50.5	51.4
Sodium	30.6	32.3	29.4	47.4	45.5	46.9	46.6
Sulfate	7.7	9.2	7.5	0.8	0.7	1.5	1.3
Magnesium	3.7	3.9	3.6	0.0004	0.0022	0.0080	0.0038
Calcium	1.2	2.4	1.3	0.20	0.03	1.05	0.68
Potassium	1.1	1.5	1.1	0.039	0.045	0.012	0.008

1. Five ebb and five flood tide Shubenacadie River estuary Water samples were averaged and then percentages calculated.

In addition to testing for major ion composition for the salt core brine and Shubenacadie River water, all samples were also analyzed for total metals. Eight metals were detected in the salt core brine including; aluminum, barium, boron, copper, iron, manganese, strontium and zinc (Table 6). While 21 metals were detected in the Shubenacadie River estuary water, including; aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, strontium, titanium, uranium, vanadium and zinc (Table 7). The aluminum levels in all Shubenacadie River samples and salt core brine samples exceeded freshwater water quality standards, Shubenacadie River water ranged from 586 to 40,700 µg/L, while the salt core brine levels ranged from 116 to 304 µg/L. The salt core brine sample 2 exceeded water quality standards for copper, while samples 1 and 3 exceeded water quality standards for zinc (Table 6). However, the Shubenacadie River estuary water exceeded water quality standards for eleven metals including copper and zinc (Table 8). The settled vs. non- settled Shubenacadie River samples showed very little differences in most parameters but did show relatively large differences in total aluminum, arsenic, boron, chromium, iron, lead, manganese, titanium and zinc (Table 7).

For easier comparison between the salt core brine sample analysis and the Shubenacadie River estuary water sample analysis, averages have been calculated and displayed in Table 8. No exceptionally high levels of metals in the salt core brine were present in the analytical results, especially in comparison to what is present in the Shubenacadie River water. The metals detected within the salt core brine may settle to the bottom of the cavern during solution mining as they are likely attached to fine particles. Nevertheless, these levels are a magnitude lower than the metal levels detected in the Shubenacadie River water. Through the life of the brining operation, standard water and total metal analysis of the brine created will be performed. If any unforeseen elements are detected, the appropriate adaptive management procedures will be implemented in consultation with regulators.

The variation of Shubenacadie River major ion and total metal composition is best shown in the five ebb and flood tide water samples collected over varying tide sizes from November 2014 to July 2015 (tables 3 and 7). However, as requested, nine water samples from the Shubenacadie River were taken through one tidal cycle to show the cycle's variation. Samples were collected on July 27, 2015 during a small tide (22.3 feet) preceded by 64.2 mm of rain in the three previous days. The size of the tide, the amount of fresh water runoff and the stage of the tide influence the major ion (Table 9), available metal (Table 10) and dissolved metal levels (Table 11). Similar to previous Shubenacadie River water samples, water quality standards were exceeded for nine metals (Table 10). For dissolved metals, only aluminum, copper and strontium exceeded water quality standards and only at certain stages of the tide (the majority of the metals are attached to the fine silt in the samples and these will be removed before the water is sent to the caverns and only the dissolved metal will remain).

Parameter	Unit	RDL	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Toxicity Reference Value Environmental Restoration Division[3]	Salt Core Samples			
						1	2	3	4
						869.5 m	873.9 m	891 m	945.7 m
Anions (Water)	ug/L								
Bromide	ug/L	30	-	-	-	ND	ND	ND	ND
Chloride	ug/L	1	-	-	-	13500	14900	12600	13700
Fluoride	ug/L	10	-	-	-	ND	ND	ND	ND
Nitrate as N	ug/L	5	-	-	-	ND	ND	ND	ND
Nitrite as N	ug/L	5	-	-	-	ND	ND	ND	ND
Sulphate	ug/L	200	-	-	-	ND	ND	368	343
Cations in Water (Tota	ug/L								
Total Calcium	ug/L	0.1	-	-	-	51.4	8.8	263	182
Total Magnesium	ug/L	0.1	-	-	-	0.1	0.6	2	1
Total Potassium	ug/L	0.1	-	-	-	10.3	12.4	2.9	2.2
Total Sodium	ug/L	0.1	-	-	-	12400	12600	11700	12400
Total Metals									
Total Aluminum	ug/L	5	-	-	87	116	304	150	263
Total Antimony	ug/L	10	500	-	-	ND	ND	ND	ND
Total Arsenic	ug/L	10	12.5	12.5	-	ND	ND	ND	ND
Total Barium	ug/L	5	500	-	-	ND	6	5	ND
Total Beryllium	ug/L	2	100	-	-	ND	ND	ND	ND
Total Bismuth	ug/L	2	-	-	-	ND	ND	ND	ND
Total Boron	ug/L	25	1200	-	-	ND	ND	68	102
Total Cadmium	ug/L	0.017	0.12	0.12	-	ND	ND	ND	ND
Total Chromium	ug/L	1	-	-	117.32	ND	ND	ND	ND
Total Cobalt	ug/L	1	-	-	23	ND	ND	ND	ND
Total Copper	ug/L	1	2	-	-	ND	5	ND	ND
Total Iron	ug/L	50	-	-	1000	ND	311	192	105
Total Lead	ug/L	1	2	-	-	ND	ND	ND	ND
Total Manganese	ug/L	2	-	-	120	ND	14	12	6
Total Molybdenum	ug/L	10	-	-	370	ND	ND	ND	ND
Total Nickel	ug/L	10	8.3	-	-	ND	ND	ND	ND
Total Selenium	ug/L	2	2	-	-	ND	ND	ND	ND
Total Silver	ug/L	0.5	1.5	-	-	ND	ND	ND	ND
Total Strontium	ug/L	5	-	-	1500	189	57	1390	732
Total Thallium	ug/L	0.5	21.3	-	-	ND	ND	ND	ND
Total Tin	ug/L	2	-	-	73	ND	ND	ND	ND
Total Titanium	ug/L	10	-	-	-	ND	ND	ND	ND
Total Uranium	ug/L	0.5	100	-	-	ND	ND	ND	ND
Total Vanadium	ug/L	2	50	-	-	ND	ND	ND	ND
Total Zinc	ug/L	5	10	-	-	13	ND	28	ND

1. Nova Scotia Environmnet (NSE) Tier 1 Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)
3. Environmental Restoration Division (ERD) of the US Environmental Protection Agency- Aquatic Toxicity Reference Values
   Table 1 Surface Water Toxicity Reference Values, 1999 - used when no CCME or NSE

RDL	Reportable detection limit
-	No established guideline concentration/not analysed
	NSE Tier 1 EQS Marine Water exceedance
BOLD	CCME Water Quality Guideline exceedance
	ERD - Aquatic Toxicity Reference Guidline exceedance
ND	Not detected

Table 6. Ion, cation, and total metals detected in the four salt core brine samples.

Parameter	Units	RDL	NSE Tier 1 EQS Marine Water [1]	CCME Water Quality Guidelines [2]	Toxicity Reference Value - Environmental Restoration Division [3]	Shunbenacadie River Water Samples											
						Ebb Tide 11/12/2014 6071877	Flood Tide 11/12/2014 6071880	Ebb Tide 11/26/2014 6127094	Flood Tide 11/26/2014 6127097	Ebb Tide 12/03/2014 6151571	Ebb Tide * 12/03/2014 6151584	Flood Tide 12/03/2014 6151587	Flood Tide * 12/03/2014 6151590	Ebb Tide 06/03/2015 6618011	Flood Tide 06/03/2015 6618015	Ebb Tide 7/14/2015 6736226	Flood Tide 7/14/2015 6736231
pH		1	-	7.0-8.7	-	6.88	7.41	7.02	7.55	6.73	6.87	7.53	7.58	7.21	7.44	7.53	7.55
Reactive Silica as SiO2	mg/L	0.5	-	-	-	3.2	3.0	3.2	2.7	2.9	2.8	2.5	2.4	2.6	2.0	2	1.4
Chloride	mg/L	1	-	-	-	42	2271	24	4010	19	18	9200	8050	28	3310	2770	12400
Fluoride	mg/L	0.1	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulphate	mg/L	2	-	-	-	25	345	19	466	19	18	955	529	25	569	436	1750
Alkalinity	mg/L	5	-	-	-	15	29	8	39	8	10	41	41	14	37	41	71
True Color	TCU	5	-	-	-	50	45	41	41	36	27	23	23	97	93	11	6
Turbidity	NTU	0.1	-	-	-	74.4	3170	97.8	3000	44.8	6.8	781	8.4	140	299	2	1.8
Electrical Conductivity	umho/cm	1	-	-	-	282	6020	204	10300	162	188	10300	10400	187	8800	7980	30300
Nitrate + Nitrite as N	mg/L	0.05	-	-	-	0.18	0.07	0.32	0.08	0.51	0.10	ND	ND	0.59	ND	ND	0.75
Nitrate as N	mg/L	0.05	-	-	-	0.18	0.07	0.32	0.08	0.51	0.10	0.08	ND	0.49	ND	ND	0.75
Nitrite as N	mg/L	0.05	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	0.10	ND	ND	ND
Ammonia as N	mg/L	0.03	-	-	-	0.03	0.03	0.05	0.04	ND	0.04	0.05	0.07	0.11	0.10	0.35	ND
Total Organic Carbon	mg/L	0.5	-	-	-	7.2	6.6	7.1	6.1	7.3	8.4	5.5	5.4	10.2	7.3	4.2	2.2
Ortho-Phosphate as P	mg/L	0.1	-	-	-	ND	0.02	ND	ND	ND	ND	0.01	0.01	ND	ND	0.02	0.02
Total Sodium	mg/L	0.1	-	-	-	34.1	1160	14.1	2290	18.7	15.2	2410	2420	9.6	2220	1760	7980
Total Potassium	mg/L	0.1	-	-	-	1.9	48.7	1.6	86.5	1.5	1.3	90.8	87.7	1.3	87.2	79.3	300
Total Calcium	mg/L	0.1	-	-	-	12.4	81.7	11.7	107	12.7	13.8	112	106	8.8	109	93.1	307
Total Magnesium	mg/L	0.1	-	-	-	5.3	137	3.4	273	2.6	2.7	304	277	2.8	275	208	985
Total Phosphorous	mg/L	0.02	-	-	-	0.06	1.24	0.08	0.43	0.17	0.17	0.13	0.28	0.16	0.12	ND	ND
Bicarb. Alkalinity (as CaCO3)	mg/L	5	-	-	-	15	29	8	39	8	10	41	41	14	37	41	71
Carb. Alkalinity (as CaCO3)	mg/L	10	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hydroxide	mg/L	5	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calculated TDS	mg/L	1	-	-	-	135	4160	84	7330	84	77	13100	11500	96	6620	5380	23800
Hardness	mg/L	-	-	-	-	52.8	768	43.2	1390	42.4	45.6	1530	1410	33.5	1400	1090	4820
Langelier Index (@20C)	NA	-	-	-	-	-2.45	-0.96	-2.59	-0.60	-2.84	-2.57	-0.61	-0.58	-2.29	-0.72	-0.65	0.06
Langelier Index (@ 4C)	NA	-	-	-	-	-2.77	-1.28	-2.91	-0.92	-3.16	-2.89	-0.93	-0.90	-2.61	-1.04	-0.97	-0.26
Saturation pH (@ 20C)	NA	-	-	-	-	9.33	8.37	9.61	8.15	9.57	9.44	8.14	8.16	9.50	8.16	8.18	7.49
Saturation pH (@ 4C)	NA	-	-	-	-	9.65	8.69	9.93	8.47	9.89	9.76	8.46	8.48	9.82	8.48	8.5	7.81
Anion Sum	me/L	-	-	-	-	2.02	71.8	1.26	124	1.13	1.09	280	239	1.63	106	88	388
Cation sum	me/L	-	-		-	2.88	73.6	1.84	135	1.99	1.71	140	136	1.81	128	101	452
% Difference/ Ion Balance (NS)	%	-	-	-	-	17.6	1.2	18.9	4.3	27.6	22.2	33.2	27.5	5.2	9.5	6.9	7.6
Total Metals																	
Total Aluminum	ug/L	5	-	-	87	1790	40700	2190	32200	2020	586	17600	2290	4410	9870	4660	6030
Total Antimony	ug/L	2	500	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Arsenic	ug/L	2	12.5	12.5	-	ND	**14**	ND	**18**	ND	ND	**31**	**19**	2	**30**	**39**	**200**
Total Barium	ug/L	5	500	-	-	13	234	14	258	8	18	107	28	22	68	51	141
Total Beryllium	ug/L	2	100	-	-	ND	2	ND	3	ND	ND	2	ND	ND	ND	ND	ND
Total Bismuth	ug/L	2	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Boron	ug/L	5	1200	-	-	27	378	16	860	15	15	290	983	21	1020	369	**3160**
Total Cadmium	ug/L	0.017	0.12	0.12	-	ND	**0.200**	ND	**0.201**	ND	ND	0.062	0.056	0.093	**0.163**	**0.168**	0.115
Total Chromium	ug/L	1	-	-	117.32	2	22	2	19	2	ND	11	4	3	5	4	4
Total Cobalt	ug/L	1	-	-	23	1	13	1	10	1	ND	5	3	2	4	2	2
Total Copper	ug/L	1	2	-	-	2	14	3	12	2	2	6	5	4	5	3	5
Total Iron	ug/L	50	-	-	1000	2420	55200	1890	41800	1560	854	22400	3340	5050	12200	7550	9310
Total Lead	ug/L	0.5	2	-	-	1.9	36.4	1.7	25.9	1.4	2.1	13.7	9.1	3.7	6.9	3.2	2.9
Total Manganese	ug/L	2	-	-	120	232	3180	193	2260	165	184	1040	590	326	512	337	399
Total Molybdenum	ug/L	2	-	-	370	ND	ND	ND	3	ND	ND	3	2	ND	3	3	10
Total Nickel	ug/L	2	8.3	-	-	3	25	2	20	3	ND	12	5	5	9	10	18
Total Selenium	ug/L	1	2	-	-	ND	12	ND	29	ND	ND	71	49	ND	41	96	331
Total Silver	ug/L	0.1	1.5	-	-	ND	0.1	ND	0.1	ND	ND	ND	ND	ND	ND	ND	ND
Total Strontium	ug/L	5	-	-	1500	125	1050	81	1560	70	82	1760	1730	82	1690	1270	5470
Total Thallium	ug/L	0.1	21.3	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Tin	ug/L	2	-	-	73	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Titanium	ug/L	2	-	-	-	39	513	39	410	24	9	270	39	45	213	139	302
Total Uranium	ug/L	0.1	100	-	-	0.1	1.6	0.1	1.4	ND	0.1	1.4	0.8	0.2	0.9	0.6	2
Total Vanadium	ug/L	2	50	-	-	4	35	4	30	3	2	15	10	5	7	ND	ND
Total Zinc	ug/L	5	10	-	-	9	58	12	46	10	7	37	14	13	15	13	13

[1] Nova Scotia Environment (NSE) Tier I Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
[2] CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)
[3] Environmental Restoration Division (ERD) of the US Environmental Protection Agency- Aquatic Toxicity Reference Values, Table 1 Surface Water Toxicity Reference Values, 1999 - used when no CCME or NSE

11/12/2014	Sampling date (M/D/Y)
6071877	Laboratory Sample ID

	NSE Tier 1 EQS Marine Water exceedance
BOLD	CCME Water Quality Guideline exceedence
	ERD - Aquatic Toxicity Reference Guideline exceedence
RDL	Reportable detection limit\
-	No established guideline concentration/not analysed

ND	Not Detected - concentration is less than the laboratory detection limit
Ebb Tide	Surface water sample at low tide
Flood Tide	Surface water sample at high tide
AO	Aesthetic objective
OG	Operational guidance value
*	allowed sediment to settle prior to analysis

Table 7. Standard water and total metal analysis of five Shubenacadie River estuary water samples collected at the end of the ebb tide and mid-flood tide at the Alton River site.

Parameter	Unit	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Toxicity Reference Value Environmental Restoration Division[3]	Salt Core Samples		Shubenacadie River Samples		
					RDL	Avg. of Four Salt Core Samples	RDL	Avg. of Five Ebb Tides	Avg. of Five Flood Tides
Anions									
Chloride	mg/L	-	-	-	1	13675	1	576.6	6238.2
Fluoride	mg/L	-	-	-	10	ND	0.1	ND	ND
Nitrate as N	mg/L	-	-	-	5	ND	0.05	ND/0.38*	D/0.25*
Nitrite as N	mg/L	-	-	-	5	ND	0.05	ND/0.11*	ND
Sulphate	mg/L	-	-	-	200	ND/355.5*	2	104.8	817
Cations in Water (Total)									
Total Calcium	mg/L	-	-	-	0.1	126.3	0.1	27.74	143.34
Total Magnesium	mg/L	-	-	-	0.1	0.925	0.1	44.42	394.8
Total Potassium	mg/L	-	-	-	0.1	6.95	0.1	17.12	122.64
Total Sodium	mg/L	-	-	-	0.1	12275	0.1	367.3	3212
Total Metals									
Total Aluminum	ug/L	-	-	87	5	263	5	3014	21280
Total Antimony	ug/L	500	-	-	10	ND	2	ND	ND
Total Arsenic	ug/L	12.5	12.5	-	10	ND	2	**ND/20.5***	**58.6**
Total Barium	ug/L	500	-	-	5	ND/5.5*	5	21.6	161.6
Total Beryllium	ug/L	100	-	-	2	ND	2	ND	ND/2.3*
Total Bismuth	ug/L	-	-	-	2	ND	2	ND	ND
Total Boron	ug/L	1200	-	-	25	ND/85*	5	89.6	1141.6
Total Cadmium	ug/L	0.12	0.12	-	0.017	ND	0.017	**ND/0.13***	**0.1482**
Total Chromium	ug/L	-	-	117.32	1	ND	1	2.6	12.2
Total Cobalt	ug/L	-	-	23	1	ND	1	1.4	6.8
Total Copper	ug/L	2	-	-	1	ND/5*	1	2.8	8.4
Total Iron	ug/L	-	-	1000	50	ND/203	50	3694	28182
Total Lead	ug/L	2	-	-	1	ND	0.5	2.38	17.16
Total Manganese	ug/L	-	-	120	2	ND/11	2	250.6	1478.2
Total Molybdenum	ug/L	-	-	370	10	ND	2	ND/3*	ND/4.75*
Total Nickel	ug/L	8.3	-	-	10	ND	2	406	16.8
Total Selenium	ug/L	2	-	-	2	ND	1	ND/96*	96.8
Total Silver	ug/L	1.5	-	-	0.5	ND	0.1	ND	ND/0.1*
Total Strontium	ug/L	-	-	1500	5	592	5	325.6	2306
Total Thallium	ug/L	21.3	-	-	0.5	ND	0.1	ND	ND
Total Tin	ug/L	-	-	73	2	ND	2	ND	ND
Total Titanium	ug/L	-	-	-	10	ND	2	57.2	341.6
Total Uranium	ug/L	100	-	-	0.5	ND	0.1	ND/0.25*	1.46
Total Vanadium	ug/L	50	-	-	2	ND	2	ND/4*	D/21.8
Total Zinc	ug/L	10	-	-	5	ND/21*	5	11.4	33.8

1. Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)
3. ERD - Aquatic Toxicity Reference Values, used when no CCME or NSE guidline exists

RDL	Reportable detection limit
-	No established guideline concentration/not analysed
	NSE Tier 1 EQS Marine Water exceedance
BOLD	CCME Water Quality Guidline exceedance
	ERD - Aquatic Toxicity Reference Guidline exceedance
ND	Not detected
ND/value*	The true average could not be calculated as some values were not detectable, the value presented is the average of the remaining detected values.

Table 8. Summary Table: Averages of major ion and total metals detected in the four salt core brine samples and the five ebb and flood tide samples.

Parameter	Unit	RDL	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Shubenacadie River Water Samples								
					Ebb Tide	Flood Tide	Flood Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide
					8:55	10:30	11:07	12:05	12:45	13:25	14:05	14:50	15:40
					1	2	3	4	5	6	7	8	9
Total Calcium	mg/L	0.1	-	-	22.2	70.7	160	113	74.9	51.5	39.6	28.8	24.2
Total Magnesium	mg/L	0.1	-	-	5.2	142	488	280	169	81.1	49.1	18.3	10.7
Total Potassium	mg/L	0.1	-	-	2.7	51.8	150	102	59.1	30	17.9	11.2	6
Sulphate	mg/L	2	-	-	33	300	875	660	307	169	97	57	42
Chloride	mg/L	1	-	-	25	1660	5800	3830	1780	1060	514	184	85
Total Sodium	mg/L	0.1	-	-	19.3	1110	3580	2590	1210	647	402	72.8	60.3

1. Nova Scotia Environment (NSE) Tier I Environmental Quality Standards (EQS)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term) RDL

RDL	Reportable detection limit
-	No established guideline concentration
Ebb Tide	Ebb tide samples
Flood Tide	Flood tide samples
8:55	Clock time
1	Sample ID

Table 9. Major ion composition of nine Shubenacadie River water samples collected at various stages of the tide on July 27, 2015 from the Alton river site. The tidal bore arrived at the Alton site at 9:45am.

Parameter	Unit	RDL	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Toxicity Reference Value Environmental Restoration Division[3]	Shubenacadie River Water Samples								
						Ebb Tide	Flood Tide	Flood Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide
						8:55	10:30	11:07	12:05	12:45	13:25	14:05	14:50	15:40
						1	2	3	4	5	6	7	8	9
pH		1	-	7.0-8.7	-	7.05	7.41	7.53	7.6	7.6	7.57	7.51	7.33	7.27
Reactive Silica as SiO2	mg/L	0.5	-	-	-	2.6	2.6	2.3	2.2	2.5	2.8	2.6	2.8	2.6
Chloride	mg/L	1	-	-	-	25	1660	5800	3830	1780	1060	514	184	85
Fluoride	mg/L	0.1	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	0.8
Sulphate	mg/L	2	-	-	-	33	300	875	660	307	169	97	57	42
Alkalinity	mg/L	5	-	-	-	15	31	46	39	31	27	24	21	18
True Color	TCU	5	-	-	-	83	54	36	39	52	62	75	77	92
Turbidity	NTU	0.1	-	-	-	150	676	270	128	437	562	438	288	220
Electrical Conductivity	umho/cm	1	-	-	-	200	4530	12200	8790	5050	2980	1690	757	402
Nitrate + Nitrite as N	mg/L	0.05	-	-	-	0.1	0.31	0.74	ND	ND	ND	0.47	0.17	0.55
Nitrate as N	mg/L	0.05	-	-	-	0.1	0.31	0.74	ND	ND	ND	0.12	ND	0.17
Nitrite as N	mg/L	0.05	-	-	-	ND	ND	ND	ND	ND	ND	0.35	0.17	0.38
Ammonia as N	mg/L	0.03	-	-	-	0.1	0.08	0.04	0.04	0.08	0.08	0.08	0.09	0.08
Total Organic Carbon	mg/L	0.5	-	-	-	11.8	10.1	7.4	8.9	9.6	10.6	10.7	11.1	11.5
Ortho-Phosphate as P	mg/L	0.1	-	-	-	0	0.02	0	0	0	0.02	0	0	0.01
Total Sodium	mg/L	0.1	-	-	-	19.3	1110	3580	2590	1210	647	402	72.8	60.3
Total Potassium	mg/L	0.1	-	-	-	2.7	51.8	150	102	59.1	30	17.9	11.2	6
Total Calcium	mg/L	0.1	-	-	-	22.2	70.7	160	113	74.9	51.5	39.6	28.8	24.2
Total Magnesium	mg/L	0.1	-	-	-	5.2	142	488	280	169	81.1	49.1	18.3	10.7
Total Phos phorous	mg/L	0.02	-	-	-	0.25	0.21	0.14	0.17	0.22	0.27	0.38	0.24	0.29
Bicarb. Alkalinity (as CaCO3)	mg/L	5	-	-	-	15	31	46	39	31	27	24	21	18
Carb. Alkalinity (as CaCO3)	mg/L	10	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hydroxide	mg/L	5	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calculated TDS	mg/L	1	-	-	-	127	3390	11100	7610	3640	2080	1160	401	256
Hardness	mg/L	-	-	-	-	76.8	761	2410	1440	883	463	301	147	104
Langelier Index (@20C)	NA	-	-	-	-	-2.03	-0.99	-0.39	-0.53	-0.78	-1.01	-1.21	-1.54	-1.72
Langelier Index (@ 4C)	NA	-	-	-	-	-2.35	-1.31	-0.71	-0.85	-1.1	-1.33	-1.53	-1.86	-2.04
Saturation pH (@ 20C)	NA	-	-	-	-	9.08	8.4	7.92	8.13	8.38	8.58	8.72	8.87	8.99
Saturation pH (@ 4C)	NA	-	-	-	-	9.4	8.72	8.24	8.45	8.7	8.9	9.04	9.19	9.31
Anion Sum	me/L	-	-	-	-	1.7	53.7	183	123	57.2	34	17	6.81	3.67
Cation sum	me/L	-	-	-	-	3.15	67.1	208	144	73.4	39.7	25.1	7.68	5.85
% Difference/ Ion Balance (NS	%	-	-	-	-	29.9	11.1	6.5	8.2	12.4	7.8	19.2	6	22.9
Total Metals														
Total Aluminum	µg/L	5	-	-	87	4490	15300	5190	3430	10300	9030	6430	9690	6310
Total Antimony	µg/L	2	500	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Arsenic	µg/L	2	12.5	12.5	-	3	7	7	8	6	6	6	3	4
Total Barium	µg/L	5	500	-	-	21	100	53	36	63	46	34	50	31
Total Beryllium	µg/L	2	100	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Bismuth	µg/L	2	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Boron	µg/L	5	1200	-	-	25	501	1290	1040	504	287	181	78	50
Total Cadmium	µg/L	0.017	0.12	0.12	-	0.018	0.05	0.031	0.022	0.039	0.046	ND	0.02	0.025
Total Chromium	µg/L	1	-	-	117.32	3	7	4	3	5	5	4	5	4
Total Cobalt	µg/L	1	-	-	23	2	4	2	2	3	3	3	3	3
Total Copper	µg/L	1	2	-	-	3	5	4	4	5	5	4	5	4
Total Iron	µg/L	50	-	-	1000	5110	17500	5520	3740	12800	14600	12400	5090	7280
Total Lead	µg/L	0.5	2	-	-	3.4	9.8	3	2	6.9	7.5	6.6	6.4	5.2
Total Manganese	µg/L	2	-	-	120	377	982	311	198	665	747	616	598	471
Total Molybdenum	µg/L	2	-	-	370	ND	ND	4	3	ND	ND	ND	ND	ND
Total Nickel	µg/L	2	8.3	-	-	6	10	12	11	9	9	7	8	7
Total Selenium	µg/L	1	2	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Silver	µg/L	0	1.5	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Strontium	µg/L	5	-	-	1500	116	881	2130	1690	825	513	362	177	138
Total Thallium	µg/L	0	21.3	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Tin	µg/L	2	-	-	73	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Titanium	µg/L	2	-	-	-	60	167	75	60	239	153	131	69	94
Total Uranium	µg/L	0.1	100	-	-	0.2	0.7	0.9	0.7	0.6	0.5	0.4	0.4	0.3
Total Vanadium	µg/L	2	50	-	-	6	11	ND	ND	7	9	8	8	7
Total Zinc	µg/L	5	10		-	11	20	12	9	17	16	14	17	14

1. Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)
3. ERD - Aquatic Toxicity Reference Values, used when no CCME or NSE guidline exists

-	No established guideline concentration/not analysed
	NSE Tier 1 EQS Marine Water exceedance
BOLD	CCME Water Quality Guidline exceedance
	ERD - Aquatic Toxicity Reference Guidline exceedance
ND	Not detected
RDL	Reportable detection limit
	Ebb Tide Samples
	Flood Tide Samples
8:55	Clock Time
1	Sample ID

Table 10. Standard Water and total metal analysis of nine Shubenacadie River estuary water samples collected at various stages of the tide on July 27, 2015 from the Alton River site. The tidal bore arrived at the Alton site at 9:45am.

Parameter	Unit	RDL	NSE Tier 1 EQS Marine Water[1]	CCME Water Quality Guidelines[2]	Toxicity Reference Value Environmental Restoration Division[3]	Shubenacadie River Water Samples								
						Ebb Tide	Flood Tide	Flood Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide	Ebb Tide
						8:55	10:30	11:07	12:05	12:45	13:25	14:05	14:50	15:40
						1	2	3	4	5	6	7	8	9
Dissolved Metals and Cations														
Dissolved Aluminum	µg/L	10	-	-	87	99	13	ND	ND	12	21	34	70	87
Dissolved Antimony	µg/L	2	500	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Arsenic	µg/L	2	12.5	12.5	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Barium	µg/L	5	500	-	-	ND	6	12	9	7	6	5	ND	ND
Dissolved Beryllium	µg/L	2	100	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Bismuth	µg/L	2	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Boron	µg/L	5	1200	-	-	24	408	1060	806	473	287	163	73	44
Dissolved Cadmium	µg/L	0.017	0.12	0.12	-	ND	ND	0.018	ND	ND	ND	ND	ND	ND
Dissolved Chromium	µg/L	2	-	-	117.32	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Cobalt	µg/L	1	-	-	23	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Copper	µg/L	2	2	-	-	ND	ND	4	4	5	7	2	3	3
Dissolved Iron	µg/L	50	-	-	1000	275	57	ND	ND	51	93	149	216	225
Dissolved Lead	µg/L	0.5	2	-	-	1	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Manganese	µg/L	2	-	-	120	2	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Molybdenum	µg/L	2	-	-	370	ND	ND	3	2	ND	ND	ND	ND	ND
Dissolved Nickel	µg/L	2	8.3	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Selenium	µg/L	1	2	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Silver	µg/L	0.1	1.5	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Strontium	µg/L	5	-	-	1500	92	568	1670	1200	686	400	256	154	122
Dissolved Thallium	µg/L	0.1	21.3	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Tin	µg/L	2	-	-	73	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Titanium	µg/L	2	-	-	-	3	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Uranium	µg/L	0.1	100	-	-	ND	0.3	0.9	0.6	0.3	0.2	0.1	ND	ND
Dissolved Vanadium	µg/L	2	50	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Zinc	µg/L	5	10	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dissolved Calcium	mg/L	0.1	-	-	-	21.3	66.7	154	109	72.6	50.5	36.5	26.1	22.2
Dissolved Magnesium	mg/L	0.1	-	-	-	3.9	129	401	272	150	79.6	42.2	16.9	9.5
Dissolved Potassium	mg/L	0.1	-	-	-	1.7	49	139	102	54	31.2	15.4	6.6	4.1
Dissolved Sodium	mg/L	0.1	-	-	-	23	1230	3890	2500	1380	735	366	134	70.2

1. Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQS) for Surface Water, Table 3, 2013 (Marine Water)
2. CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine Water - Long Term)
3. ERD - Aquatic Toxicity Reference Values, used when no CCME or NSE guidline exists

-	No established guideline concentration/not analysed
	NSE Tier 1 EQS Marine Water exceedance
BOLD	CCME Water Quality Guidline exceedance
	ERD - Aquatic Toxicity Reference Guidline exceedance
ND	Not detected
RDL	Reportable detection limit
	Ebb Tide Samples
	Flood Tide Samples
8:55	Clock Time
1	Sample ID

Table 11. Dissolved metal and cation analysis of nine Shubenacadie River estuary water samples collected at various stages of the tide on July 27, 2015 from the Alton River site. The samples were allowed to settle and then the top clear water was filtered through a 0.45 uM filter prior to analysis. The tidal bore arrived at the Alton site at 9:45am.

2.6 Determination of Toxicity of Brine-Estuary Mixture to Fish

CRA Statement

> *"To be most informative, the bioassays should focus on replicating conditions in the mixing channel; i.e., **mixing of real brine water with real Estuary water**."* (CRA report, section 3.4, page 8)

CRA Recommendation

> *"The potential toxicity of the brine to ambient biota has not been characterized even though this was a specific comment from DFO as part of the EA review process. Recommend completing bioassays of Striped bass eggs and larvae using diluted brine water (diluted using Estuary water) under various saline conditions to characterize potential toxic effects to fish at early life stages."* (CRA report, section 4, page 12)

Alton Proposed Action

A protocol to test the acute toxicity of Alton Natural Gas brine on early life stage striped bass was designed by Dr. Jim Duston and Mr. Juan Manriquez-Hernandez of Dalhousie University and reviewed by the Department of Fisheries and Oceans in February 2015, to determine the median toxicity threshold (LC_{50}) of the brine water and its constituents on egg, larvae and juvenile stages of striped bass, *Morone saxatilis* (see Appendix A & B).

The study will commence once actual brine is available from the project, during May, June, July, August and September when wild Shubenacadie River Striped bass eggs, larvae and juveniles are available.

Alton agrees with CRA that toxicity tests must be conducted with actual brine produced by the Alton Natural Gas operation, as opposed to brine made in the laboratory with salt core and Shubenacadie River water. The composition of both the salt and Shubenacadie estuary water is known (see section 2.5). Conducting the study with "real" brine is crucial in case any other components are introduced in the brining operation that would not be a part of a lab created brine.

Testing for the toxicity of the brine was recommended in an August 1, 2014 letter from Mark McLean (DFO) to David Birkett (Appendix C), which stated:

> *"Upon review of the proposed Monitoring Plan, it is **recommended** a study be completed to determine the median toxicity threshold (LC_{50}) of the **brine water and its constituents from the brining operation** on egg, larvae and juvenile Striped bass survival. Based on the results of this toxicity study, modifications to the mitigation measures may be required."*

The results of the toxicity study will be submitted to DFO once available and any mitigation measures, if needed, will be discussed and implemented into the long term monitoring plan.

OTHER IDENTIFIED UNCERTAINTIES

3.1 Impacts on Atlantic Salmon and Atlantic Sturgeon Are Uncertain

CRA Statement

> *"In response to these concerns, the project has taken an interactive and collaborative approach to assessing potential impacts. Thus, potential risks to fish were screened first based on available life history information and on the assumption that very small life forms, such as fertilized eggs (eggs) and very early life stage larvae, would be most sensitive to effects. These very life stages are typically planktonic, which means they are carried around largely by ambient water currents rather than active locomotion."* (CRA report, section 3.2, page 5)

The Environmental Assessment Condition 2.1 c states:

c) A plan to gather baseline information on water temperature and the **presence** of Atlantic salmon, Striped bass and Atlantic sturgeon **eggs and larvae** during **one** spawning season prior to the commencement of solution mining.

CRA Statement

> *"In response to this directive/recommendation, a detailed and continuing monitoring program has gathered baseline information of the last 8 years and counting. The physico-chemical information includes not just water temperature but salinity and flow. The sampling of biota has focused on times and locations most pertinent to Striped bass, but the <u>detailed sampling of eggs, fry, and juvenile fish has also sought the presence of salmon and sturgeon. As was predicted by life history considerations but also their very small populations, salmon and sturgeon eggs and larvae were apparently never observed in the rather extensive sampling</u>."* (CRA report, section 3.2, page 6)

The Alton Natural Gas monitoring plan was designed to meet the Environmental Condition 2.1c and gather base line data on the <u>**presence**</u> of Atlantic Salmon, Atlantic Sturgeon, and Striped Bass <u>**eggs**</u> <u>**and larvae**</u>. However, Atlantic salmon and Sturgeon do not spawn near the site, and their eggs and larvae are not present at the site and were not found during the monitoring program.

> *"Thus, for his Masters thesis, Reesor took over 554 plankton net tow samples between 13 May to 6 November, 2008 and 5 May to 28 October, 2009. Neither Atlantic salmon nor Atlantic sturgeon were caught during this rather intensive study. These negative results support the conclusion that sensitive eggs and larvae of these two species will not occur in the area affected by the project."* (CRA report, section 3.4, page 11)

Image 10: Plankton net being released in the Shubenacadie River.

Following the initial two years of monitoring, the total number of plankton net tows (Image 10) collected and analyzed as of August 1, 2015, equals 3,302. This would equate to over 4,000 hours spent sampling on the river and over 10,000 hours spent in the laboratory counting the samples and subsequently analyzing data.

Over the eight year (2008-2015) monitoring program, extensive species monitoring was done using plankton nets at the Alton Natural Gas river site (Shubenacadie river kilometer 25) as well as up-estuary to the limit of the tidal saltwater on both the Shubenacadie and Stewiacke rivers and to the Cobequid Bay. The upstream limit of the tidal water is on average 11 km upstream from the Alton river site, or 36 km upstream from the mouth of the Shubenacadie river. However, the salt front location varies daily and is influenced by the size of the tide and the amount of freshwater runoff. The upstream limit of the tide is the furthest the proposed discharged brine could travel. The Alton project will not alter salinity above the head of the tide, thus organisms living upstream in freshwater habitats cannot be impacted. Within that tidal range no Atlantic salmon or sturgeon eggs or larvae were detected during the monitoring program. An absence of both Atlantic salmon and sturgeon eggs and larvae in this range is not surprising as these species spawn in freshwater habitats with firm substrate where the eggs and larvae remain for an extended period of time (Scott and Scott, 1988).

Atlantic salmon spawn in freshwater habitats, the females bury fertilized eggs in streams with gravel bottoms in late fall. The eggs hatch into alevins in late spring where they remain in the gravel for three to six weeks while they absorb their yolk sac. Fully developed juveniles emerge from the gravel to seek food and are known as Fry or young of the year Parr. Parr feed and grow in fresh water for two to four years before becoming smolts and migrating to the ocean during May and June (DFO 2008). The closest known salmon spawning locations in tributaries of the Stewiacke and Shubenacadie Rivers are over 30 kilometers upstream of the Alton river site on the Little River and above Grand Lake (COSEWIC 2006). Smolts are the earliest salmon life stage to move through the area of the brine discharge and are at low risk as they migrate through the area quickly and are prepared to encounter ocean water salinities. Healthy smolts can survive an instantaneous change in salinity from freshwater at 0.1 ppt to full coastal sea water at 30 ppt for 84 hours but are fully tolerant if instantaneously introduced to sea water at or less than 27ppt (Parry 1960). In 2008, Atlantic salmon smolts were tracked through the Stewiacke-Shubenacadie estuary. Alton co-funded the study in cooperation with an existing study being conducted by DFO (Gibson et al. 2015). The smolts traveled downstream with the current, taking one to three tidal cycles to exit the Shubenacadie River. Once the mixing channel is operational, salmon smolts will once again be tagged and tracked to identify if they travel through the constructed channel.

Atlantic sturgeon spawn in the spring/summer (16-20ºC) in freshwater over rocky/gravel/firm substrates where their eggs adhere to the substrate before hatching in three to seven days. Larvae hatch and are nourished by their yolk sac and drift downstream. Initially, larvae are benthic and cryptic but as they grow move into softer bottom habitats (COSEWIC 201). Juveniles remain in river conditions for at least their first summer before migrating into estuary conditions (DFO 2013,Bemis and Kynard,1997). The Shubenacadie and Stewiacke Rivers have not been identified as known or potential spawning locations for Atlantic sturgeon. The only known spawning locations occur in the St. Lawrence (Quebec) and the Saint John Rivers (NB, COSEWIC 2011). If spawning were to take place on the Shubenacadie or Stewiacke River, the closest upstream suitable spawning habitat would be over 25 kilometres upstream of the Alton site.

Despite not detecting Atlantic salmon or sturgeon eggs or larvae, a variety of other species were collected each year through plankton and seine net sampling, including: gaspereau/American shad (*Alosa sp.),* Atlantic silverside (*Menidia menidia*), threespine stickleback (*Gasterosteus aculeatus*), mummichog (*Fundulus heteroclitus*), banded killifish (*Fundulus diaphanous*), cunner *(Tautogolabrus adspersus),* American eel *(Anguilla rostrata),* Northern pipefish *(Syngnathus fuscus),* Atlantic tomcod *(Microgadus tomcod),* winter flounder *(Pleuronectes americanus),* grass shrimp *(Palaemonetes vulgaris),* sand shrimp *(Crangon septemspinosa),* mysid (*Neomysis americana*), amphipods and five species of copepods.

3.2 Alteration of the Estuary's Bouquet and Disruption of Anadromous Fish Spawning

CRA Statement

> *"However, this is considered a minor data gap for two reasons. First, the contribution of brine to the bouquet of smells at the mouth of estuary will likely be negligible since the brine will make up such a tiny proportion of the water at the mouth. Second, the science on the importance of olfaction in anadromous fish homing is unsettled."* (CRA report, section 3.4, page 9)

Alton agrees that:

> "*the contribution of brine to the bouquet of smells at the mouth of estuary will likely be negligible since the brine will make up such a tiny proportion of the water at the mouth. Second, the science on the importance of olfaction in anadromous fish homing is unsettled. As with many rivers discharging to the Ocean, the bouquet of smells at the mouth of the Shubenacadie Estuary will vary dramatically from time to time depending on the amount of upstream river flow. Thus, recent analyses suggest that salmon use a combination of homing methods – magnetic fields for migration in the ocean to the mouth of the natal stream and, once in natal estuary, olfaction to determine the natal tributary. If this latter theory is true, potential effects on anadromous fish will be non-existent since the brine discharge cannot effect the earth's magnetic field, and the point where olfaction becomes critically important occurs upstream of the brine discharge."* (CRA report, section 3.4, page 9)

Approximately 5.5 million cubic meters of water flow into the Shubenacadie River estuary at the Alton site each tidal cycle. The maximum of 5,000 cubic meters of brine to be discharged each tidal cycle contributes an insignificant volume of a benign substance to the "bouquet of smells". In comparison to the municipal waste water and the agricultural runoff within the Shubenacadie watershed, the impact of diluted salt water on the "bouquet of smells" is expected to be negligible.

Paired with the negligible amount of brine, the importance of olfaction in anadromous fish homing is unknown. The hypothesis that odor detection plays a role in anadromous fish homing was first presented in 1951(Hasler and Wisby 1951), yet little progress has been made since that early research to isolate and identify the odors used, nor its importance in homing. In spite of hundreds of studies through the decades, research has been inconclusive because of the complexities involved in both the environment and animal behavior (Jensen and Duncan 1971; Dittman and Quinn, 1996). It is still not known what chemical components are involved in homing. Current scientific methods are not sufficient to examine the complex olfactory characteristics of water chemistry (McIntyre et al. 2008). The logistics of conducting this type of research are also very complex and time consuming, often with inconclusive results (Dittman and Quinn, 1996). On top of the complexities of the water chemistry, many studies require rearing fish to maturity, which is expensive, labor intensive, and time consuming (Hasler and Scholz, 1983). Physiological tests provide information regarding odor detection, but lack the ability to test odor discrimination. Some methods have the power to determine whether a fish is able to detect a particular odor, but unable to test fine-scale water source discrimination (Havey, 2008).

CONCLUSION

The five CRA recommendations are all in progress, complete, or will be on-going through monitoring programs during operations. Alton Natural Gas Storage is pleased that the third party review confirmed that the EA document was complete and in accordance with requirements. Additionally, CRA concluded that subsequent fish studies were completed using defensible scientific methods to meet DFO requirements and that the data was used to minimize potential effects on the environment.

Alton has confidence that the project has been planned, engineered, and constructed to safeguard the river and its ecosystem from potential negative impacts during construction and operations.

We look forward to continuing to work with the Mi'kmaq of Nova Scotia, governments, and members of the community as the project progresses.

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Appendix A

Alton Natural Gas Storage River Site Monitoring Plan During Cavern Development

Alton Natural Gas Storage River Site
Monitoring Plan During Cavern Development
Dec 10, 2015

Monitoring required for industrial approval

This monitoring plan can be adjusted by agreement between Nova Scotia Environment and Alton Natural Gas Storage based on new information that may become available during cavern development.

DFO recognizes that the 24 day shutdown period could include days with minimal volumes of eggs in the river, however due to the unpredictability of the start of peak spawning, a conservative period of 24 days is recommended for the first year of brining operations. DFO will work with Nova Scotia Environment, the proponent and other stakeholders to examine methods to better predict spawning activity as well as understand the potential risks of operations during the spawning period which may allow for a shorter shutdown period in the future.

Plankton and fish monitoring

1. River monitoring

a) Alton river site monitoring – Plankton sampling, to determine Striped bass egg and larvae presence

- Day time flood tide (30 second long) plankton net sampling in the main river channel at the river site will be conducted every 10 minutes on the 90 minute flood-tide. Sampling frequency, when the mean daily water temperatures reach 11^{0}C, sampling will be daily on the daytime flood tide seven days a week until live Bass eggs are detected
- When eggs are detected at the Alton site on the flood tide sampling, brine discharge will be stopped and Nova Scotia Environment will be notified. This will trigger operational measures to further protect the eggs. See discharge monitoring and the operational plan sections

b) Striped bass spawning site monitoring

- Water temperature will be monitored continuously at the Alton river site during operations and when the spring time mean daily temperature reaches 11^{o}C then degree days will calculated as an additional indicator of potential Striped bass spawning events
- When the mean daily water temperature is above 11^{o}C, the Striped bass spawning site will be monitored daily as described below
- Weather forecasts will be closely monitored in anticipation of warming temperatures leading to spawning events
- Gaspereau fishers congregating at the ‘Fish Shack’ (local fishing community hub, Main St West, Stewiacke) will be consulted at least twice weekly. Through

their handling of striped bass by-catch and word-of-mouth, they know the state of sexual maturation of the striped bass

- Striped bass spawning locations from the hwy 102 to the CN Bridge on the Stewiacke River will be visually monitored for indication of spawning events
- These will give us an indication of when to expect Bass spawning to begin.

c. River wide monitoring will be supported throughout cavern development to better understand the ecological function and productivity of the estuary

2. Constructed Channel Monitoring

a) Channel use monitoring - migration routes, DFO permit required

- Atlantic salmon smolt acoustic tagging will be conducted to see if they use the channel – in the spring of the first year of operation
- Striped bass acoustic tagging will be conducted to see if they use the channel – in the first year of operation
- Vemco receivers: one will be located in the center of the new channel and one on each side of the river up-estuary of the channel

b) Water intake

- Pump tests sampling for all the species, numbers, life stage and mortalities based on the cubic meters of water sampled
- Samples will be taken at the intake face, and in the intake well inside of the gabion face
- Velocities at the intake face will be measured during low flow, mid-flood tide, slack tide, and mid-ebb tide along transects along the face to obtain a picture of the current patterns during intake
- Sampling frequency will be three times a week when withdrawing water starting the first Monday in May through to July 15, then once a week through to September 30th
- Additional tests may be approved by DFO and scheduled to coincide with Science sampling in the river during the shutdown period to determine the potential impact on Bass eggs and larvae. This information is to be used in developing modifications to the intake operation when the brine release has been stopped.
- The plankton including Bass eggs and larvae are not harmed in the sampling and can be counted and returned to the river. This will not give information on how mature the eggs and larvae are just their number. It should be noted that natural conditions result in 7% to 10% dead eggs in a sample.
- Pump tests in the wet well may be taken when not withdrawing to see if tidal flows bring any eggs or larvae into the intake.

c) Brine discharge site during outfall operation

- Pump test sampling as above at the discharge site at low water /mid tide /high water

- Five meters from the outfall in the direction of the flow at low flow, mid-flood tide, slack tide, and mid-ebb tide
- Sampling frequency will be three times a week when discharging brine from the first Monday in May through July 15, then once a week through to September 30th
- This sampling has to be paired with the plankton tows in the river so that we know the portion of dead eggs naturally in the water column
- Additional tests may be approved by DFO and scheduled to coincide with Science sampling in the river during the non-brining period to determine the potential impact on Bass eggs and larvae to be used in modifications to the operations n as toxicity test do not duplicate exposure times and concentrations they will be subject to at the outfall. .

- The eggs and larvae can be checked and returned to the river but some live eggs and larvae collected during brine release should be kept to study the long term survival. This will require a DFO science permit.

Water chemistry and temperature monitoring

a) River wide monitoring

Alton site

- Conductivity Depth Temperature (CDT) data logger will be placed on the bottom of the river 100 meters downstream of the constructed channel
- Frequency: On-going, real-time logger recording each 10 minutes and downloaded bi-weekly during the ice free months, and when there is safe to access them during the winter

Alton Channel Monitoring (the river site)

Discharge site

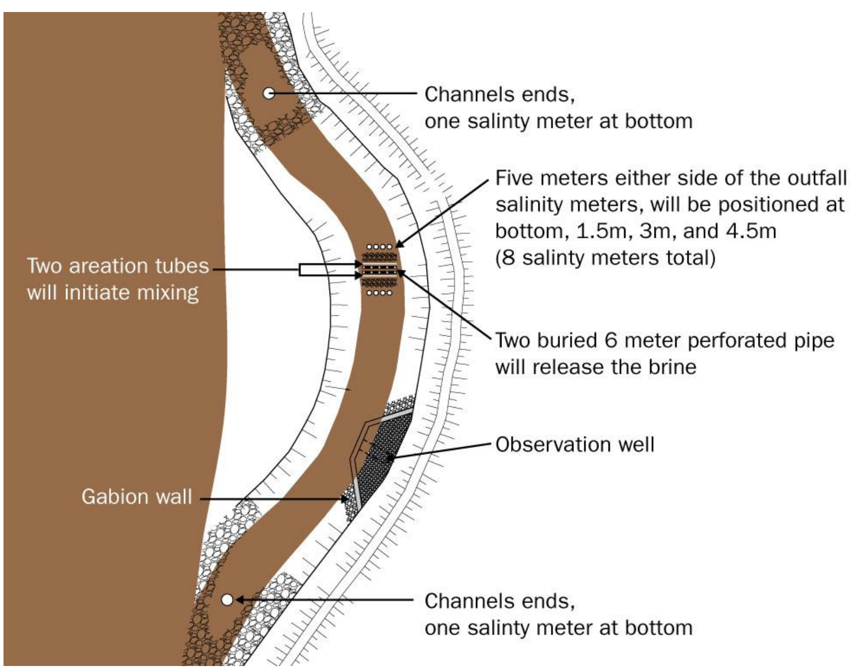
- At five meters either side of the toe of the outfall an array of conductivity sensors at 1.5m vertical spacing. Bottom, 1.5m, 3.0 m and 4.5m linked to the computer system for ongoing salinity calculation and adjustment of discharge flow. Sampling frequency planned for all year but may have to be adapted if ice cover affects probe's functioning. Only during discharge

Channel ends

- CDT data loggers at bottom at both ends of the channel. Sampling Frequency, ongoing readings recorded each 10 minutes. Data down loaded daily during the first week of start-up and then weekly until full brining is achieved. Following that ramp up period the data will be downloaded weekly. Weekly during periods of no brine release. These are the compliance points.

General water sample testing

- Starting in spring 2015 and continuing for one year, water samples will be collected monthly at high and low tide at the Alton site on the Shubenacadie River estuary. Samples will be tested for standard water analysis, and total metals. This testing will allow for baseline data to capture the natural water quality conditions in the river. Sampling may not be completed in months when the river is ice-covered
- When the Alton Natural Gas project is withdrawing Shubenacadie River water and brining the salt caverns, water samples will be collected from the water tank at the cavern site (river water that the sediment has settled out of and has gone through the filters), the brine pond at the outlet end and the Shubenacadie River at low and high tide. All four samples will be tested for standard water analysis, total and available metals, and petroleum hydrocarbons. These samples will be collected monthly for the first four months, then will move to quarterly sampling Additional samples may be requested by the Government based on this data.
- Core samples of the mud flat on the west bank of the Shubenacadie River at the Alton site were collected to document background conditions and tested for total and available metals and NORMs
- The Shubenacadie River water will be tested for NORMs twice before brining begins.
- Brine in the brine pond will be tested for NORMs before caverns are 25% developed. Based on that sample, additional sampling may be required



Schematic of the placement of the ten salinity meters within the constructed mixing channel.

Operational Plan

Discharge operation

- Salinity data is recorded every minute from the meters immersed in water column. They will be averaged automatically by the computer (five meters either side of the brine discharge averaged separately). If average salinity over a 10 minute period is 7ppt above background or above 28ppt, the discharge flow will be reduced by 20% by the computer system. The discharge flow will continue to be reduced by 20% every 10 minutes until the average salinity is within 7ppt of background and at or below 28ppt
- From the date that Stripped bass eggs are detected the brine discharge will be stopped for 24 days. From start-up following the no brine release period until July 5th, the discharge will be regulated as above to maintain salinities at or below 7ppt above background and at or below 20ppt.
- The compliance points are the loggers at the ends of the channel. Meeting the standard 5m from the outfall is precautionary and allows time for adjustments in brine flow as above
- The automatic reduction in brine flow will shut down all the brining within 50 minutes

Striped bass egg and larvae

- Spawning site non-invasive information gathering, combined with the detection of eggs in the tows on a day time flood tide and intake structure at the Alton site, will trigger the stop of brine release operations for 24 days
- After 24 days when brine release operations resume, sampling will be restarted at the intake structure as per the proposed schedule in the intake monitoring section above.
- If Striped Bass eggs are detected in the intake well or river at the site after the 24 day period, both NSE and DFO will be contacted to determine if further action is necessary.

Intake and outfall samples

- Eggs, larvae and fish of all species will be visually checked for signs of injury due to the intake or contact with the brine
- If impacts are identified corrective action plan will be prepared and implemented by changing operating conditions to prevent further harm
- It is not expected Bass eggs will enter the intake well, but if they are found in the intake well, changes in operations will be made to prevent further intake. This may mean a shutdown, but could also be corrected by shifting the timing of intake on the tide

Water samples

- Changes in water chemistry of the brine during cavern development will be kept within the background levels in the river. This will be done by comparing the tidal river water quality with the average quality of the brine diluted to equal to or less than 7ppt salinity

- River water and brine mix elemental composition will be within the natural variation in the river

Striped bass egg and larvae toxicity testing

- Toxicity testing on the bass eggs and larvae will be conducted using the protocol approved by DFO

Reporting

- The monitoring data will be available to Nova Scotia Environment, Fisheries and Oceans Canada and Environment Canada and a designated First Nations organization upon request.
- Reports will be sent to Nova Scotia Environment on a quarterly basis

Appendix B

Procedure for Acute Toxicity Testing of Alton Gas Brine on Striped Bass

Procedure for Acute Toxicity Testing of Alton Gas Brine on Striped Bass

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Overview

The objective is to develop a protocol that is satisfactory to all concerned parties for determining the median toxicity threshold (LC_{50}) of the brine water and its constituents on egg, larvae and juvenile stages of striped bass (*Morone saxatilis*). The work will be conducted at Dal-AC. This revised version is based on feedback received on February, 12, 2015 of a first draft submitted to Marc McLean, DFO on January, 26, 2015.

Biological material: Tests will be conducted on wild-domesticated striped bass (WDSB), with hatchery striped bass (HSB) serving as a back-up. WDSB will be derived from eggs caught by plankton net tows in the Stewiacke River. The eggs will be trucked to Dal-AC Aquaculture-Centre and on-reared at 3 to 5 ppt salinity and 18-20 °C to provide larvae and juveniles for testing. If there is opportunity to catch wild larvae (5-7 mm total length, TL), they will be included in tests. True wild larvae may have experienced salinity ranging from 0.5 to >20 ppt, due to the ebb and flow of the tides, which may alter their salinity tolerance compared to lab reared fish at constant 3-5 ppt.

Advantages of WDSB: Since wild striped bass will be exposed to brine effluent in the Shubenacadie River, it is important to replicate factors as best we can. WDSB will have a greater genetic diversity than HSB, the latter likely will be half-siblings. Also, the nutritional condition of WDSB and HSB yolk sac larvae will likely differ due to potential differences in nutrients derived from the egg yolk. Egg quality from captive broodstock at DAL-AC is inferior to wild eggs: they are smaller, the chorion is weaker, and hatch rates are lower.

Disadvantages of WDSB: a) A batch of wild eggs from a plankton net tow may contain a mixture of developmental stages, which will hatch at different times, generating a confounding factor in the response to the toxicity test. b) Parasites are an unknown confounding factor. c) A sufficient supply of wild eggs is not assured. Wild eggs are only available for about three weeks starting mid-May and spawning is episodic.

Advantages of including HSB as a back-up: a) Response of each developmental stage to brine may prove to be similar to WDSB, increasing our confidence level in the results. b) Relying 100% on catching sufficient wild eggs to produce enough fish for tests at all developmental stages is risky.

Brine collection and storage: Brine will be collected from the brine pond at the Alton Gas site with a pump (2 inch Honda water pump, loaned from Alton Gas) into a 700L water tank on a ¾ ton HD truck (Dal-AC farm or rent). At Dal-AC, the brine will be stored in 200 L plastic drums in a walk-in cold room (4 ºC) in darkness and aerated.

Dilution water: Tidal water from the Alton Gas settling pond will be pumped (2 inch Honda water pump, loaned from Alton Gas) through a 500 µm screen into a 700L water tank on a ¾ ton

HD truck (Dal-AC farm or rent). The water, at Dal-AC, will sit in the tank for about 2 hours to allow the silt to settle, then be siphoned through a 50 µm screen into 200 L plastic drums. Water will be stored in a walk-in cold room (4 ^{o}C) in darkness and aerated. It will be used to both dilute the brine to the test concentrations and dilute away the test salinity after the 1 hour test period.

Shubenacadie River water contains some heavy metals (Al, Fe, Zn, Ni, Cu, Pb, and Cr) that exceed the values recommended by the EPA (2002), and some parameters and heavy metals (ammonia, chlorine, Al, Fe, Pb and Zn) exceed Environment Canada recommendations for toxicity testing specifically for rainbow trout in full freshwater (EC 1998). In addition, the alkalinity, 8-10 mg/L, is lower than recommended (EC 1998). Despite these concerns, using Shubenacadie River water for the tests is the most realistic approach to assessing the toxicity of the diluted brine discharge. The fish are adapted to these conditions. High metal content is common to rivers in Nova Scotia (Dennis and Clair 2012).

Concentrations analyzed: An estimated total of 48 tests will be conducted between May and September, 2016 (Table 1). Each test will include five concentrations will be analyzed at each life stage, plus a control (2 ppt) and brine (100 ppt). Each test salinity will have three replicates. Initially, the test concentrations will be 15, 25, 35, 45 and 55 ppt. However, the range of salinities needed to determine the median toxicity threshold may need adjusting to match the ontogenetic changes in euryhalinity (Cook et al. 2010). The control salinity is 2 ppt and not 0 ppt (freshwater) because Shubenacadie River striped bass eggs and larvae are not found in tidal freshwater in the wild and in culture exhibit poor survival in pure freshwater. Underyearling juveniles (up to 15 g) also exhibit better survival at 2 ppt than in pure freshwater.

Brine (100 ppt) is included to determine the effect of an accidental discharge of brine. The suggestion by the reviewers to use 240 ppt salinity to match the highest possible concentration seems unreasonable. No teleosts can survive 240 ppt, similarly 100 ppt is likely highly toxic.

Temperature and salinity interact to affect survival of striped bass early life stages (Cook et al. 2010). Spawning usually occurs at 14-18 ^{o}C, after which a cooling trend to 11-12 ^{o}C is quite common during the Nova Scotia spring. Hence toxicity tests will be run at both 12 and 18-20 ^{o}C for the egg and larvae stages only (Table 1).

For quality control purposes, an additional series of trials will be conducted with “Instant Ocean” sea-salt as a reference toxicant.

Life stages: Six life stages will be analyzed:

1) Eggs; 2) Yolk-sac larvae; 3) 5-10 days post hatch (dph) larvae; 4) 10-20 dph larvae; 5) Early juveniles (30 mm total length, TL); 6) Large juveniles (120 mm TL).

The appendix lists the specific experimental conditions for each stage:

Table 1: Estimated Number of Salinity Toxicity Tests on Shubenacadie Striped Bass

Material to analyze	**Biological material**	**Temperature**	**Eggs**	**Yolk-sac**	**4-10 dph**	**10-20 dph**	**30 mm**	**120 mm**
Brine	Wild	12 ºC	2	2	2	2	0	0
		18-20^{o}C	2	2	2	2	1	1
	Captive	12 ºC	2	2	2	2	0	0
		18-20^{o}C	2	2	2	2	1	1
Instant Ocean	Wild	18-20 C	1	1	1	1	1	1
	Captive	18-20^{o}C	1	1	1	1	1	1
Sub-total			10	10	10	10	4	4
Total								**48**

References

Cook, AM., Duston, J., and Bradford, R.G. (2010). Temperature and salinity effects on survival and growth of early life stages of Shubenacadie River striped bass. Transactions of the American Fisheries Society, 139:749-757.

Dennis IF and TA Clair 2012. The distribution of dissolved aluminum in Atlantic salmon (*Salmo salar*) rivers of Atlantic Canada and its potential effect on aquatic populations. Canadian Journal of Fisheries and Aquatic Science, 69:1174-1183.

EC 1998. Biological test method: toxicity tests using early life stages of salmonid fish (Rainbow trout). Second ed. Report: EPS 1/RM/28-1E. 122 pp.

EPA 2002. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. 266 pp.

Table 2: Egg Stage Test Conditions

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt in one hour
Test duration	To hatch (range: 12 to 96h)
Temperature	12 ºC and ambient (18-20 ºC)
Light quality	Dim ambient laboratory illumination
Light intensity	30 lux
Photoperiod	24 h
Test chamber size	4 L (McDonald jars)
Test solution volume	1 L for 1 h, then fill jar to 4 L during dilution
Renewal of test solutions	No renewal
Age of test organisms	Eggs
Nº organisms per test chamber	100
Nº replicate chambers per concentration	3
Nº organism per concentration	300
Feeding required	No
Test chamber cleaning	Cleaning not required
Test solution aeration	Gentle aeration needed to maintain eggs in suspension. O_2 will checked 2 times per day
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Hatch and mortality
Volume of brine (100 ppt) required	Minimum 2 L per test
Test acceptability criterion	≥70% survival in wild egg controls ≥50% survival in eggs from captive broodstock

Table 3: Yolk-Sac Larvae Test Conditions

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt
Test duration	24 h
Temperature	12 ºC and ambient (18-20 ºC)
Light quality	Dim ambient laboratory illumination
Light intensity	30 lux
Photoperiod	24 h
Test chamber size	4 L (McDonald jars)
Test solution volume	1 L for 1 h, then fill jar to 4 L during dilution
Renewal of test solutions	No renewal
Age of test organisms	1-3 days post hatch
Nº organisms per test chamber	50
Nº replicate chambers per concentration	3
Nº organism per concentration	150
Feeding required	No
Test chamber cleaning	Cleaning not required
Test solution aeration	No aeration, O_2 will checked 3x per day
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Mortality
Volume of brine (100 ppt) required	Minimum 2 L per test
Test acceptability criterion	≥70% survival in controls

Table 4: 5-10 dph Larvae (Swim Bladder Inflated, ‘First Feeding’ Stage) Test Conditions

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt
Test duration	48 h
Temperature	12 ºC and ambient (18-20 ºC)
Light quality	Dim ambient laboratory illumination
Light intensity	30 lux
Photoperiod	24 h
Test chamber size	4 L (McDonald jars)
Test solution volume	1.5 L for 1 h, then fill jar to 4 L during dilution
Renewal of test solutions	No renewal
Age of test organisms	5 – 10 day post hatch
Nº organisms per test chamber	50
Nº replicate chambers per concentration	3
Nº organism per concentration	150
Feeding required	No
Test chamber cleaning	Cleaning not required
Test solution aeration	Gentle aeration, O_2 checked 2x per day
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Mortality
Volume of brine (100 ppt) required	Minimum 3 L per test
Test acceptability criterion	70% or greater survival in controls

Table 5: 10-20 dph Larvae Test Conditions

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt
Test duration	72 h
Temperature	12 ºC and ambient (18-20 ºC)
Light quality	Dim ambient laboratory illumination
Light intensity	30 lux
Photoperiod	24 h
Test chamber size	4 L (McDonald jars)
Test solution volume	2 L for 1 h, then fill jar to 4 L during dilution
Renewal of test solutions	No renewal
Age of test organisms	10 - 20 days post hatch
Nº organisms per test chamber	50
Nº replicate chambers per concentration	3
Nº organism per concentration	150
Feeding regime	Feeding of *Artemia* may be required to prevent cannibalisms
Test chamber cleaning	Cleaning not required
Test solution aeration	Gentle aeration, O_2 checked 2x per day
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Mortality
Volume of brine (100 ppt) required	Minimum 4 L per test
Test acceptability criterion	70% or greater survival in controls

Table 6: 30 mm Total Length Juveniles Test Conditions

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt
Test duration	96 h
Temperature	Ambient (18-20ºC)
Light quality	Dim ambient laboratory illumination
Light intensity	300 lux
Photoperiod	24 h
Test chamber size	15 L (green plastic buckets))
Test solution volume	14 L
Renewal of test solutions	No renewal
Age of test organisms	30 – 40 days post hatch
Nº organisms per test chamber	10
Nº replicate chambers per concentration	3
Nº organism per concentration	30
Feeding required	No
Test chamber cleaning	Cleaning not required
Test solution aeration	Aeration provided, O_2 checked 2x daily
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Mortality
Volume of brine (100 ppt) required	Minimum 25 L per test
Test acceptability criterion	90% or greater survival in controls

Table 7: Test Conditions and Procedures for Striped Bass 120 mm Juveniles

Test type	Static non-renewal
Exposure time	1 h, then dilute to 2 ppt
Test duration	96 h
Temperature	Ambient (18-20ºC)
Light quality	Normal ambient laboratory illumination
Light intensity	300 lux
Photoperiod	24 h
Test chamber size	15 L (green plastic buckets)
Test solution volume	14 L
Renewal of test solutions	No renewal
Age of test organisms	100 days post hatch
Nº organisms per test chamber	10
Nº replicate chambers per concentration	3
Nº organism per concentration	30
Feeding required	No
Test chamber cleaning	Cleaning not required
Test solution aeration	Aeration provided, O_2 will checked daily
Dilution water	Shubenacadie River
Test concentrations	Control (2 ppt), five concentrations (15, 25, 35, 45, 55 ppt) and brine (100 ppt)
Endpoint	Mortality
Volume of brine (100 ppt) required	Minimum 25 L per test
Test acceptability criterion	90% or greater survival in controls

Appendix C

Letter from Fisheries and Oceans Canada

Fisheries and Oceans Canada | Pêches et Océans Canada

Ecosystem Management
Fisheries and Oceans Canada / Pêches et Océans Canada
1 Challenger Dr. P.O. Box 1006, Station B610
Dartmouth, Nova Scotia, B2Y 4A2

Your file *Votre référence*

August 1, 2014

Our file *Notre référence*
06-HMAR-MA7-00182

David Birkett
AltaGas Natural Gas Storage Ltd.
1700, 355 4th Ave. SW
Calgary, Alberta T2P 0J1

Dear Mr. Birkett:

Subject: Review of Alton Natural Gas Estuary Monitoring Plan – condition of the Nova Scotia Environmental Assessment and Fisheries and Oceans Canada

The Fisheries Protection Program (The program) of Fisheries and Oceans Canada (DFO) received the proposed Alton Gas Estuary Monitoring Plan on June 18, 2014.

Our review consisted of:

- Alton Natural Gas Estuary Monitoring Plan submitted by the consultant, Mr. Bob Rutherford, Thaumus Environmental Consultants Ltd. on June 18, 2014.
- DFO letter of advice drafted by Melanie McLean, Habitat Assessment Biologist and submitted to AltaGas Natural Gas Storage Ltd. (formerly Alton Natural Gas Storage LP- the proponent) on November 5, 2010.
- Nova Scotia (NS) Environment Assessment Supplemental Information Application to develop natural gas storage caverns in Shubenacadie, NS by the proponent, received on November 23, 2007.

DFO participated in the Nova Scotia Environmental Assessment of the proposal submitted by the proponent to develop natural gas storage caverns in 2007. Condition 2.1 of the NS Environmental Assessment Approval dated December 18, 2007, stipulated the proponent was to provide monitoring programs and plans to the Nova Scotia Environment (NSE) and DFO for review. Also, based on the outcome of the monitoring program, the proponent was to make modifications to the mitigation plans and/or operations to prevent any unacceptable environmental effects.

Monitoring programs A, C and D, listed in Attachment 1 were developed between DFO and the proponent and were administered from 2008 to 2013. The purpose of this proposed plan titled: 'Alton Natural Gas Estuary Monitoring Plan' [herein referred to as the Monitoring Plan] submitted on June 18, 2014 was to take the results from the monitoring programs and make modifications to mitigation plans and/ or operations to prevent continuing unacceptable environmental effects to the satisfaction of NSE and DFO. The plan was also developed to satisfy conditions, B and E of Attachment 1.

Upon review of the proposed Monitoring Plan, it is recommended a study be completed to determine the median toxicity threshold (LC_{50}) of the brine water and its constituents from the brining operation on egg, larvae and juvenile Stripped bass survival. Based on the results of this toxicity study, modifications to the mitigation measures may be required.

The results of the toxicity study, including possible additional mitigation measures, and design revisions are to be implemented as per the Monitoring Plan and should be provide to DFO for review once available.

If the proponent has any questions, please contact Carol Jacobi at our Dartmouth, NS office at (902) 426-2545, by fax at (902) 426-1489, or by email at Carol.Jacobi@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,

Mark McLean
A/ Manager, Regulatory Reviews
Fisheries Protection Program

COPY LIST: Helen MacPhail, Nova Scotia Environment
Carol Jacobi, FPP

Appendix D

Third Party Review: Alton Natural Gas LP Brine Storage and Discharge Facility Project

CONESTOGA-ROVERS & ASSOCIATES

www.CRAworld.com

Final

Third Party Review

Alton Natural Gas LP Brine Storage and Discharge Facility Project

Prepared for: Kwilmu'kw Maw-klusuaqn Negotiation Office

Conestoga-Rovers & Associates
45 Akerley Boulevard
Dartmouth, Nova Scotia B3B 1J7

July 2015 • 11102228 • Report No. 2

Partners in Sustainability

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Section 1.0 Introduction

The Kwilmu'kw Maw-klusuaqn Negotiation Office (KMKNO) retained Conestoga-Rovers & Associates (CRA) to review the Environmental Assessment Registration (EA) report and associated documentation for the proposed Alton Natural Gas LP Brine Storage and Discharge Facility Project (the Project). In this report, CRA focused on the review on the assessment of potential impacts of the proposed Project on fish and fish habitat of the Shubenacadie Estuary (Estuary) and upstream river area.

The purpose of the review is report is to:

- Complete a literature review of existing information for similar operations around the world, specifically, on solution mining, brine discharge requirements and the associated environmental impacts.
- Review the existing information to evaluate the scientific and technical information for completeness and for comparison to documented and validated scientific methods including the interpretation of the information with generally accepted standards of good scientific practice.
- Identify any information gaps and, if warranted, recommendations on how to address the information gaps.

The CRA team completing the documentation review and data gap analysis was selected from a team of environmental professionals that has experience in environmental assessments and aquatic ecology with specific project experience in natural gas storage projects involving brines and brine discharge.

1.1 Project Description

The Alton Natural Gas storage project consists of the development of an underground hydrocarbon storage facility near Alton, Nova Scotia. As outlined in the Environmental Assessment Alton Gas prepared for the Nova Scotia Minister of the Environment, the main aspects of construction involved in the project are: the water intake and diluted brine discharge facilities; laying and connecting the water and brine pipelines; drilling vertical holes to initiate the creation of the salt caverns; and developing the salt caverns.

The water intake facility will take water from the Shubenacadie River which will then be used in the dissolution of the salt bodies under the site. This water will then mix with the dissolved salt from the deposit and be brought back to the surface creating cavern space for the storage of natural gas. This brine will then be stored in a brine pond before being discharged to a mixing channel constructed alongside the Estuary. The brine will be discharged via a diffuser pipe at the bottom of the channel overtopped by coarse rock berm; this combination is designed to dilute the brine by an order of magnitude or more before the brine actually reaches the water column of the mixing channel. From the mixing channel the now diluted brine will then be released back into the river on a schedule that attempts to conform to the natural salinity fluctuations that occur in the estuary system.

Once construction of the caverns has been completed natural gas will be injected and withdrawn to meet market demands within the surrounding area. Through the development of this project, Alton Gas has prepared and submitted an Environmental Assessment Report in 2007, a report of additional information as requested by Nova Scotia Environment in 2007. An additional Environmental Assessment for the construction of a natural gas pipeline was completed in 2013. As of 2015, brine water pipeline and site facility construction has been completed and drilling at the cavern site has begun.

1.2 Existing Environmental Conditions

The Alton Natural Gas site is located next to the Shubenacadie River, which is part of a very complex tidal estuary system. This Estuary is the source of water intake for the project as well as the location for brine discharge. As such, the conditions within the estuary, both environmental and biological, are of great importance to the project, since any positive or negative effects of the project will be experienced by the river Estuary system.

As part of the 2007 Environmental Assessment, Martec Ltd. completed a description of the Shubenacadie River, which is included in the Assessment; Appendix A, "Physical Description of the Shubenacadie River". Martec completed a field program in 2006 to establish trends in salinity, flow, and water elevation throughout the Shubenacadie-Stewiacke river system. Through this description Alton Gas obtained the majority of their data with regards to this system's salinity.

The Shubenacadie River is a tidal bore river in Nova Scotia, Canada. The Estuary experiences extreme changes in salinity, temperature, water elevation, suspended sediment and river bottom configuration over very short temporal periods (less than 1-hour). The river meander length is approximately 50 kilometers from its source at Shubenacadie Grand Lake to its mouth at Maitland on Cobequid Bay. The river system receives freshwater from a relatively large watershed area (2600 km^2) that includes the Stewiacke River, a tributary to the Shubenacadie River. The confluence of the Stewiacke and Shubenacadie Rivers is located approximately 22 kilometers upriver of the latters mouth. Due to the extreme tidal forcing (> 10 m large tidal range) from Cobequid Bay, the lower 30 kilometers of the river (Figure 1.0) of both rivers is tidal. Within this lower reach (tidal) of the river, the brackish water has salinities that can vary from 0 to 25 ppt over a single tidal cycle (Martec Ltd. 2007).

Due to the variance in salinity experienced in the Shubenacadie – Stewiacke Estuary it is home to diadromous, anadromous and catadromous fish species. It is also home to various invertebrate species. Three species found with the system are classified as being of concern; Atlantic salmon, Striped bass, and Atlantic sturgeon. Atlantic salmon are protected under the Species at Risk act (SARA), striped bass are listed as threatened by the Committee on the Statis of Endangered Wildlife in Canada (COSEWIC), and the Nova Scotia Department of Natural Resources (NSDNR) has red listed the Atlantic Sturgeon. Fish species that are known to spawn in the Estuary or the associated fresh water system include:

- Sea Lamprey
- Atlantic Sturgeon
- Brook Trout
- Atlantic Salmon
- Brown Trout
- Striped bass
- Gaspereau
- Blueback herring
- American shad
- Rainbow smelt
- Stickleback species
- Mummichog
- Atlantic silverside
- Atlantic tomcod
- Chain pickerel
- Yellow perch
- White perch
- American eel

Some benthic organisms present include microalgaes, tube dwelling amphipod, *Corophium volutator*, and various worm species. Aquatic mammals which can be present include river otters, mink, harbor seals, and harbor porpoises.

Water intake facilities and brine discharge facilities were designed by Matrix Solutions Inc. for Alton gas and a design summary is included as Appendix B1 of the 2007 Environmental

Assessment The water intake facility will take 11,750 m^3 /day of water, of which 1750 m^3 /day will return directly to the river as discharge from the hydrocyclones, which remove most suspended matter. The brine discharge facility will take the brine returned from the caverns and store it in a pre-mixing pond before it is discharged to the mixing channel. The salinity of this brine before mixing is expected to be 260 ppt. No pumping would be require as non-tidal river flow enters the mixing channel and is then discharged during times of higher salinity flood tides.

Section 2.0 Methods

CRA assembled a project team to complete a comprehensive literature review of existing information on the Alton Natural Gas project. The CRA team has carefully reviewed the documents Alton Gas provided to the province to obtained approval of their Environmental Assessments. The team has also reviewed all documents provided to KMKNO by Alton Gas and has created a table which summarizes the contents of all of these documents. (Appendix A) Review of the contents of these documents has led to the conclusions discussed within this report. A number of external documents were also consulted to contextualize the actions taken and decisions made by Alton Gas throughout the process of developing and registering their Environmental Assessment.

Section 3.0 Results

3.1 Overreaching Observations

In general, the EA methods and subsequent data provided by Alton have allowed the Nova Scotia Department of Environment and Labour (NSDEL) to make a decision for the Project to proceed. The following are some general observations on the EA documentation provided:

- The EA submitted for the project was generally completed consistent with the guidelines for NS Environmental Assessment Regulations and provided a logical approach in identifying potential impacts to environment and potential mitigation measures
- The EA submitted for the project was limited to development of the salt cavern for storage of natural gas as well as the brine discharge infrastructure but did not include an evaluation of the construction of a natural gas pipeline from the Maritimes and Northeast pipeline to the storage cavern. A separate EA for the natural gas pipeline was to be submitted to the NSDEL. The splitting of project components into separate EAs is atypical and does not allow for the evaluation of overlapping effects from the proposed project or potential cumulative effects

- Cumulative effects from the proposed project and other on-going projects in the area were not specifically addressed in the EA report but were considered to be negligible as part of subseqent correspondence.

3.2 Scientific and Technical Completeness of Provided Information

Over the course of the planning and approval process, starting in 2007, the project has received extensive review from a variety of government sources, especially DFO. As part of the long-term and on-going consultation, potentially critical environmental issues identified were impacts on fish stocks and fish habitat. Of special concern were potenitial impacts on three species of concern: Atlantic salmon, Atlantic sturgeon, and Striped bass. However, other species of fish and invetebrate prey species were considered in various background documents. Based on consideration of the project, several potential impacts of the project were noted: potential disruption of upstream migration of anadromous fish by alteration of the river's bouquet; potential entrainment and impingement of fish associated with water withdrawals; toxicity of brine/estuary water mixtures; and impacts on sediment loads. Other issues considered, and then quickly dismissed, were significant effects on salinity of the Estuary and the thermal regime of the Estuary.

In response to these concerns, the project has taken an interative and collaborative approach to assessing potential impacts. Thus, potential risks to fish were screened first based on available life history information and on the assumption that very small life forms, such as fertilized eggs (eggs) and very early life stage larvae, would be most sensitive to effects. These very life stages are typically planktonic, which means they are carried around largely by ambient water currents rather than active locomotion. In contrast to the ichthyoplankton, larger larval, juvenile, and adult fish can typically swim fast enough to avoid impingement, entrainment, and plumes of potentially toxic brine mixtures. Given this background, potential effects on many resident fish species could be, and were, dismissed in early stages of this process because those species do not spawn or have vulnerable eggs/larvae near the Site.

In contrast, Striped bass do have eggs/larvae near the Site so this basic screening process focused attention on Striped bass. Striped bass are a species of concern in the Estuary and also an important part of the fishery. These fish are known to spawn upstream in the Stewiake River, and their eggs and developing larvae are subsequently carried down to the Estuary alongside the Site, potentially into harms way. However, the specifics of spawning and life history dynamics of bass in the Estuary were not well known. The Shubernacadie Estuary differs in important respects from other esturaries in which bass spawn, so an early recommendation of regulatory reviewers was that more information on the temporal and spatial distribution of Striped bass eggs needed to be obtained. This recommendation was a specific condition of the Nova Scotia Environment approval.

"A plan to gather baseline information on water temperature and the presence of Atlantic salmon, Striped bass and Atlantic sturgeon eggs and larvae during one spawning season prior to the commencement of solution mining".

Although consideration of life history characteristics indicated the salmon and sturgeon eggs/larvae would not likely be impacted, the directive for futher study included these two additional species. Although the rationale for this is not stated, it is likely because these two populations are so precarious that even low levels of uncertainty about potential impacts were considered unacceptable.

In reponse to this directive/recommendation, a detailed and continuing monitoring program has gathered baseline information of the last 7 years and counting. The physico-chemical information includes not just water temperature but salnity and flow. The sampling of biota has focussed on times and locations most pertinent to Striped bass, but the detailed sampling of eggs, fry, and juvenile fish has also sought the presence of salmon and sturgeon. As was predicted by life history considerations but also their very small populations, salmon and sturgeon eggs and larvae were apparently never observed in the rather extensive sampling.

This collected information (since 2007) has greatly expanded the knowledge base concerning Striped bass dynamics and to lesser extent, their prey in the Shubernacadie Estuary. Based in part on the last seven years of sampling, it is now well established that this stock is currently as numerous as it has been in decades. At the same time, these detailed studies suggest that the Shubenacadie population is vulernable. Nova Scotia is at the edge of the habitat range for Striped bass, and the Estuary poses additional significant constaints on bass recruitment.

Although all the factors causing successful or failed recruitment are not well established, very good recruitment probably relies on succession of favorable weather conditions all of which must occur. Thus, weather conditions must sequentially spur good spawning, good retention in the Estuary, and provision of adequate densities and types of prey at appropriate locations and times in bass larval development. Even if all of these propitious event occur in the same year, age zero fish in this northern clime have a very short period in which to grow to a size sufficient to allow over-wintering. Thus, recruitment in the Estuary tends to fail in many years; the currently large population of Striped bass is thought to be due almost entirely to one or two very good year-classes, rather than constant successful recruitment per year. During the intensive sampling of eggs and fry, even though populations of adult fish are high, recruitment has probably been low because all essential conditions have not been optimal.

3.3 Existing Information for Similar Operation

Largely because of the enormous tides, the physico-chemical environment present in the Bay of Fundy and the Shubenacadie River are very unique. The massive tidal force of the bay influences the Shubenacadie River, making the Estuary a somwhat unique environment in a way that has very few anaologus environments. As such, a single analagous project was not found in available literature for comparison to the Alton Project. However, aspects of various projects, including biological and environmental chemistry components, can be used for comparison purposes and described in the following paragraphs.

Projects that have similar aspects of brine discharge are variuous desalination projects which often discharge into near shore tidal environments. Alton Gas' research and design of the discharge facility has taken into consideration and referenced existing mathematical models of brine desemination such as the work of D.D. Shao's "Brine discharge into shallow coastal waters with mean and oscillatory tidal currents".

Numerous papers and studies exist which atempt to determine the effects of salinity changes on fish species. With the introduction of a brine to the area surrounding the project site some species, at various life stages, could be exposed to slight or potentially higher salinity changes near the outfall area. Species found in the Shubenacadie River and associated estuary are regularly exposed to a change in salinity of 0-30 part per thousand (ppt) due to the 30 km tidal influence from the Bay of Fundy. Therefore many of the fish species in the River have to ability to adapt to changes in salinity and may be unaffected by the changes in salinity. A study completed by Hiroi, and McCormick exposed lake trout, brook trout, and Atlantic Salmon directly to 30 ppt salinity waters, and gradually to 10, 20, and 30 ppt waters. Atlantic salmon, which are of concern in the project area, showed a 100% survival rate to both experiments. Brook trout, which are also present, had a 50% survival rate in the direct exposure scenario and 100% in the gradual exposure experiment. This study does not help to understand effects on recrutment or growth but does indicate dramatic increases in salinity are acutely lethal to some salmoniod species.

A study from Mississippi State University in collabaration with the University of British Columbia produced a paper intitled "Salinity affects on Atlantic Sturgeon". In this study, juvenile Sturgeon were exposed to waters ranging in salinity from 0-33 ppt. The Sturgeon were identified to have the ability to grow and adapted to salinity changes up to 30 ppt. Salinty concentrations greater than 30 ppt were toleratred by sturgeon but concentrations higher than that inhibited growth. Fish were on average 10 cm shorter and 5 kg smaller (sturgeon can grow up to 370 kg and 4.3 m). The effects on juveniles is important as Atlantic Sturgeon may travel up the Shubenacadie River to spawn thus exposing the juveniles to conditions near the project site.

3.4 Identified Uncertainties and Data Gaps

Major Ion Composition of Brine

The major ion composition of the brine and brine-estuary water mixtures are not apparently known. According to several reports in the provided information, the salt deposits are almost entirely sodium chloride, but analytical data reports of the concentrations of other major ions were not available in the literature reviewed. This is important because although dissolved solids in ocean water are largely sodium chloride, ocean water also includes significant concentrations of other biologically active ions, notably potassium, magnesium, calcium, and sulfate. Aquatic species may, therefore, be impacted by changes in salinity and also by changes in the ionic composition of salinity. We believe this to be a minor datagap. The brine will be diluted by an order of magnitude or more in the mixing channel, so it is unlikely that ionic differences between brine and Estuary water would be biologically meaningful. However, this datagap can be filled easily; the chemical analyses are inexpensive and easily done. Therefore, the ion composition for various mixtures of brine and estuary water should be tested with a range of Estuary water salinities that would be taken in for mixing. Ironically, if ion composition is a critical factor in fish effects, the effects of brine might be most extreme during periods of very low salinity in the Estuare adjacent to the Site and resulting relatively low salinity in the brine/river water mixture. In addition, if there is a potential that salt/brine quality varies from cavern to cavern or within the same cavern, this potential datagap can be easily addressed by chemical analyses suggested above.

Determination of Toxicity of Brine-Estuary Mixture to Fish

Along the same lines, the potential toxicity of the brine/estuary misture to ambient biota has not been established. At several points in the record, DFO recommends and the proponent agrees that toxicity information for Striped bass will be produced. However, it has not yet been produced. To be most informative, the bioassays should focus on replicating conditions in the mixing channel; i.e., mixing of real brine water with real Estuary water. DFO originally asked for bioassays with all life stages of Striped bass, but most recently asked for bioassays with only smaller life stages, which we believe is appropriate. However, because very small organisms are much less mobile and, because of their size, much quicker to equilibrate with abrupt changes in water quality, potential effects on eggs,larvae, and juveniles are the more important datagaps.

Alteration of the Estuary's Bouquet and Disruption of Anadromous Fish Spawning

The issue of the brine addition affecting homing of anadromous fish is also a data gap. The potential concern here is based on the fairly well established hypothesis that salmon, and maybe other fish, smell the way back to their natal tributary. This potential effect is discussed but not really addressed in the provided information (and given the small numbers of salmon, may not be addressable with any sampling). However, this is considered a minor datagap for two reasons. First, the contribution of brine to the bouquet of smells at the mouth of estuary will likely be negligible since the brine will make up such a tiny proportion of the water at the mouth. Second, the science on the importance of olfaction in anadromous fish homing is unsettled. As with many rivers discharging to the Ocean, the bouquet of smells at the mouth of the Shubenacadie Estuary will vary dramatically from time to time depending on the amount of upstream river flow. Thus, recent analyses suggest that salmon use a combination of homing methods – magnetic fields for migration in the ocean to the mouth of the natal stream and, once in natal estuary, olfaction to determine the natal tributary. If this latter theory is true, potential effects on anadromous fish will be non-existent since the brine discharge cannot effect the earth's magnetic field, and the point where olfaction becomes critically important occurs upstream of the brine discharge.

Potential Effects of Entrainment and Impingement on Ichthyoplankton

The issues of entrainment and impingement of icthyoplankton are data gaps. However, effects of entrainment and impingement for water taken to the caverns is very likely negligible since the volumes of water are also very small. Entrainment of eggs and larvae in the mixing channel could be potentially significant only if both the following are true: 1) a significant number of eggs and larvae are entrained into the mixing channel and 2) the brine-river water mixture is either poorly mixed and/or acutely toxic after mixing in the channel. According to the EA supporting documentation, the mixing channel may entrain about 14% of the eggs and fry, so the potential effects are assumed to be limited even if the brine were toxic. However, this estimate is beset by two antagonistic uncertainties. First, the estimate of 14% of eggs/fry being entrained in the mixing channel pertains to a single ebb flow. However, at lower upstream river discharges, the same group of eggs might pass the site repetitively and, thus, have a potential of being entrained into the mixing channel for each ebb flow. Thus, the estimated 14% chance of being entrained and exposed to brine mixture might significantly underestimate the total potential for entrainment/exposure. Second, the current plan calls for stopping brine discharge during peak spawning times. If this is done, entrainment AND exposure to brine in the mixing channel would be less than 14% of total eggs/fry, albeit only during each ebb flow. As such, to aleviate the datagap associated with point number 1 above, potential entrainment in the mixing channel should be estimated for ichthyoplankton which accounts for the potential repetitive entrainment during repeated ebb flows. The datagap for point number 2 can be addressed with chemical analyses of the brine-estuary mixture and/or fish toxicity studies recommended above.

Understanding Critical Factors Causing Success or Failure of Striped Bass Recruitment

The exact factors causing success or failure of Striped bass recruitment is potentially a significant data gap. Despite intensive sampling over now several years, the critical factors affecting Striped bass recruitment are not fully understood. The now fairly extensive information suggests that total egg released and fertilized may be affected by the weather. Near-term survival of the fertilized eggs and of early larvae is probably largely dependent on subseqent rainfall and runoff. Heavy rains/high runoff soon after spawning presumably carries the fertilized eggs and larvae out of the estuary, where temperatures, salinities, and prey densities are suboptimal. Assuming that fertilized eggs and larvae are not prematurely flushed out of the Estuary, subsequent survival and growth for juvenile bass is presumably a function of prey densities. The densities and distribution of the critical first prey, copepods and then major prey of large fry, mysids, are also a not-well understood combination of dependent of rivers flows and water temperature. Hence, very successful bass recruitment may depend on the simultaneous occurrence of several unrelated weather events, which means that recruitment success is both very sporadic and currently difficult to predict.

The naturally precarious nature of Striped bass recruitment has antagonistic effects on the effectiveness of the long-term monitoring program. Notably, meager recruitment during brining operations is not strong evidence of impacts since recruitment is often poor for other reasons. Without understanding why recruitment failed, it would be difficult to requre significant changes to the project or even what those changes should be.

Unfortunately, this datagap cannot be filled easily. Despite almost 7 years of detailed sampling, the scientists still do not fully understand factors controlling recruitment. Nonetheless, filling other datagaps and results of during-project monitoring will reduce the uncertainty associated with this data gap. Thus, for example, a better understanding of brine ionic composition, its potential toxicity, and success of mixing of brine/estuary water in the mixing channel could help dismiss brine discharges as a signficant cause of bass mortality. Similarly, the ichthyoplankton will be monitored at several locations during projecte operation, and these data can also be useful in determining whether the project could cause significant effects.

Definition and Determination of Peak Spawning Events During Which Brine Discharge Will Be Curtailed

The current sampling plan suggests that brine discharge will be discontinued during "peak spawning events". However, it is unclear how "peak spawning events" will be defined and determined effectively. Based on extensive sampling already conducted, it is likely that "peak" will be defined as some threshold of eggs and planktonic larvae per volume of Shubenacadie River water at the Site or flow across the Site per time. The specific values should be provided. A second datagap that should be filled is how this will be effectively determined. The following factors suggest that a major spawning event might be well underway, along with ongoing brine discharge, before it was noticed with the sampling plan. Thus, spawning events can be short-lived, there may be several days interval between samples (planned samples are every 4 to 5 times per week), and there appears to be some lag between sampling and analysis of eggs. This is probably not a major data gap because major spawning activity by adult fish is apparently obvious, at least during the daytime, and somewhat predictable by water temperature and date. Given this, samples might be taken more often, and with fewer consecutive days without samples, during periods of observed or likley spawning. With appropriate labor, the lag time from sampling to analysis and results can be set to some minimum (e.g., next day or sooner after sampling) to minimize the lag between sample and results.

Impacts on Atlantic Salmon and Atlantic Sturgeon Are Uncertain

Given their small, precarious populations, potential impacts on both Atlantic salmon and Atlantic sturgeon will be both difficult to measure and have a very low tolerance. Even impacts on a small numbers of individuals may be too much, although they will be very difficult to discern. As described several places in the reviewed information, Project-related impacts on these two species are quite unlikely because of their life histories and the negligible effects of the project on physio-chemical environment of the Estuary. Nonetheless, a condition imposed for this project was that there be baseline monitoring of eggs and larvae of these two species.

Although monitoring specifically for salmon and sturgeon was not apparently done, a very considerable amount of monitoring of fish eggs and fry in the Estuary was conducted since 2007. At least some of these analyses looked for salmon and sturgeon. Thus, for his Masters thesis, Reesor took over 554 plankton net tow samples between 13 May to 6 November 2008 and 5 May to 28 October 2009. Neither Atlantic salmon nor Atlantic sturgeon were caught during this rather intensive study. These negative results support the conclusion that sensitive eggs and larvae of these two species will not occur in the area affected by the project. There also is some sampling planned to determine whether salmon smolts enter the mixing channel, but CRA could not find any information at all on past or planned sampling for Atlantic Sturgeon.

The Potential for Sediment Fouling of Rock Berm/Diffuser is Unknown

The current plan is to discharge the brine to a diffuser pipe buried below a coarse rock berm in the middle of the mixing channel. The combination of the diffuser and flow through the coarse rock berm are estimated to dilute the brine by more than an order of magnitude prior to the brine reaching the water column. An airline will also installed in the berm to add additional mixing if monitoring shows insufficient mixing of brine or "to help flush out sediment." In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel's water column. The potential for this to happen is unknown. However, this data gap can potentially be reduced with some sort of modeling prior to construction and ongoing monitoring after construction.

Section 4.0 Conclusions and Recommendations

In accordance with CRA's scope of work, the literature provided by KMKNO pertaining to the proposed Alton Project was reviewed as well as available information on similar development projects. Based on CRA's review, the EA registration document was completed in general accordance with NSDEL requirements. A critical part of the approval process was the requirement for a baseline study of the eggs and larvae of the three native species of concern, Atlantic salmon, Atlantic sturgeon, and striped bass. Because striped bass eggs and larvae occur at and near the Site and are most likely to be impacted, these baseline studies focused on eggs/larvae. Subsequent fish stock studies completed for the Shubenacadie Estuary and River provided additional information on the ecosystem to meet DFO requirements. These additional studies were generally completed using defensible scientific methods, and the data obtained used to develop mitigation strategies to minimize potential effects to the environment. However, the paucity of similar salt cavern development projects with brine discharges to estuaries limited the comparative environmental impact evaluation among similar operations.

Although the Project EA and subsequent studies have provided substantial information on the status of selected fish stocks and fish habitat within the Shubenacdie River and Estuary, CRA has identified several potential data gaps specific to the monitoring and evaluation of effects of the project on fish and fish habitat. These potential data gaps and associated recommended additional studies include the following:

- The major ion composition of the brine and brine-estuary water mixture is not known. Recommend collecting undiluted brine water as well as the brine water diluted with estuary water under various saline conditions to characterize the ionic composition of water potentially being discharge to the Estuary.
- The potential toxicity of the brine to ambient biota has not been characterized even though this was a specific comment from DFO as part of the EA review process. Recommend completing bioassays of Striped bass eggs and larvae using diluted brine water (diluted using Estuary water) under various saline conditions to characterize potential toxic effects to fish at early life stages.
- The EA supporting document estimated 14% of Striped bass eggs and fry passing the Site would be entrained in the intake channel. This estimate of entrainment is based primarily on water flows during a single ebb/flow. It does not take into account the potential for eggs and larvae to repetitively pass into the channel during ebb flow conditions resulting in an underestimate of potential entrainment and exposure of eggs and fry to the diluted brine discharge. Recommend that the planned monitoring of eggs and fry entrainment in the channel be conducted to validate the EA predictions using ichthyoplankton which will account for potential for repetitive entrainment.

- The recruitment of Striped bass within the Shubenacadie River and Estuary are not well understood and current factors causing success or failure of this fish species present limitations in its use as an indicator species for assessing potential effects related to the Project. Recommend that the proposed monitoring plan clearly define "peak spawning events" for discontinuing brine discharge and include a contingency to reduce lag times between sampling and analysis of eggs in the river. In addition, the plan needs to detail how natural variances in Striped bass recruitment in the river will be monitored and correlated to evaluate potential negative recruitment effects related to Project activities.
- In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the mixing channel berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel's water column. The potential for this to happen is unknown. Recommend that modeling prior to construction and ongoing monitoring after construction occur to confirm the issue is not creating unacceptable impacts.

Section 5.0 Study Limitations

CRA was provided data from KMKNO for this review that has been relied upon for the conclusions reached in this report. CRA also used publically available information as referenced in the report that has been relied upon. This report is intended solely for the Client(s) named. The material in it reflects our best judgement in light of the information available to CRA at the time of preparation. No portion of this report should be used as a separate entity, as it is written to be read in its entirety. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties.

Section 6.0 References

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