City of Rochester, New Hampshire

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June 17, 2022

Via Overnight Delivery and Electronic Mail

Ms. Robin Johnson
U.S. Environmental Protection Agency – Region 1
5 Post Office Square, Suite 100 (06-1)
Boston, MA 02109-3912
Email: Johnson.Robin@epa.gov

Re: Renewal of Rochester Wastewater Treatment Facility
NPDES Permit No. NH0100668
Rochester, New Hampshire

Dear Ms. Johnson:

The City of Rochester hereby submits its comments to the above-referenced Draft NPDES permit renewal. We appreciate the extension of time granted to the City to do so. Enclosed herein are the collective comments of City representatives and their consultants and legal counsel, all of which is incorporated and should be considered part of the Administrative Record.

Rochester is deeply committed to protecting the water quality of the Cocheco River and the Great Bay watershed. As you know, we are currently implementing several million dollars worth of improvements and additions to our Wastewater Treatment Facility (WWTF) to improve the efficiency of the facility and to reduce nitrogen in the WWTF effluent. We are an active member of the Municipal Alliance for Adaptive Management (MAAM) and are funding studies to better understand the interplay of nitrogen and other factors that may impact the health of eelgrass in the Great Bay estuary.

Our enclosed comments offer greater detail of the technical and legal concerns that we have with the proposed draft permit. Due to the significance of several of those concerns, I would like to highlight a few of them here as well.

First and most importantly, we do not agree that a 0.12 mg/L limit on total phosphorus (TP) is necessary or appropriate. It is an extremely low limit that will be difficult to achieve without spending millions of dollars to do so. And, most importantly, it is not warranted because the non-tidal portion of the Cocheco River is not currently, nor has it been historically, nutrient impaired. Our consultants Brown & Caldwell have undertaken extensive and detailed studies of the health of the freshwater Cocheco River both above and below our WWTF discharge. Their scientific conclusion based on those studies is that there is no evidence of nutrient impairment and, in fact, the water quality below the WWTF discharge is very similar to the water quality *above* our WWTF discharge.

The current estimate of the cost to upgrade our WWTF to treat TP to the very low threshold that EPA proposes is approximately $18.3 million in today's dollars. By the time the plant upgrade is designed and constructed, especially in our current economic environment, it will likely be in the mid-$20 millions to complete. This extraordinary expense imposed on the citizens of Rochester – on top of the financial commitments the City has already made for Nitrogen reductions at its WWTF and stormwater projects - will cause dramatic increases in the water and sewer rates. For many residents this will be a significant burden, as they are already struggling with the inflationary prices of commodities such as food, gasoline and electricity.

Attachment 3 to our comments is a Financial Capability Assessment for Rochester, which indicates that for the Lowest Quintile Residential (LQI) population, coupled with the Poverty Indicator (PI), the impact rating score was a "medium" burden. This would suggest that, at the very least, if a TP limit is imposed on the City that will require an expensive upgrade to the WWTF, we be given an extended schedule to complete the work. We are seeking a twelve-year schedule from the time the permit is effective *if* an expensive upgrade is required.

However, we are seeking an alternative approach to an immediate imposition of this very low TP effluent limit. In the Brown & Caldwell comments (Attachment 1 to our comments), we are proposing to undertake a full-scale demonstration testing at our WWTF of Neo WaterFX$_{300}$ (formerly known as RE300), together with a vigorous study to derive a site-specific phosphorus target in accordance with New Hampshire's revised rules. The details of this proposal are set forth in Brown & Caldwell's comments.

We also wish to highlight the City's concern about the *significant* additional planning, monitoring and reporting requirements included in the draft permit. Collectively, these requirements impose a burden that cannot be met with our current staff, and many of them are unreasonable and unnecessary. The City is already struggling to fill two open positions out of a total of eight WWTF staff. There is a current industry-wide lack of trained recruits and it poses considerable recruiting and hiring challenges. Because of these challenges to staffing, we ask that you seriously pare back the extensive planning, monitoring and reporting obligations contained in the permit to make it more workable for our staff to comply with.

On a related note, the City would like to suggest that EPA and NHDES consider re-instituting the operator training programs that were nation-wide in the early 1980's. The Operator Training Program began in 1982 to provide technical assistance to small wastewater treatment plants that were experiencing difficulties in meeting their discharge permits. Benefits to systems receiving CWA §104(g)(l) assistance included improved compliance, cost savings for communities, enhanced operator professionalism and improved operations, maintenance, and safety.

These training programs were conducted mainly through state environmental agencies and state training centers in, for example, junior colleges or vocational education institutions. These centers provided primarily entry-level and upgraded training. As state training programs matured, program objectives and resources expanded to emphasize continuing education and technical assistance as well as operator certification. As of February 1985, nearly 44 states had mandatory operator certification programs. The majority of operators were certified and received continuing education training annually. These centers were largely funded by EPA. Today there is considerable monies directed to EPA for various programs from ARPA, BIL and other sources. We strongly urge EPA to use some of these funds to re-create the operator training programs that were so successful in the 1980's.

Thank you for the opportunity to comment on the draft NPDES permit. We hope you give our concerns serious consideration, and we look forward to continued discussions.

Very truly yours,

Blaine Cox

Blaine Cox
Rochester City Manager

cc: Stergios Spanos, NHDES

Public Comments to the
Draft NPDES Permit Renewal for
Rochester's Wastewater Treatment Facility
**(NPDES Permit No. NH0100668)**
June 17, 2022

The City of Rochester, New Hampshire (Rochester), hereby submits its public comments to the draft NPDES Permit Renewal for Rochester's Wastewater Treatment Facility located in Rochester, New Hampshire (NPDES General Permit: NH0100668) ("Draft Permit").
Rochester's public comments consist of the cover letter by City Manager Blaine Cox, the comments set forth herein, as well as all the Attachments 1-4 that are hereby incorporated, particularly the technical comments of Rochester's consultants Brown and Caldwell (Attachment 1).

## 1.0 Background and Issuance of Draft Permit

The City of Rochester, New Hampshire owns and operates a wastewater treatment facility (WWTF) which discharges treated effluent to the Cocheco River. The Cocheco River is within the Great Bay watershed and forms the Piscataqua River at the confluence of the Cocheco and Salmon Falls Rivers. Currently Rochester's WWTF is operating under a NPDES permit that was issued July 23, 1997, which has been administratively continued since its expiration in July 2002, almost twenty years ago.

The continued permit includes the following effluent limitations:

| Parameter | NPDES Permit Limit |
|---|---|
| Carbonaceous biochemical oxygen demand | 6 mg/L summer, 13 mg/L winter |
| Total suspended solids | 6 mg/L summer, 13 mg/L winter |
| Total ammonia as NH3 (ave monthly) | 3.61 mg/L summer, 7.65 mg/L winter |
| pH | 6.5 to 8.0 SU |
| Dissolved oxygen | 7.0 mg/L |
| E-coli | 126/100 mL (geo mean), 406/100 mL (max day) |
| $LC_{50}$ | 100% |
| C-NOEC | ≥69% |

The continued permit includes the following monitoring requirements:

| Effluent Characteristic | Reporting Requirements | | | Monitoring Requirements | |
|---|---|---|---|---|---|
| | Average Monthly | Average Weekly | Maximum Daily | Measurement Frequency | Sample Type |
| Flow | Report | --- | Report | Continuous | Recording |
| Dissolved Copper | Report | --- | Report | 1/Month | Grab |
| Dissolved Lead | Report | --- | Report | 1/Month | Grab |
| Dissolved Zing | Report | --- | Report | 1/Month | Grab |

By comparison, the current Draft Permit includes the following effluent and monitoring requirements:

| Effluent Characteristic | Effluent Limitation | | | Monitoring Requirements[1,2,3] | |
|---|---|---|---|---|---|
| | Average Monthly | Average Weekly | Maximum Daily | Measurement Frequency | Sample Type[4] |
| Rolling Average Effluent Flow[5] | 5.03 MGD[5] | --- | --- | Continuous | Recorder |
| Effluent Flow[5] | Report MGD | --- | Report MGD | Continuous | Recorder |
| $CBOD_5$ (June 1 - October 31) | 6 mg/L<br>252 lb/day | 6 mg/L<br>252 lb/day | 9 mg/L<br>378 lb/day | 2/Week | Composite |
| $CBOD_5$ (November 1 – May 31) | 13 mg/L<br>546 lb/day | 21 mg/L<br>882 lb/day | 23 mg/L<br>965 lb/day | 2/Week | Composite |
| $CBOD_5$ Removal | ≥ 85 % | --- | --- | 1/Month | Calculation |
| TSS (June 1 - October 31) | 6 mg/L<br>252 lb/day | 6 mg/L<br>252 lb/day | 9 mg/L<br>378 lb/day | 2/Week | Composite |
| TSS (November 1 - May 31) | 13 mg/L<br>546 lb/day | 21 mg/L<br>882 lb/day | 23 mg/L<br>965 lb/day | 2/Week | Composite |
| TSS Removal | ≥ 85 % | --- | --- | 1/Month | Calculation |
| pH Range[6] | 6.5 - 8.0 S.U. | | | 1/Day | Grab |
| *Escherichia coli* | 126 /100 mL | --- | 406 /100 mL | 3/Week | Grab |
| Dissolved Oxygen | ≥ 7.0 mg/L | | | Continuous | Recorder |
| Ammonia Nitrogen (May 1 – October 31) | 2.0 mg/L | Report mg/L | 4.31 mg/L | 2/Week | Composite |
| Ammonia Nitrogen (November 1 - April 30) | 6.3 mg/L | Report | 26.3 mg/L | 2/Week | Composite |

| | | | | | |
|---|---|---|---|---|---|
| | | mg/L | | | |
| Total Phosphorus (April 1 – October 31) | 0.12 mg/L Report lb/day | --- | --- | 2/Week | Composite |

| **Effluent Characteristic** | **Effluent Limitation** | | | **Monitoring Requirements**[1,2,3] | |
|---|---|---|---|---|---|
| | **Average Monthly** | **Average Weekly** | **Maximum Daily** | **Measurement Frequency** | **Sample Type**[4] |
| Total Phosphorus (November 1– March 31) | Report mg/L Report lb/day | --- | --- | 2/Month | Composite |
| Perfluorohexanesulfonic acid (PFHxS)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorononanoic acid (PFNA)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorooctanesulfonic acid (PFOS)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorooctanoic acid (PFOA)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| **Whole Effluent Toxicity (WET) Testing**[8,9] | | | | | |
| $LC_{50}$ | --- | --- | ≥ 100 % | 1/Quarter | Composite |
| C-NOEC | --- | --- | ≥ 77 % | 1/Quarter | Composite |
| Hardness | --- | --- | Report mg/L | 1/Quarter | Composite |
| Ammonia Nitrogen | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Aluminum | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Cadmium | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Copper | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Nickel | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Lead | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Zinc | --- | --- | Report mg/L | 1/Quarter | Composite |
| Total Organic Carbon | --- | --- | Report mg/L | 1/Quarter | Composite |

| **Ambient Characteristic[10]** | **Reporting Requirements** | | | **Monitoring Requirements[1,2,3]** | |
|---|---|---|---|---|---|
| | **Average Monthly** | **Average Weekly** | **Maximum Daily** | **Measurement Frequency** | **Sample Type[4]** |
| Hardness | --- | --- | Report mg/L | 1/Quarter | Grab |
| Ammonia Nitrogen | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Aluminum | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Cadmium | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Copper | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Nickel | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Lead | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Zinc | --- | --- | Report mg/L | 1/Quarter | Grab |
| Total Organic Carbon | --- | --- | Report mg/L | 1/Quarter | Grab |
| Dissolved Organic Carbon[11] | --- | --- | Report mg/L | 1/Quarter | Grab |
| pH[12] | --- | --- | Report S.U. | 1/Quarter | Grab |
| Temperature[12] | --- | --- | Report °C | 1/Quarter | Grab |
| Total Phosphorus[13] (April 1 – October 31) | --- | --- | Report mg/L | 1/Month | Grab |

| **Influent Characteristic** | **Reporting Requirements** | | | **Monitoring Requirements[1,2,3]** | |
|---|---|---|---|---|---|
| | **Average Monthly** | **Average Weekly** | **Maximum Daily** | **Measurement Frequency** | **Sample Type[4]** |
| $CBOD_5$ | Report mg/L | --- | --- | 2/Month | Composite |
| TSS | Report mg/L | --- | --- | 2/Month | Composite |
| Perfluorohexanesulfonic acid (PFHxS)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorononanoic acid (PFNA)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorooctanesulfonic acid (PFOS)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |
| Perfluorooctanoic acid (PFOA)[7] | --- | --- | Report ng/L | 1/Quarter | Composite |

| Sludge Characteristic | Reporting Requirements | | | Monitoring Requirements[1,2,3] | |
|---|---|---|---|---|---|
| | **Average Monthly** | **Average Weekly** | **Maximum Daily** | **Measurement Frequency** | **Sample Type[4]** |
| Perfluorohexanesulfonic acid (PFHxS)[14] | --- | --- | Report ng/g | 1/Quarter | Composite[15] |
| Perfluorononanoic acid (PFNA)[14] | --- | --- | Report ng/g | 1/Quarter | Composite[15] |
| Perfluorooctanesulfonic acid (PFOS)[14] | --- | --- | Report ng/g | 1/Quarter | Composite[15] |
| Perfluorooctanoic acid (PFOA)[14] | --- | --- | Report ng/g | 1/Quarter | Composite[15] |

In addition to commenting on this Draft Permit, and to put Rochester's CWA commitments into perspective, the City of Rochester is also complying with the requirements of a recently issued General Nitrogen Permit. On November 24, 2020, EPA Region 1 issued the NPDES Great Bay Total Nitrogen General Permit NHG58A000 (Nitrogen GP) which covers discharges from thirteen wastewater treatment facilities (WWTFs) located in twelve communities that discharge treated wastewater containing nitrogen within the Great Bay watershed. Rochester is one of those communities. The GP provisions include effluent limitations and extensive studying, monitoring and reporting requirements. In order to comply with the effluent limitations in the GP, Rochester has entered into an Administrative Order on Consent with EPA Region 1 effective March 8, 2021 that grants Rochester an interim TN effluent limit until October 31, 2025. During this interim period, Rochester has committed to implement the following projects in order to meet the nitrogen effluent limitation of 198 lbs/day set forth in the Nitrogen GP. Those projects include:

1. Pilot Septage Facility Upgrade – The City has completed and evaluated a pilot septage receiving facility upgrade, which included pilot testing of septage quantities and process response conditions when adding septage at the Headworks Facility. The Pilot evaluated the impacts of the additional carbon source from the septage to the influent of the aeration basin and simultaneous nitrification/denitrification (SND) system. A report was generated and submitted to EPA in September 2021. This report informed the design and implementation of the permanent septage facility upgrade.

2. Permanent Septage Facility Upgrade - The City is designing and will bid and construct the full septage facility upgrade at the Headworks Facility utilizing the results of the pilot and evaluation, originally due by December 31, 2022. Upon completion of the upgrade, the City will evaluate efficacy of the constructed, permanent septage facility upgrade and report results in the Nitrogen Reduction Report. The City will be requesting a formal extension of approximately 1 year for this project deadline to account for federal funding recently awarded for this project.

3. Carbon Storage and Feed Building - The City designed this project to provide a permanently installed building at the WWTF to house four (4) 10,000 gallon storage tanks, feed pumps, piping, controls and appurtenances for supplemental carbon to support the simultaneous nitrification/denitrification (SND) system that the City is currently

operating to reduce effluent total nitrogen. Because the influent biochemical oxygen demand (BOD) to nitrogen ratio is low, there is insufficient carbon (BOD) in the influent to support the SND process. Carbon, in the form of acetic acid, was previously stored in two (2) 5,000 gallon tanks located outside, adjacent to the aeration basins. Upwards of 18,000 gallons of acetic acid is delivered to the WWTF on weekdays. The temporary storage system does not have sufficient capacity for the total volume of acetic acid delivered, nor does the system have a means to precisely meter the acetic acid into the treatment process. And, since the current storage tanks are located outside and open to the elements, the storage system was subject to freezing from mid-October to mid-May. Currently, acetic acid delivered to the WWTF is discharged directly into the aeration tank (anoxic zone), which does not provide for the best use of the product. The City will complete the project by October 31, 2022. The City will then evaluate the efficacy of the carbon storage and feed building project and report results in the Nitrogen Reduction Report.

4. Aeration Automation Project – The City will complete engineering construction, equipment purchases, installation and programming and optimization of the full aeration automation project by October 31, 2022. The project included aeration diffuser replacement project has been completed and a Bioprocess Aeration Control System (BioChem® Technology, Inc.) that was installed. This system uses process-based calculations to combine the control of aeration blowers and control valve actuators to achieve proper levels of DO in each aeration basin zone. Electric valve actuators, in-basin analyzers (ORP, DO, nitrate) and mechanical mixers were required to help maximize benefits. Also, to enhance the denitrification process, an aeration timer has been added to the program to aid in stabilizing anoxic conditions in the anoxic selectors and sidewall zones. Commissioning, start-up and optimization of the full system benefits is closely tied to completion of the Carbon Storage and Feed Building operations. The City will report results of the this project in the Nitrogen Reduction Report.

5. Sewer System Master Plan Study – The City submitted a scope of work to EPA and NHDES in September 2021, but the ongoing work includes a Sewer System Master Plan conducted by Weston & Sampson, including flow metering and modelling efforts, infrastructure evaluation and facility inspections to fully evaluate the sanitary system and identify and reduce sources of inflow and infiltration in the POTW. The City shall report the findings and recommendations of the study in the Nitrogen Reduction Report.

6. Nitrogen Reduction Report – The City shall submit a Nitrogen Reduction Report to EPA and NHDES by October 31, 2024. The Nitrogen Reduction Report shall indicate what actions the City will take to further reduce Nitrogen discharges in order to ensure consistent compliance with the rolling seasonal average effluent limit for Total Nitrogen of 198 lbs/day. Upon submission of the Nitrogen Reduction Report, the City will begin to implement the recommended actions set forth in the Report.

The Draft NPDES Permit Renewal for the City was issued on April 14, 2022. EPA extended the public comment period to June 17, 2021. The below comments are in response to the Draft Permit.

## 2.0 Total Phosphorus

Permit Pages 2-3, Part 1.A.1, Fact Sheet, Pages 5 (Part 2.2), 6 (Part 2.2.1, 2.2.2, 2.2.3), 7 (Part 2.2.4), 8 (Part 2.2.4) – Total Phosphorus (April 1 – October 31) 0.12 mg/L and (November 1 – March 31):

In its Draft Permit, EPA has set an average monthly phosphorus effluent limitation of 0.12 mg/L from April 1 through October 31 annually. As is set forth in more detail in the attached technical comments by the City's consultants, Brown and Caldwell (Attachment 1), Rochester objects to the proposed phosphorus limit for several reasons, not the least of which is that the freshwater Cocheco is not phosphorus-related impaired. EPA's observations of impairment do not demonstrate nutrient impairment of the Cocheco River, and are unrelated to established assessment protocols or are highly subjective statements without basis in established objective or measurable goals. The freshwater Cocheco River is not listed as impaired for nutrients in the State of New Hampshire's 2020-2022 CWA §303(d) list for any non-tidal assessment unit downstream of the Rochester WWTF discharge.

Multiple lines of evidence support the lack of phosphorus impairments. The available water quality and biological data support a positive interpretation of the Cocheco River's health and ability to assimilate nutrients. Much of this evidence was compiled by Brown and Caldwell (2020) which summarized multiple data types from multiple sources both upstream and downstream of the City's outfall. An evaluation of the most recent 10 years of data indicated:

1. Favorable dissolved oxygen concentrations;
2. No pH impacts;
3. Low chlorophyll-a;
4. No nutrient-related impacts to benthic macroinvertebrates; and
5. Moderate algal levels consistent with a conceptual model of strong light limitations that allow moderate levels of algal growth and assimilation of phosphorus.

As an initial observation, we note that EPA's 2010 Permit Writer's Manual (Sec. 6.4) provides guidance on assessing the reasonable potential using water quality models. For nutrients, EPA recommends "modeling *that accounts for biological activity or reaction chemistry*." We also note that the EPA's 2010 Permit Writer's Manual (Sec. 6.1) suggests that states adopt seasonal or annual averaging periods for nutrients, as opposed to conditions applied to toxic pollutants.

With respect to biological activity or reaction chemistry, the Cocheco River has specific characteristics that aid in the assimilation of phosphorus. In promoting a one-size-fits-all phosphorus permitting approach, using the Gold Book standard and applying it to a 7Q10 stream flow, EPA has failed to recognize the specific characteristics of the Cocheco River that increase phosphorus assimilative capacity and reduce nutrient impacts. For more than four river miles downstream of the City's outfall, the Cocheco River is relatively narrow and has abundant shading from a riparian corridor that consists of relatively tall and dense tree cover. In addition, the Cocheco River has naturally high levels of dissolved humic substances and TOC that impart a darkened color to the water that further increases the light limitation on algal growth.

According to the Maine Department of Environmental Protection (2021):

Natural environmental conditions [mitigate] the impact of phosphorus enrichment and the risk of those conditions changing. For example, limiting factors can reduce light availability (e.g., shade, turbidity, water color), bind phosphorus (e.g., clay, dissolved organic carbon…[and] can make phosphorus unavailable for plant growth.

The light limitations imposed by the combination of shade and natural color do not prevent algal growth; rather, they limit algal growth rates to moderate levels, such that phosphorus can be assimilated without causing nuisance levels of periphyton. EPA has failed to consider these characteristics when developing the low phosphorus limit in this Draft Permit. Consistent with the EPA's 2010 Permit Writer's Manual and as the State of Maine has recognized, we strongly suggest that EPA should consider these factors that are site-specific to the Cocheco River before imposing a generalized permitting approach to the Rochester WWTF.

EPA's proposed phosphorus limit is based on the 7Q10 streamflow and Gold Book phosphorus target (100 ug/L). While application of this standardized approach simplifies EPA's permitting, it ignores the specific characteristics of the Cocheco River that are discussed above and in more detail in Attachment 1. In taking this simplified approach, EPA is imposing on the blue-collar community of Rochester a near-limits of technology effluent limit, which will cost in excess of $18.3 million to construct, and at least $300,000 annually in operation and maintenance costs. (See Brown and Caldwell Cost Estimates, Attachment 2).

These costs, layered on to what Rochester has already committed to as it seeks to achieve nitrogen reductions in wastewater and stormwater, will be extremely burdensome to the community. The City of Rochester completed a Financial Capability Assessment indicating the costs associated with these upgrades would present a medium burden upon the City's ratepayers, which allows for an extended schedule of compliance of up to 15 years. See City of Rochester Financial Capability Assessment – June 16, 2022, incorporated by reference as Attachment 3.

EPA's simplistic approach will result in an overly stringent TP effluent limit that saddles the City with compliance costs that are higher than necessary and permanent in nature. A more scientifically defensible limit would utilize an appropriate streamflow for nutrients (i.e. an August median streamflow) and a phosphorus target that is informed by the Cocheco River's assimilative capacity.

In lieu of the standardized 7Q10/Gold Book permitting approach, the City requests an opportunity to do a phosphorus treatment full-scale demonstration test of a product called Neo WaterFX$_{300}$ (formerly known as RE300), along with a special condition and schedule to derive a site-specific phosphorus target and final limit.

New Hampshire is currently engaged in a rulemaking process which will fundamentally change the approach it takes to nutrient permitting (Env-Wq 1705). The revised version of the rule is expected to be out for public comment this summer, well within the timeframe for consideration in EPA's permitting process for Rochester. The forthcoming rule will provide an alternative to the 7Q10 streamflow for nutrient permitting and will offer options for deriving waterbody-specific phosphorus targets such as model or data-based evaluations.

Given the imminence of this change of approach for nutrient permitting in New Hampshire, we ask that EPA incorporate that changed approach into the permitting process for Rochester. Rochester is willing to be the test case for application of the new nutrient permitting approach that New Hampshire is seeking to implement. Specifically, the City recommends that the NPDES permit include the following elements in lieu of the proposed phosphorus limit:

1. **A Phosphorus Pilot Project** that will run in parallel with the Special Condition work set forth below. The City has recently completed a bench-scale jar testing to estimate the coagulant dose and costs for reducing effluent total phosphorus discharges using Neo WaterFX$_{300}$ (formerly known as RE300). Neo WaterFX$_{300}$ shows some promise, but it is unclear whether it will work on a full-scale basis at the plant given the plant's unique configuration. Within 6 months of the effective date of the NPDES permit, Rochester will submit a plan to EPA and NHDES for full-scale demonstration testing at its WWTF. Once final and approved by EPA and NHDES, the City would implement this demonstration testing plan (implementation expected to be scheduled for summer 2023).

2. A **Special Condition and Schedule** to derive a site-specific phosphorus target in accordance with New Hampshire's revised rules. Such a condition would include a schedule for the City to (a) develop a monitoring and analysis plan subject to DES and EPA review and approval; (b) perform the monitoring and analysis plan; and (c) interpret the results to propose a site-specific phosphorus target that would maintain or achieve desirable levels of response variables such as DO, chlorophyll-a, pH, and plant/algae growth. The details of this Special Condition: Site Specific Phosphorus Linkage Study are set forth in more detail in Attachment 1.

The Special Condition and Schedule and associated monitoring/study is modeled after the 2020 General Nitrogen Permit that allows communities to operate their WWTFs under an interim limit while undertaking extensive site-specific studies to determine the appropriate nitrogen target for the Great Bay Estuary. In addition, the timing of this work should not appreciably change the schedule that Rochester would be following if it is otherwise required to implement a phosphorus treatment upgrade at its plant.

Given the burden both financially and staffing-wise placed upon Rochester due to all of its Clean Water Act commitments, Rochester is seeking a schedule for implementation of the phosphorus upgrades to commence, if needed, after the completion of the work that the City is currently undertaking pursuant to its February 26, 2021 Administrative Order on Consent with EPA. That Order expires as of October 31, 2025. The City proposes a schedule for compliance in Section 3.0 for implementation of the phosphorus upgrade given the medium impact burden on ratepayers for the upgrade and other factors outlined below.

## 3.0 Schedule for Compliance

In addition to the technical objections and proposed alternative method (including interim effluent limit and special condition) in Section 6 of Attachment 1, and mindful of the City's objections to the exceedingly low proposed phosphorus limit, should a final low Total Phosphorus effluent limit be imposed, the City specifically requests a compliance schedule in order to meet the new, low Total Phosphorus limit within the draft permit. If EPA's new limit is instituted immediately, the City of Rochester cannot comply with this term of the proposed permit which is a new requirement issued after July 1, 1977. This request is therefore consistent with Env-Wq 1701.03(a) which authorizes a compliance schedule to afford a permittee adequate time to comply with one or more permit conditions. The estimated cost of upgrading the facility to meet the proposed Total Phosphorus will cost the City in excess of $18.3 million dollars (not adjusted for current inflation, service and supply chain limits, increasing interest rates and other potential factors escalating costs for an upgrade), plus an estimated $300,000 per year increase in operation and maintenance costs. As set forth above and in Attachment 3, this upgrade will result in a medium burden upon the City's ratepayers. When combined with the medium burden, a lack of available staffing and other regulatory burdens created by this draft permit, a compliance schedule is needed to provide adequate time to comply. This schedule would work in parallel to the alternative approach (including an interim limit) proposed in Section 6 of Attachment 1.

The request for inclusion of a reasonable compliance schedule is consistent with 40 C.F.R. 122.47(a)(1) which provides time for the City to design, bid, seek grants and loan opportunities, fund, procure services and supplies, construct and complete the necessary upgrades. Consistent with 40 C.F.R. 122(a)(3) and Env-Wq 1701.3(b), the City proposes that EPA incorporate the following schedule of compliance for an upgrade of the City's facility to meet the phosphorus limit once the permit becomes effective:

1. Design – In parallel with the proposed special condition and monitoring proposed in Section 6 of Attachment 1, the City will complete a design of the wastewater facility upgrade within 48 months of the effective date of the permit. The City will need an extended period to incorporate the results of the monitoring, but also perform technical review of best available technology and value engineering to determine the best upgrade design for the facility. third-party technical review and value engineering evaluations of any bids. The City will submit the necessary plans to EPA and NHDES for review and comment.

2. Funding – During the Design phase, the City will review potential funding mechanisms, including grants and loans, such as but not limited to Clean Water SRF funding opportunities and Bipartisan Infrastructure Law programs, for plant upgrades to meet the anticipated phosphorus limit, as well as other upgrades necessary for compliance with this permit (including back-up power generation, necessary monitoring equipment upgrades, etc.). Upon completion of the Design, the City anticipates applying for applicable loans and grants within 12 months of the completion of the design.

3. Upon review and approval of the design plans by EPA and NHDES, the City shall submit the plans for public bid and solicitation. Given that the City intends to seek either state or

Federal funding to assist with this project, additional approvals may be anticipated before bidding and award of the project. The City also anticipates, given the potential cost of the upgrades, hiring a third-party for technical review of the bids. The City therefore expects the bidding and procurement to be completed over a twenty-four (24) month period.

4. Upon completion of bidding and award of a contract, the City anticipates (current inflation and anticipated supply chain challenges) a construction schedule of forty-eight (48) months to complete the necessary phosphorus related facility upgrades. The City will provide annual progress reports to EPA during the interim construction phase of the project, consistent with 40 C.F.R. 122.47(a)3)(ii).

5. This extended schedule of compliance will also allow the City to complete construction of its dewatering facility and planned dewatering of its sludge from its lagoons over the next five years. Once the sludge dewatering project is completed, the City expects that it will reduce the amount of phosphorus levels in the WWTF's effluent.

6. Upon substantial completion of construction of the facility upgrades (including additional back-up power), the City anticipates a twelve (12) month period to complete bringing the facility online and monitoring the effectiveness of the facility upgrades.

This schedule of compliance is designed to ensure compliance with the proposed phosphorus limits after the effective date of the permit because the City cannot meet the effluent limits as proposed without an upgrade. Placing the City in immediate non-compliance is inconsistent with the intent of the Clean Water Act and provisions of 40 C.F.R. s. 122.47[1] and Env-Wq 1701.03. The financial burden given current inflation, staffing challenges, supply shortages, limited availability of necessary chemicals for treatment, other regulatory burdens from MS4 and the Nitrogen General Permit obligations, present challenges to the City's ability to increase sewer rates burdened by these costs combined with anticipated pressure to limit sewer rate increases given current inflation. The combined increases caused by the anticipated debt service, increased annual maintenance and chemical costs and other associated maintenance and operational costs associated with any upgrade would place a heavy burden upon the City.

<u>Permit Pg 17, Part 1.G.2 – Ambient Phosphorus Monitoring</u> – The City requests this provision be deleted given the proposed alternative approach offered by the City in the technical comments from Brown & Caldwell incorporated in Attachment 1.

<u>Permit Fact Sheet Pg 6, Part 2.2.3;</u> <u>Pg 7, Part 2.2.4; Pg 8, Part 2.25; Pg 13, Part 3.1.1</u> The City incorporates the technical responses and objections of its consultant, Brown & Caldwell found in Attachment 1. The City requests that NHDES provide a statement to the extent that effluent limits in the Draft Permit can be made less stringent without violating the requirements of Env-Wq 1700, et seq., in light of the proposed change in regulations for nutrient permitting and the

[1] This request for inclusion of a schedule of compliance is also consistent with EPA's guidance entitled, "Compliance Schedules for Water Quality-Based Effluent Limitations in NPDES Permits," dated May 10, 2007. Specifically, while the City objects to the proposed phosphorus limit, if imposed on the City, EPA and NHDES should grant the proposed schedule of compliance given the factors and steps necessary for the City to install and modify treatment at the existing facility to achieve the new, low phosphorus limits proposed in this draft permit.

suggested alternatives provided by the City's consultant, Brown & Caldwell found in Attachment 1.

The City requests that EPA review the technical comments and alternative approach provided by Brown & Caldwell in Attachment 1. Please note that the City may encounter temporarily elevated discharges of legacy total phosphorus during removal of sludge from the lagoons and de-watered once the new biosolids facility is completed. This work is anticipated to be completed over a five-year period. The City offers this point in support of the schedule for compliance proposed above, as the schedule should allow for completion of the sludge removal and dewatering discussed in Section 3.0 (5), above. The City has proposed a pilot chemical treatment process test to evaluate reduction of phosphorus, but also anticipates a reduction in total phosphorus discharges upon completion of the sludge removal and dewatering work.

## 4.0 Rolling Average Effluent Flow

Permit Pg 2, Part I.A.1; Permit Pg 5, Part I.A.1 - Footnote 5:

The City objects to the inclusion of a 5.03MGD rolling average flow limit as unnecessary given the 80% flow notification requirements in Part 1.C.6(f) and Part 1.I.6, which ensure compliance for any prolonged capacity exceedances for the facility. The City also objects to the rolling average effluent flow limit by EPA because EPA is using flow as a surrogate for pollutants and EPA lacks authority to regulate flow as a pollutant. See *Virginia Department of Transportation et al v. United States Environmental Protection Agency et al.*, case number 1:12-cv-00775. In addition, while EPA may utilize flow based upon design flow for its calculation of reasonable potential for phosphorus and other water quality-based effluent limitations, the inclusion of the design flow limit is not necessary to preserve the integrity of the reasonable potential and effluent limitation determinations.[2] The City's effluent flows are limited by other provisions of this permit including the requirements to reduce Infiltration/Inflow and report any exceedances of 80% flow over a three (3) month period which requires reporting and affirmative steps by the City. See Permit Pg 22, Part 1.I.8. Should EPA nevertheless persist in maintaining this condition despite it being unnecessary and potentially unlawful, the City requests that EPA add language to the permit to the effect that: "The facility shall not be subject to non-compliance for individual exceedances of the 5.03MGD limit due to isolated wet weather events."

## 5.0 Staffing

As a general comment on the draft permit and as noted in City Manager Cox' cover letter, the City currently has vacancies in two (2) wastewater positions (out of 8 total positions) and has had difficulty recruiting and retaining staff. The additional obligations of the industrial pretreatment program, when coupled with the mandatory CMOM obligations, increased monitoring resulting from this draft permit and existing ongoing compliance activities related to the City's wastewater collection system will require the City to add approximately six (6) additional full time equivalent positions. Given the regional and nation-wide challenges of recruiting, training and retaining qualified staff, the City includes comments related to various draft permit provisions which will require additional time for development, implementation and enforcement to ensure

[2] See In Re City of Lowell, NPDES Appeal No. 19-03, 2020 WL 3629979 at 37 (June 29, 2020).

compliance with these requirements. The City of Portsmouth recently noted in its public comments in response to the draft NPDES permit for its Pease facility that their staffing is down 25%. The staffing challenges also support the City's request for a compliance schedule as discussed in Section 3.0 above.

Also as discussed in City Manager Cox' cover letter, EPA previously provided funding during the 1970's and 1980's to establish wastewater collection training programs that were housed in local vocational schools, community colleges or universities throughout New England and beyond. Recognizing a lack of adequately trained wastewater operators, the Administration implemented training programs called the "Onsite Technical Assistance Training Program"[3] working in collaboration with the states.

The Clean Water Act specifically provides a mechanism for EPA to make grants to or contract with institutions of higher learning for developing programs to prepare undergraduate students to enter an occupation involving the design, operation and maintenance of treatment works.[4] The federal government actively established and promoted these training programs through the early and mid-1970's; however, by the late 1980's the federal government phased out its role with these programs, transitioning that obligation to the individual state programs. EPA's focus then shifted to supporting the state self-sufficient programs by assisting in developing training materials.

The industry is once again facing shortages of trained personnel to replace the aging workforce in these facilities. Given the recent passage of the American Rescue Plan (ARPA), the Bipartisan Infrastructure Law (BIL), and other federal monies being directed to EPA, the City requests that EPA consider utilizing a portion of those funds to revitalize the Technical Assistance Training Program to support local vocational schools, community colleges or universities to establish EPA-funded training programs on a regional scale that will assist cities and towns throughout Region 1. This will not only promote employment within this sector, but also provide opportunities for well-paying, meaningful careers.

## 6.0 Ammonia

<u>Permit Page 2, Part I.A.1 – Ammonia Nitrogen (May 1 – October 31) 2.0 mg/L and Ammonia Nitrogen (November 1 – April 30) 6.3 mg/L; Permit Fact Sheet Pg 20 – 21, Part 5.1.8; Permit Fact Sheet Page 21, Part 5.1.8:</u>

For the reasons set forth in Brown and Caldwell's technical comments (Attachment 1), the City objects to these lower Ammonia Nitrogen limits. There is no reasonable potential that the existing limits would cause exceedance of acute criteria. The existing winter monthly limit of

[3] See 33 U.S.C.A. §1254

[4] See 33 U.S.C.A. §1259(a) – Training grants and contracts – "(a) The Administrator is authorized to make grants to or contracts with institutions of higher education, or combinations of such institutions, to assist them in planning, developing, strengthening, improving, or carrying out programs or projects for the preparation of undergraduate students to enter an occupation which involves the design, operation, and maintenance of treatment works, and other facilities whose purpose is water quality control….".

7.7 mg/L is protective, and the appropriate summer monthly limit should be 2.8 mg/L instead of 2.0 mg/L.

The City also objects to the inclusion of reference to Atlantic salmon in the vicinity of the City's WWTF in the second paragraph on page 21 of the Fact Sheet. There is no fish ladder at the Watson Dam and therefore no way for Atlantic salmon to swim upstream beyond the dam and EPA should not assume that salmonids could be present in the receiving water segment at the WWTF. Finally, the City objects to the expansion of the warm weather season to include May for Ammonia limits and other proposed effluent limits including Phosphorus (expanded to April).

## 7.0 WET Testing

Permit Pg 3, Part I.A.1; Permit Pg 4, Part 1.A.1:

For the reasons set forth in Brown and Caldwell's technical comments attached as Attachment 1, the City objects to the requirement to test effluent quality (hardness, ammonia, metals and TOC) in conjunction with WET testing and requests that it be removed. The City already monitors ammonia routinely and its limit is set to prevent toxicity to aquatic life. Given that there is no reasonable potential for metals toxicity, and the lack of water quality standards for hardness and TOC, this testing would impose significant cost upon the City without a useful purpose. The City also questions EPA's authority to impose this chemical testing in the absence of reasonable potential.

The City also objects to the inclusion of ambient monitoring requirements (hardness, ammonia, metals, TOC, DOC, pH, temperature and total phosphorus). As with the chemical effluent monitoring associated with the WET test, this monitoring imposes a significant cost on the City without a useful purpose. Similarly, the City questions the EPA's authority to impose these monitoring requirements given that there is no reasonable potential for exceedances. While phosphorus monitoring may be beneficial, it should be conducted in accordance with the proposed phosphorus linkage study as discussed in Section 2.0 above.

The City requests that EPA modify the Whole Effluent Toxicity (WET) Testing measurement frequency to once per year given the City's limited historic exceedances during prior WET testing. The nature of the exceedances were related to diluent water toxicity, which is understood to not be considered a WET test violation. As noted above in Section 5.0, a reduction of measurement frequency would enable the City to deploy limited funds and staffing resources more effectively elsewhere in implementing this permit.

## 8.0 General Limitations

Permit Pg 8, Part I.A.2:

The City objects to the inclusion of the following sentence: "The discharge shall not cause a violation of water quality standards for the receiving water." This provision is overly broad and should be removed. It is contrary to the Clean Water Act permit shield afforded to the City for regulated discharges and does not provide fair notice to the City of what it might do to comply.

The provision provides no opportunity for due process in the context of the City's right to know what limits EPA and NHDES believe are warranted, provides no opportunity to comment on the correctness of those limits and no right to appeal any such determination. This also deprives the City of a schedule for compliance to come into compliance with a new or more stringent requirement.

The City notes recent permit changes by EPA Region 3 on March 27, 2019 to remove this language from State of West Virginia Permits. The City also references and incorporates the briefs from ongoing litigation in the 9th Circuit Court of Appeals, *In re: City and County of San Francisco* appealing an EAB decision on NPDES Appeal No. 20-01 (December 1, 2020) disputing this particular issue of generic prohibitions. The permit fact sheet provides no factual basis for this general prohibition, nor does the permit or fact sheet clearly state how the City must operate its facility to ensure which limits the discharges must meet to comply with this general prohibition, despite the specific applicable water quality-based effluent limitations set forth in the permit[5].

## 9.0 PFAS

Permit Pg 3, Part I.A.1; Permit Page 4, Part 1.A.1, Attachment D, Paragraph 18; Permit Pg 15, Part 1.F(4); Permit Fact Sheet Page 36, Part 5.3.3; Permit Fact Sheet Pg 36, Part 5.3.3; Permit Attachment D, Paragraph 18 Perflourohexanesulfonic acid (PFHxS), Perflourononanoic acid (PFNA), Perflourooctanesulfonic acid (PFOS), Perflourooctanoic acid (PFOA):

While the City appreciates the health and environmental concerns that the PFAS chemicals pose, the City objects to inclusion of influent, effluent and sludge monitoring for PFAS chemicals as there is no federal or state wastewater narrative water quality standard. This additional monitoring on a quarterly basis will be unnecessary and overly burdensome. As stated by EPA, the purpose is to gather information; however, the proposed sampling for influent and effluent should be limited to four (4) quarterly grab samples (instead of composite samples) over the first year of the permit rather than quarterly during the entire permit term. This sampling data should be sufficient to provide EPA with background PFAS results, especially in light of similar PFAS sampling obligations and data collection efforts at other WWTFs in the region.

The City objects to the proposed sludge sampling on a quarterly basis for the above-referenced PFAS constituents as unnecessary and overly burdensome because the City landfills its sludge solids at the Turnkey Landfill which serves a municipal landfill function pursuant to 40 CFR §257.2 and §258.2. While the City recognizes the concern with PFAS, there is no federal or state limit (load, concentration, or narrative standard) for PFAS in wastewater or sludge. The City asks that EPA eliminate the required sampling for sludge, given the expense and burden, as well as the lack of available labs to conduct this testing. If EPA requires this testing, the City asks that it be reduced to four (4) quarters, rather than the full permit term to provide EPA and NHDES with sufficient background information on PFAS constituents in sludge, especially when combined with similar recent requirements for other facilities. The City does not utilize land application methods for disposal of its sludge solids.

[5] See In re: City and County of San Francisco, Brief of the Petitioner City and County of San Francisco, 2021 WL 3950988 at 30, C.A. No. 21-70282 (9th Cir., August 25, 2021).

The City also notes that pending legislation, New Hampshire House Bill 1185 is currently awaiting signature by the Governor, having passed both the House and Senate. HB 1185 will provide cities and towns with the option of requiring industrial or commercial facilities or septage haulers to test their discharges to determine PFAS levels. If determined to be above what the wastewater treatment facility deems acceptable, the facility may refuse to accept those discharges. The bill also authorizes cities and towns to fine discharges producing excess levels of PFAS. In light of this bill shifting the burden from the municipalities to the industrial/commercial/septage discharges, the City asks that EPA either remove the PFAS sampling obligation for industrial dischargers or authorize the City to delegate that obligation to dischargers upon the effective date of HB1185. If sampling is required, then the City requests the use of grab samples instead of the composite sampling methods.

## 10.0 pH

Permit Pg 16, Part 1.G.1; Permit Pg 20, Part 1.I.5; Permit Fact Sheet Pg 19, Part 5.1.5:
The City requests a modification of the pH range from 6.0 to 9.0 rather than 6.5 to 8.0 due to the City's nitrification/denitrification process being implemented at the WWTF. Note that this range is within DES's acceptable upper range.

## 11. CBOD/TSS/Bacteria/Dissolved Oxygen

Permit Fact Sheet Pg 17, Part 5.1.2.2 – CBOD Mass Limits. The City objects to the inclusion of the Maximum Daily (Summer, Winter) CBOD limits as legally inconsistent with EPA's regulations which specify either monthly/weekly technology based limits or require monthly and weekly average limits.[6] EPA has included average monthly and weekly limits for both Summer and Winter seasons and therefore the maximum daily limits are unnecessary and inconsistent with EPA regulations and permitting in other regions.

Permit Fact Sheet Pg 18, Part 5.1.3.1 – TSS Concentration Limits. The City objects to inclusion of the Maximum Daily (Summer, Winter) TSS limits as legally inconsistent with EPA's regulations which specify either monthly/weekly technology based limits or require monthly and weekly average limits.[7] EPA has included average monthly and weekly limits for both Summer and Winter seasons and therefore the maximum daily limits are unnecessary and inconsistent with EPA regulations and permitting in other regions.

Permit Fact Sheet Pg 19, Part 5.1.6 – Bacteria. The City requests that EPA modify the sampling location for bacteria collection to after the City's UV disinfection outlet rather than in the receiving water sampling because the treated effluent travels from the UV disinfection outlet along an open-air channel that could pick up additional bacteria either from animals or other sources and is not representative of the treated discharge. Since the City of Rochester utilizes a UV disinfection system which is a zero residual disinfection process, the most representative sample site to measure treatment effectiveness and permit compliance is immediately

[6] 40 CFR §122.45(d)(2)
[7] 40 CFR §122.45(d)(2)

downstream from all entering wastewater streams prior to discharge into the receiving stream. In this case this is in the effluent channel directly after the UV disinfection equipment.

Permit Fact Sheet Pg 20, Part 5.1.7 -Dissolved Oxygen. The City objects to the continued inclusion of the Dissolved Oxygen limit of 7.0 mg/L because as cited by EPA, there has been no exceedances of the DO limitations and DO is not listed as an impairment in the approved 2020/2022 303(d) List for the freshwater Cocheco River. The City requests that it be removed from the permit, similar to the action by EPA to remove the metals limits in this permit.

Permit Pg 5, Part 1.A.1. – Footnote 1 – Sampling Days and Times – The City objects to the requirement in Footnote 1 that effluent samples have to be taken on the same days and same time each month. This restriction is not supported in either the federal or state regulations. Moreover, it is impractical because sampling should occur on different days and different times to ensure that the City is getting representative data. For example, non-domestic users may vary operations, therefore sampling the same day of the month at the same time might miss fully characterizing their contributions. The requirement that samples be representative is all this is necessary (and typical of the vast majority of NPDES permits issued nationwide).

## 12. CMOM/I&I/Alternative Power Source

Permit Pg 9, Part 1.C.1 – CMOM – Staffing – The City requests EPA grant 18 months from the effective date of the permit to implement this requirement for sufficient staffing to recruit, hire, and train necessary and qualified. The City incorporates its comments on staffing set forth in Section 5.0, above.

Permit Pg 9, Part 1.C.2. – CMOM – Preventative Maintenance – The City requests 18 months from the effective date of the permit to develop a preventative maintenance plan to prevent overflows and bypasses caused by malfunctions or failures, for the reasons stated in the City's comments in Section 5.0, above.

Permit Pg 10, Part 1.C.3 – CMOM – Infiltration/Inflow – The City requests additional time to complete the ongoing Sewer System Master Plan, which is an ongoing, existing study and project to be completed by October 31, 2024, consistent with the AOC referenced in Section 1.0 above. The City incorporates its comments on staffing set forth in Section 5.0, above.

Permit Pg 10, Part 1.C.4 – CMOM – Collection System Mapping. The City requests sixty (60) months to develop mapping required in Part 1.C.4(k) related to pipe diameter, date of installation, type of material, distance between manholes, and direction of flow. The City also asks that the language in Part 1.C.4 be amended as follows:

> Within 30 months of the effective date of this permit, the Permittee shall prepare a map of the sewer collection system it owns. The map shall be on a street map of the community, with sufficient detail and at a scale to allow easy interpretation. The collection system information shown on the map shall be based on current conditions *to the extent known and/or discoverable,* and shall be kept up-to-date and available for

review by federal, state, or local agencies. Such map(s) shall include, but not be limited to …

Permit Pg 10-11, Part 1.C.5. – CMOM – Collection System O&M Plan. The City requests an additional one (1) year beyond the effective date of the permit to submit parts 5.a(1-3). The City also requests that deliverables for the O&M Plan 5.b(1-8) be submitted within 24 months of the submission of the 5.a(1-3) deliverables to EPA. The City incorporates its comments on staffing set forth in Section5.0, above.

Permit Pg 11, Part I.C.5.b.(6) - CMOM – Collection System O&M Plan – This paragraph requires a description of "…programs preventing I/I related effluent violations and all unauthorized discharges of wastewater, including overflows and by-passes and the ongoing program to identify and remove sources of I/I." It is generally understood that no program can prevent overflows or bypasses under every conceivable scenario caused by external factors such as extreme precipitation events, and that all overflows must be reported pursuant to the conditions of the permit and the Clean Water Act. The City therefore requests that EPA amend the permit language to modify or remove the word "preventing" and replace it with "minimizing, to the extent practicable."

Permit Pg 12, Part 1.C.6 – CMOM – Annual Reporting Requirement – The City notes that consistent with the reporting requirement in Part 6.f the City must submit a report that includes the 80% flow capacity notification, plan development and additional reporting obligations if the monthly average flow exceeds 80% 5.03MGD for 3 consecutive months. Given this obligation to notify the EPA and State, as set forth above in Section 4.0, the City asks that EPA remove the rolling effluent flow limit.

Permit Pg 12, Part 1.D – Alternative Power Source – The City requests that EPA include this requirement within the City's requested compliance schedule in the permit to allow time to design, procure, permit and implement the additional power source(s) in conjunction with an upgrade to the facility, which may require additional power than does the existing facility. See discussion on same in Section 3.0, above. The City has experienced delays of up to a year or longer to procure generators for other City facilities.

Permit Fact Sheet Pg 38, Part 5.6 – Infiltration/Inflow (I/I) – While the City is working to study the collection system and identify sources of I/I, it objects to inclusion of this requirement within the draft permit as it should be given the autonomy to operate and maintain its facility in an appropriate manner consistent with 40 CFR §122.41(e).

Permit Fact Sheet Pg 39, Part 5.7 – Operation and Maintenance of the Sewer System – The City repeats and incorporates its comments above in both the Permit and Fact Sheet related to the CMOM plan, Staffing, Preventative Maintenance, I/I reduction, and Industrial Pretreatment Program.

**13. Industrial Pre-Treatment**

Permit Pg 9, Part 1.A.9 – The City requests 18 months to implement the industrial pretreatment plan to identify the volume and character of flow from all significant industrial users (SIUs), and re-evaluation on an annual basis going forward. The City incorporates its comments related to staffing in Section 5.0, above.

Permit Pg 12-13, Part 1.E.1 – Industrial Users and Pretreatment Program- Provides only 90 days from the effective date of the Permit for the City to develop and enforce specific local effluent limits and submit a written technical evaluation to EPA analyzing the need to revise local limits. The City requests one year from the effective date of the permit to conduct and submit this evaluation. The City also requests 180 days to revise and submit its Sewer Ordinance after notification by EPA that the Sewer Ordinance must be revised.

Permit Pg 13, Part 1.E.2(a) – The City requests that EPA amend this obligation to make inspection, surveying and monitoring each industrial user on a schedule of every two years, given the current limitations on staffing and available resources available to the City as stated in Section 5.0, above.

Permit Pg 13, Part 1.E.2(a)- – This section requires the City to "Carry out inspection, surveillance, and monitoring procedures…" for all significant industrial users. The word "surveillance" in this context is understood to differ from the inspection and monitoring of these users. However, it is unclear what action is to be undertaken by the City; therefore, the City asks that the permit language be modified to remove the word "surveillance" from the permit.

Permit Pg 14, Part 1.E.5 – The City requests that EPA amend this provision to remove the words "must assure" and substitute the following: The Permittee will, to the maximum extent practicable, ensure that applicable National Categorical Pretreatment Standards are met by all categorical industrial users of the POTW."

Permit Pg 14, Part 1.E.6 – The City notes that EPA requires the City within 180 days of the effective date of the Permit to provide a separate submission to update its pre-treatment program to EPA for approval. While this is noted as a separate obligation, the City believes it should be permitted to submit this at the same time as the local limits analysis in Part 1.E.1 of the Permit. Consistent with comments to Part 1.E.1, the City requests an extension of 1 year to be consistent with Part 1.E.1.

Permit Pg 14, Part 1.E.7 – The City requests, for ease of monitoring, that the EPA change the requirement for collection of composite samples to the collection of grab samples for industrial parameters.

Permit Pg 14, Part 1.E.7 – This section requires that annual sampling be conducted on a list of multiple types of industrial discharges into the POTW, subject to the availability of a multi-lab validated method for wastewater sampling of four (4) specific PFAS compounds. Several of these provisions are addressed as follows:

a. *Manufacturers of Parts with Polytetrafluoroethylene (PTFE) or Teflon type coatings.* It is unclear whether the OSHA Standard Industrial Classification (SIC) Manual guidance explicitly lists industries that may produce PTFE or Teflon coated parts as part of their manufacturing process.

b. *Any Other Known or Expected Sources of PFAS*. It is understood by the scientific community that PFAS represents a family of man-made chemicals that are ubiquitous in the environment, world-wide. The EPA online document titled Understanding PFAS in the Environment, which may be found at https://www.epa.gov/sciencematters/understanding-pfas-environment, notes that "PFAS are found in everyday items such as food packaging and non-stick, stain repellent, and waterproof products, including clothes and other products used by outdoor enthusiasts. PFAS are also widely used in industrial applications and for firefighting. PFAS can enter the environment through production or waste streams and are very persistent in the environment and the human body." Based on this understanding, it is unclear how known or expected sources of PFAS would be identified.

The City therefore requests that EPA modify or remove these two (2) categories of industrial discharges from the list in this part required for annual sampling.

<u>Permit Fact Sheet Pg 37, Part 5.4 – Industrial Pretreatment Program.</u> The City repeats and incorporates its objections above related to this section and the industrial pretreatment program, including its staffing comments in Section 5.0.

**14. SSO Notification**

<u>Permit Pg 20, Part 1.I.4.0</u> – The City requests that NHDES identify any and all public and privately owned water systems 20 miles downstream of the City's WWTF to allow for a complete list of waste systems in the event of a required notification for a bypass or upset. In addition, this notice requirement is overly broad. The City requests that the provision should be replaced with the following:

> "The Permittee shall notify the downstream community water systems identified by NHDES of any emergency condition, plant upset or bypass, or permit noncompliance that could potentially adversely affect their ability to adequately treat drinking water. The Permittee may consult with such community water systems for the purpose of developing written agreements as to the type of events/releases by the Permittee that they want notice of. Any such agreement shall be provided to EPA and NHDES."

<u>Permit Pg 9, Part 1.B.2</u> – The City requests 18 months from the effective date of the permit to develop and implement the required website notification within 24 hours of unauthorized discharge (except SSOs that don't impact surface waters) on the City's website. This request is due to limited availability of staff as stated in the City's Comment in Section 5.0 above.

**15. Corrections and Clarifications**

<u>Permit Pg 1 - Change Street Address –</u> The City requests EPA change the street address listed in the draft permit for the facility to 245 Pickering Road, Rochester, NH 03867 (not 175 Pickering Road, Rochester, NH 03839). This change should also be made at the Permit Fact Sheet, Pg 1, and on the page after Appendix B, B-3.

Permit Pg 1 – Change Mailing Address – The City requests EPA change the mailing address listed in the draft permit for the facility to 31 Wakefield Street, Rochester, NH 03867 (not 45 Old Dover Road, Rochester, NH 03867). This change should also be made at the Permit Fact Sheet, Pg 1, and on the page after Appendix B, B-3.

Permit Fact Sheet Pg 1 – The City requests EPA to change mailing address to 31 Wakefield Street, Rochester, NH 03867, and change Facility address to 245 Pickering Road.

Permit Fact Sheet Pg 12, Part 3.1 – Location – Figure 2 referenced in the Fact Sheet is incorrect and needs to be updated. The City incorporates a new, modified Figure 2 attached as Attachment 3. The City also requests that EPA amend the latitude and longitude of the outfall which should be 43°15'50" N, 70°58'11" W, which is incorrectly stated in the Fact Sheet.

Permit Fact Sheet Pg 13, Part 4.1 – The first paragraph, second sentence EPA should remove the reference to "Mill Pond Dam" and substitute it with "Gonic Sawmill Dam." EPA should change the reference location of the Isinglass River in this paragraph to "Rochester, NH" instead of "Pickering, NH."

Permit Fact Sheet Pg 14, Part 4.1 – The City notes that in Part 4.1, second paragraph and Table 1 that the 2020/2022 303(d) List is now approved and should be referenced here. The City also notes that only pH and iron are listed in the 2020/2022 303(d) List for this segment of the Cocheco River. The segment immediately downstream from the receiving water segment is AU NHRIV600030608-03. EPA also includes a fragmented sentence which does not make any sense and omits information related to EPA's analysis/conclusion of this water segment, "EPA notes that the segment immediately downstream from receiving water segment, AU NHIMP600030608-02 (Watson Waldron Dam)," EPA should re-issue and clarify this point, and provide the City with an opportunity to respond to this sentence.

Permit Fact Sheet Pg 35, Part 5.2.2 – Total Phosphorus – Site Specific Analysis – The City requests that EPA amend the Permit and Fact sheet to remove references to the "Town of Rochester" and substitute the "City of Rochester".

Permit Fact Sheet, Pg 45 – Figure 2. The City requests that EPA amend Figure 2 attached as Attachment 3, as stated in the comments above from page 12 in Part 3.1 of the Fact Sheet.

# ATTACHMENT 1

## Technical Comments on EPA Draft NPDES Permit and Fact Sheet for City of Rochester WWTP (Brown & Caldwell)

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# Technical Memorandum

Prepared for: City of Rochester, NH on behalf of Rath Young Pignatelli, PC

**Technical Memorandum** [**No. 1**]

Subject: Technical Comments on EPA Draft NPDES Permit and Fact Sheet for City of Rochester WWTP

Date: June 17, 2022

To: Ms. Sherry Burnett Young, *Attorney-At-Law; Rath Young Pignatelli, PC*

From: Clifton Bell, Dan Hammond, Mark Allenwood

Copy to: Mr. James Steinkrauss, *Of Counsel; Rath Young Pignatelli, PC*

Mr. Dave Green, *City of Rochester, NH*

# Section 1: Introduction

In coordination with the City of Rochester, NH (City) and Rath Young Pignatelli, PC, Brown and Caldwell (BC) has prepared technical comments on the Draft National Pollutant Discharge Elimination System (NPDES) permit and accompanying Fact Sheet for the Rochester Wastewater Treatment Facility issued by the Environmental Protection Agency (EPA). These comments are respectfully submitted for EPA's consideration prior to issuance of the final NPDES permit for the Rochester Wastewater Treatment Facility.

# Section 2: Proposed Phosphorus Limit (Permit pp 2-3)

The City objects to the proposed phosphorus limit on multiple technical bases, and seeks an alternative approach to controlling phosphorus that more directly considers the characteristics and assimilative capacity of the Cocheco River. We believe that EPA has mischaracterized the nutrient-related status of the Cocheco River, which has distinctive characteristics that allow it to assimilate certain levels of phosphorus inputs without impairment. Moreover, USEPA's nutrient permitting method is overly simplistic and cannot consider the site-specific characteristics of the receiving water. The proposed limit is overly stringent and would incur high costs for no additional environmental benefit over more moderate limits. The City proposes an alternative, cooperative approach to identify defensible levels of phosphorus control for the Cocheco River, in accordance with New Hampshire's forthcoming rules for permitting-related standards (Env-Wq 1705). More detailed comments on the City's perspective and proposed path forward are provided below. Some of the comments reference extensive monitoring performed by the City, and reports on those monitoring studies are attached as exhibits:

- Exhibit A – Visual Algal Survey of the Cocheco River (Brown and Caldwell, 2016)
- Exhibit B – 2016 Field Investigations of the Cocheco River and Regional Waters (Brown and Caldwell, 2017)
- Exhibit C – 2017 Field Investigations of the Cocheco River and Downstream Waters (Brown and Caldwell, 2018)
- Exhibit D – Non-Tidal Cocheco River Data Matrix (Brown and Caldwell, 2020)

1. *The City disagrees with EPA's claims of phosphorus-related impairments in the Cocheco River*. In the draft permit fact sheet, EPA makes various claims of phosphorus-related effects or impairments of the Cocheco River. The City believes that EPA observations do not demonstrate nutrient impairments. Rather, they are unrelated to established assessment protocols or are highly subjective statements without basis in any objective or measurable goal. In fact, the freshwater Cocheco River is not listed as impaired for nutrients in any non-tidal assessment unit downstream of the Rochester discharge. The following comments address specific EPA observations/claims:
    a. Claim: "The level of instream phosphorus dropped" (Draft Fact Sheet p. 27). Response: Phosphorus settling/uptake is expected in stream systems. Phosphorus reduction is not a response variable that indicates impairment, and by itself has no significance for designated use attainment. As discussed in comment 5, the Cocheco River has specific characteristics that allow phosphorus assimilation without causing nuisance algal conditions.
    b. Claim: "Elevated levels of macrophytes"; "emergent and submergent aquatic vegetation…aquatic bryophytes". (Draft Fact Sheet p. 26) Response: EPA uses terms such as "elevated" aquatic macrophyte conditions, but does not link the conditions to non-attainment of designated uses, quantify what level of aquatic macrophyte abundance would indicate

designated uses have been attained, or demonstrate a useful relationship between external nutrient loads and macrophyte abundance. Most of these plants are native plants growing in normal densities and do not represent nuisance growths. EPA has no basis for citing these plants as impairments.

NHDES also cites the Cocheco River as having high densities of variable milfoil. This rooted aquatic plant is not native to New Hampshire but has become established in many water bodies throughout the state (NHDES, 2019a). A literature review (Brown and Caldwell, 2017; Exhibit B) revealed that rooted macrophytes obtain nutrients from the sediment and can practice luxury nutrient consumption. As a result, rooted macrophytes are usually limited by space/light rather than by nutrient concentrations, and can proliferate even in oligotrophic water bodies. In fact, most of the water bodies with abundant milfoil in New Hampshire are lakes with relatively low nutrient concentrations. There is essentially no record of controlling rooted macrophytes such as milfoil by external nutrient load reductions. Potential control strategies cited by NHDES (2019b) include hand-pulling, diver-assisted suction harvesting, benthic barrier placement, and herbicide treatment. The lack of practical nutrient control options for invasive rooted macrophytes is also emphasized by the fact that submergent and emergent vegetation is also abundant upstream of the Rochester WWTP outfall, despite much lower phosphorus concentrations (Brown and Caldwell 2018, 2020, Exhibits C and D).

c. Claim: “Elevated levels of algal growth” “algal mats less than 1 mm thick”. (Draft Fact Sheet p. 26-27) Response: The City believes that these EPA statements regarding elevated algal levels are arbitrary and without merit. They are not based in any regulatory standard, non-regulatory guideline, or recreational threshold. In fact, the visual periphyton scores were in the range of ~1—2 on a scale that runs from 0 to 4, indicating moderate productivity (Brown and Caldwell, 2018, 2020; Exhibits C and D). There was no apparent relation between visual periphyton scores and up-stream/downstream position relative to the Rochester WWTF or to total phosphorus concentration. Extensive monitoring reveals that benthic algae were not observed to reach nuisance levels in the Cocheco River (Exhibits A, B, C, and D), and EPA has no basis for claims such as algal mats “greater than 1 mm thick” represent impairments. The algal conditions were consistent with a conceptual model of strong light limitations that allow moderate levels of algal growth and assimilation of phosphorus.

d. Claim: “Dissolved oxygen levels.” (Draft Fact Sheet p. 28) Response: EPA presents DO data from more than four miles downstream of the City’s discharge point as evidence of the need for further reductions in TP concentrations in the draft NPDES permit. EPA references three individual DO observations ranging from 104 to 117 percent saturation in August of 2017 from the Watson Road dam downstream to the Dover Dam. These measurements were taken in the late morning and early afternoon hours when photosynthetic activity typically results in higher saturation levels. While these measurements are an indication that photosynthetic activity was taking place, they do not indicate non-attainment of any designated use.

Additionally, EPA presents DO concentration data from within the Watson Dam impoundment measured on six days in August 2019. EPA claims DO measurements below 5 mg/L taken from below 2 meters in depth are evidence of the reasonable potential for the City’s discharge to cause or contribute to cultural eutrophication and must be treated to remove phosphorus. However, DO measurements taken from depth are typically lower than surface measurements and for this reason are not used in use assessments (NHDES 2022). In impoundments such as the Watson Dam, NHDES requires DO measurements from the epilimnion (if stratified) and from the upper 25 percent of depth (if not stratified) (NHDES 2022). This does not appear to be the case for the measurements presented by EPA. DO measurements below 5 mg/L at depth are not indicative of cultural eutrophication, but rather indicative of natural processes in lakes and impoundments that result in increased oxygen demand compared to surface waters. Therefore, EPA's assessment of DO non-attainment is not relevant to the discussion of the need for a reduced TP concentration limit in the City's NPDES permit.

e. Claim: "Pervasive" or "elevated" duckweed (Draft Fact Sheet p. 26-29), Response: We placed floating plants last in this sub-comment list because we believe it merits the most consideration both with regard to interpretation of NH's narrative nutrient standard and exploration of potential phosphorus linkages. The City's own monitoring studies have confirmed the presence of duckweed in limited locations and times in the Cocheco River (Brown and Caldwell, 2016; attached as Exhibit A). However, the visible occurrence of this native plant does not necessarily indicate an impairment of designed uses, and the phosphorus limit proposed by EPA lacks any quantitative or even semi-quantitative link to a reasonable goal for floating plant coverage in the Cocheco River. The City proposes to explore such linkages through the special permit condition discussed in comment 6. In the meantime, EPA's assertions of "pervasive" duckweed growth as a basis for the proposed phosphorus limits are not supported, for the following reasons:

   i. *The floating plant biomass is not "pervasive" in space nor in time*: An initial review of 15 historical aerial/satellite images from 1998 to 2022, we found that:

      - 10 images showed negligible floating plant coverage on the Cocheco River between the outfall and Dover.
      - 4 images showed only small patches of coverage; primarily in the immediate vicinity of dams that retain floating material transported from upstream.
      - Only 1 image (October 2020) showed a higher coverage near dams.

      This simple evaluation is not comprehensive, and there is an opportunity to refine it with a systematic review of more frequent satellite imagery (e.g., Landsat) that might also compare coverage with season, streamflow, phosphorus loading. This is a topic for the special condition recommended in comment 6. In the meantime, the data do not support statements that duckweed coverage is either pervasive or frequent. Small patches of floating vegetation in the immediate vicinity of dams do not represent exceedances of NH's narrative standard.

   ii. *The relation between floating plants and phosphorus loads is currently undefined*. EPA assumes but makes no demonstration that the proposed duckweed will respond to point source phosphorus controls, and that the proposed phosphorus limit is the correct control level. Duckweed is part of the natural flora of New Hampshire water bodies, and is common in lakes, ponds, and other stagnant waters throughout the state (NHDES, 2007). In the non-tidal Cocheco, duckweed appears to be favored by dam backwater effects that create ideal hydraulic conditions for duckweed accumulation. The spatial pattern of duckweed occurrence is consistent with advective transport from upstream segments and accumulation in the most stagnant locations. Under this hydraulic regime, it would not be necessary to have high rates of in situ duckweed growth in order for short segments of visible duckweed to develop under favorable conditions.

An extensive literature review (Brown and Caldwell, 2016; Exhibit A) revealed considerable uncertainty regarding the practicality of controlling duckweed growth with nutrient controls in impoundments. The scientific literature suggests that if temperature, light, and hydraulic conditions are favorable, duckweed can grow even under low nutrient concentrations (Hasan and Chakrabarti, 2009; McCann, 2016). As stated by Leng and others (1995):

> As a generalization, duckweed growth is controlled by temperature and sunlight more than nutrient concentrations in the water. At high temperatures, duckweeds can grow rapidly down to trace levels of P and N nutrients in water.

Other references infer linkages between floating biomass and nutrient concentrations. However, the literature has little in the way of demonstrated, point source-drive reductions in total floating biomass. For example, the Massachusetts Department of Environmental Protection (MDEP) set similar limits on phosphorus for POTWs as that proposed for the Rochester discharge, in part for the purposes of reducing biomass of aquatic macrophytes (MDEP 2004). That TMDL modeling study acknowledges considerable limitations/uncertainties on the practicalities of limiting floating plant biomass with point source controls. Since then, monitoring has revealed significant phosphorus reductions and interannual variations in duckweed on the Assabet River, but total floating plant biomass has actually increased (Field-Juma and Roberts-Lawler, 2021).

We do not raise this issue of uncertainty to negate the possibility of a useful link between phosphorus loads and floating biomass. Rather, we believe there is an opportunity to use the City's long-term data on phosphorus loading in conjunction with image- and field-based estimates of floating plant coverage to explore the linkage and inform the correct level of phosphorus controls. For example, a systematic analysis might reveal the seasonal, streamflow, and phosphorus loading conditions associated with higher levels of floating plant coverage (e.g., October 2020) with other conditions in which coverage is much lower.

iii. *Regulatory action related to floating plants should be based on a measurable and reasonable goal*. Assuming that there is a useful link between phosphorus and floating plant coverage, planning/permitting should be based on a reasonable goal for floating plant coverage. Considering that duckweed is a species that naturally grows in NH waters, it would not be appropriate that the goal be "no duckweed". Similarly, the hydraulic properties of impounded rivers will inevitably allow a certain amount of accumulation of floating vegetation near dams or other obstructions under favorable seasonal and streamflow conditions. As part of a Phosphorus Linkage Study, we recommend a review of related goals set for other rivers, in conjunction with a more detailed evaluation of the spatial extent and frequency of floating plant coverage on the Cocheco. This information can be interpreted to set a measurable goal for floating plant coverage on the Cocheco River, to include both magnitude and frequency components.

2. *Multiple lines of evidence support lack of phosphorus impairments*. Comment 1 above addresses specific EPA claims of nutrient-related impairment in the Cocheco. But beyond those claims, the available water quality and biological data support a positive interpretation of the Cocheco River's health and ability to assimilate nutrients. Much of this evidence was compiled by Brown and Caldwell (2020) (Exhibit D), which summarized multiple data types from multiple sources (e.g.,

NHDES, City of Rochester) both upstream and downstream of the City's outfall. The analysis focused on summer low-flow conditions to increase the likelihood of detecting nutrient impacts, if they were present. An evaluation of the most recent 10 years of data indicated the following:

*Favorable dissolved oxygen concentrations*: Both discrete measurements and DES sonde deployments showed favorable dissolved oxygen concentrations. Only a single grab sample (out of 145 under the selected conditions) has a DO concentration less than the water quality criterion of 5 mg/L, and that value was only slightly lower (4.9 mg/L). NHDES installed data loggers in three assessment units (NHRIV600030607-15, NHIMP600030608-02, and NHRIV600030608-03) over the data period, and none showed 24-hour minimum DO concentrations to fall below 5 mg/L.

*No pH impacts*: Values of pH were moderate on the Cocheco River below the Rochester WWTF under summer low flow conditions. The 90th percentile pH values were 7.5 or lower for all segments. Fewer than 3 percent of observations exceeded the water quality criterion of 8.0 in all segments. These data provide direct evidence that algal/plant growth rates are not high enough to cause pH exceedances on the Cocheco River.

*Low chlorophyll-a*: The 12 chlorophyll-a measurements taken under low-flow summer conditions had a median value of 3 ug/L. None exceeded the value used for assessment in non-tidal river segments (15 ug/L).

*No nutrient-related impacts to benthic macroinvertebrates:* The majority of the B-IBI scores (9 of 12) available for the Cocheco River since 2004 exceeded the relevant B-IBI threshold, indicating attainment of aquatic life uses. This included about 70% (5 of 7) of the scores from upstream of the Rochester WWTF outfall and 80% (4 of 5) of the scores from downstream of the Rochester outfall. Considering all observations, the median B-IBI score upstream of the Rochester WWTF was 61.0, and the median score downstream of the Rochester WWTF was 62.6. This was the case even though phosphorus concentration increased downstream of the outfall. The two lowest B-IBI scores were measured in September 2016 during a special NHDES evaluation of the Cocheco near the Rochester WWTF outfall. The scores upstream of the outfall (at CCH-16) and downstream of the outfall (at CCH-15) were similar, showing that the scores were unlikely to be related to ambient phosphorus levels.

*Moderate algal levels:* Visual periphyton scores were in the range of ~1—2 on a scale that runs from 0 to 4, indicating moderate productivity. As with B-IBI scores, there was no apparent relation between visual periphyton scores and up-stream/downstream position relative to the Rochester WWTF or to total phosphorus concentration. Benthic algae were not observed to reach nuisance levels at the segment. The algal conditions were consistent with a conceptual model of strong light limitations that allow moderate levels of algal growth and assimilation of phosphorus.

3. *The Cocheco River has specific characteristics that aid in the assimilation of phosphorus*. In promoting a simplistic, one-size-fits-all phosphorus permitting approach, EPA has not recognized the specific characteristics of the Cocheco River that increase phosphorus assimilative capacity and reduce nutrient impacts. In the vicinity of the City's outfall and for more than 4 river miles downstream, the river is relatively narrow (~50 ft) and has abundant shading from a riparian corridor that mostly consists of relatively tall and dense tree cover (Figures 1 and 2). Even where nearby land uses are not forest, a forest buffer is maintained. The river widens somewhat at 4-5 river miles below the outfall, but maintains a forested riparian corridor all the way to Dover.

   In addition to high shading from the riparian corridor, the Cocheco River has naturally high levels of dissolved humic substances and TOC (5-10+ mg/L) that impart color to the water and further increase the light limitation on algal/plant growth (Figure 1). For example, color measures at station

CCH-18 ranged from 140 to 210 PCU. To put these values in context, the Maine Department of Environmental Protection (2021) defines “colored” as water having >25 PCU, and states that

> Natural environmental conditions [mitigate] the impact of phosphorus enrichment and the risk of those conditions changing. For example, limiting factors can reduce light availability (e.g., shade, turbidity, water color), bind phosphorus (e.g., clay, dissolved organic carbon…can make phosphorus unavailable for plant growth)…

The light limitations imposed by the combination of shade and natural color do not prevent algal growth in the Cocheco River; rather, they limit algal growth rates to moderate levels, such that phosphorus can be assimilated without causing nuisance levels of periphyton. These segment-specific characteristics should be considered when choosing a phosphorus permitting approach and targets for the Cocheco River.

**Figure 1-Cocheco River near England Road, downstream of the Rochester WWTF. This photo illustrates the tree canopy and high CDOM concentration which impose light limitations and increase assimilative capacity for phosphorus**


**Figure 2 - Landsat image showing the typical forested riparian corridor the of the Cocheco River downstream of the City outfall.**

4. *<u>The appropriate background phosphorus concentration for permitting is 13 ug/L</u>*. EPA calculated a background P concentration of 27 ug/L, using all available data from station CCH-18. This station is actually in a small impoundment on the river and is farther upstream from the Rochester outfall than the river station CCH-16. Phosphorus concentrations in CCH-16 tend to be lower than those at CCH-18, presumably due to additional opportunity of phosphorus uptake in the stream downstream of CCH-18, and higher rates of algal/plant phosphorus uptake in the shallower river environment of CCH-16 than in the impoundment environment of CCH-18.

   Background phosphorus concentrations also tend to be lower during the critical conditions for phosphorus permitting (summer low flow), compared with other conditions. This is because biological phosphorus uptake rates and phosphorus settling is higher under summer low flow conditions, and nonpoint source phosphorus inputs are lower. For this reason, it is important that the data used to calculate the background phosphorus condition reflect the appropriate seasonal and hydrologic condition. When the streamflow is equal to or less than 20.5 cfs (the August median streamflow, a streamflow statistic that DES is recommending for replacement of the 7Q10 for phosphorus permitting), the median phosphorus concentration at station CCH-16 is 12.5 ug/L. We are providing these data and our calculations to EPA for review (Exhibit E). EPA should therefore utilize the appropriate background phosphorus concentration of 13 ug/L.

5. *<u>EPA's phosphorus permitting approach is overly simplistic and conservative</u>*. EPA's proposed phosphorus limit is based on the 7Q10 streamflow and Gold Book phosphorus target (100 ug/L). The primary appeal of this approach appears to be simplicity. The proposed limit is close to the limits of technology and extremely burdensome to the community. Unfortunately, EPA is ignoring the very real possibility that a simplistic permitting approach could result in an overly stringent limit and saddle the community with compliance costs that are higher than necessary and permanent. A

scientifically defensible limit would utilize a more appropriate streamflow for nutrients and a phosphorus target that is informed by the Cocheco River's assimilative capacity.

a. *The 7Q10 value streamflow is technically inappropriate for permitting nutrients.* The 7Q10 streamflow was specifically derived for toxics permitting (USEPA, 1991), and its use for phosphorus represents a failure to adapt the toxics-based procedures to nutrients. The 7Q10 represents an extremely low and rare streamflow condition. Its use is highly conservative even for toxics, but completely inappropriate for nutrients. The implicit concept—that a one-in-ten year exceedance of a 7-day average nutrient concentration would cause impairments—does not reflect the temporal, spatial, and mechanistic aspects of how water bodies respond to nutrient inputs. The 10-year frequency is rarer than the 1-in-3 year exceedance frequency that is allowed even for toxics (USEPA, 1991). Similarly, the 7-day duration is shorter than the time scale at which eutrophication-related problems manifest themselves in streams, which can conservatively be stated as 30 days. Basing nutrient WLAs on very rare hydrologic conditions (7Q10 flows) will result in unnecessarily low WLAs.

   New Hampshire is currently in a rulemaking process to consider revisions to permitting-related standards including those for phosphorus (Env-Wq 1705). We understand that NH is likely to recommend an alternative streamflow statistic (e.g., the August median streamflow) for phosphorus permitting. This rulemaking could be completed this year, well in time to be considered in parallel with the results of the site-specific phosphorus linkage study as discussed in comment 6.

b. *The Gold Book value should be replaced with a site-specific phosphorus limit that considers the Cocheco River's response to nutrient inputs*. The simple use of the Gold Book value as toxics-like threshold for permitting is not scientific. This approach fails to consider water body-specific characteristics and therefore cannot be assumed to be founded in actual cause-effect linkages specified in NH's narrative standard. As stated by USEPA's Science Advisory Board (2010) regarding numeric nutrient targets:

   > For criteria that meet EPA's stated goal of "protecting against environmental degradation by nutrients," the underlying causal models must be correct. Habitat condition is a crucial consideration in this regard (e.g., light, hydrology, grazer abundance, velocity, sediment type)…Numeric nutrient criteria developed and implemented without consideration of site specific conditions can lead to management actions that may have negative social and economic and unintended environmental consequences [emphasis added] without additional environmental protection.

   Moreover, we disagree with application of the Gold Book phosphorus target as a not-to-exceed target. The Gold Book's use of the phrase "…should not exceed…" was referring to spatial (…"at any point…") rather than temporal variability. The Gold Book's *only* reference for the 0.100 mg/L target (Mackenthun, 1973) discussed the value in context of a simple estimate of how much algae could be grown assuming "optimal growth conditions and maximum phosphate utilization". Even this overly simplistic estimate would inherently assume time for the growth to occur, as opposed to an unrealistic "instantaneous" algal response. Hence, the Gold Book value should be interpreted as a monthly or seasonal target rather than one to be applied under rare critical conditions.

   It should also be pointed out that the Gold Book value is not the upper end of in-stream nutrient targets used by states, approved by EPA, or paired with typical summer flows that are significantly higher than the 7Q10 streamflow. Examples of higher nutrient targets come from Minnesota River Eutrophication standards (up to 0.150 mg/L), Boulder Creek, CO (up to 0.170 mg/L), Black River VT (0.26 mg/L), and Ohio's draft phosphorus targets (0.130 – 0.300 mg/L). In some settings, EPA has approved the use of a target similar to the Gold Book value, but applied at typical summer flows rather than a rare low streamflow. Examples include New Jersey's Technical Manual for Phosphorus Evaluations (0.100 applied at 70% exceedance flow, the Malibu Creek TMDL CA (0.100 mg/L applied at summer median flow, and Wisconsin phosphorus criteria (0.100 mg/L as a median growing season value). Hence, a site-specific evaluation for the Cocheco River should consider a wide range of values, and select a goal that considers the river's characteristics and responses. The recommend approach is described in the following comment.

6. *In lieu of the simplistic phosphorus permitting approach, the City requests an interim phosphorus demonstration test and a special condition and schedule to derive a site-specific phosphorus target and final limit, in accordance with NH's forthcoming rules*. As mentioned above, New Hampshire is currently in a rulemaking process to consider revisions to permitting-related standards including those for phosphorus (Env-Wq 1705). The next version of the rule language is expected to be available for comment this summer, well within the timeframe for consideration prior to finalization of the City's NDPES permit. The forthcoming rule language will contain an alternative to the 7Q10 streamflow for phosphorus permitting, and also will include options for deriving water body-specific phosphorus targets such as model or data-based evaluations. Given the imminence of this rulemaking, the City's NPDES permit should allow time for application of the state's new science-based process instead of the simplistic 7Q10/Gold Book-based limit. Specifically, the City recommends that the NPDES permit include the following in lieu of the proposed phosphorus limit:

   a. *Interim phosphorus demonstration test*: The City has recently completed a bench-scale jar testing to estimate the coagulant dose and costs for reducing effluent total phosphorus discharges using Neo WaterFX300 (formerly known as RE300). Neo WaterFX300 shows some promise, but it is unclear whether it will work on a full-scale basis at the plant given the plant's unique configuration. Within 6 months of the effective date of the NPDES permit, Rochester will submit a plan to EPA and NHDES for full-scale demonstration testing at its WWTF. Once final and approved by EPA and NHDES, the City would implement this demonstration testing plan (implementation expected to be scheduled for summer 2023).

   b. *A special condition to derive site-specific phosphorus target in accordance with New Hampshire's forthcoming rules*: We recommend that the permit include a special condition derived site-specific phosphorus concentration or loading target, to be based on the phosphorus concentrations or loads necessary to maintain or achieve desirable levels of response variables such as dissolved oxygen, chlorophyll-a, pH, and plant/algae growth. The special condition would include a schedule for the City to (1) develop a monitoring and analysis plan subject to DES and EPA review/approval; (2) perform the monitoring and analysis plan; and (3) interpret the results to propose a site-specific phosphorus target. Although the details of the monitoring and interpretation would be determined during the first phase, potential elements include:

      i. Water quality monitoring (including sonde deployment) and algae/plant monitoring at locations to be agreed upon between the City, DES, and EPA. Based on preliminary consultation with DES, at least two years of additional monitoring would be required.

      ii. A focused evaluation of floating plant coverage, including compilation of historical aerial satellite images to quantify the extent and frequency of duckweed coverage on the Cocheco River. In parallel, a review of how goals for floating plants have been quantified in prior regulatory situations, used to support the development of a reasonable goal for floating plants in the Cocheco River.

iii. An empirical or model-based analysis to link phosphorus loads or concentrations with response variables and floating plant coverage, considering other environmental factors such as season and streamflow. The outcome of this evaluation would be a phosphorus loading or concentration target that is both protective and representative of the receiving water.

The City and DES have performed various other types of water quality and algal/plant monitoring in recent years, and these data can also be considered in the analysis. The additional monitoring/analysis would be intended to fill any data gaps and consider specific conditions such as floating plant biomass. Following is recommended language for the special condition:

Special Condition: Site Specific Phosphorus Linkage Study

Within 120 days of the effective date of this permit, the Permittee shall submit a Phosphorus Linkage Study Plan to EPA and NHDES. The plan will describe the City's method for deriving a site-specific phosphorus target for the non-tidal Cocheco River below the Rochester WWTP outfall. The plan shall include: (1) water quality monitoring methods, locations, and frequencies; (2) algae/plant monitoring methods, locations, and frequencies; (3) quality assurance and control measures; (4) interpretive methods for linking phosphorus loads or concentrations to key response variables in the river; and (5) methods for identifying response variable targets (e.g., water quality criteria or floating biomass goals). The interpretive methods should include the use of historical monitoring data, such as water quality data from the NHDES and the City. They may also include an evaluation of floating plant historical biomass as interpreted from historical aerial or satellite images, with empirical or model-based linkages to environmental factors such as phosphorus loads/concentrations, season, and streamflow.

The agency review period for the Phosphorus Linkage Study Plan shall be 60 days. The City shall revise and re-resubmit the plan to EPA and DES within 60 days of receipt of those comments. Upon notification of an approved Phosphorus Linkage Study Plan by NHDES, EPA will review any changes and, if acceptable, will submit written notice of approval to the Permittee.

Within 36 months of the effective date of this permit, the Permittee shall complete the monitoring described in the Phosphorus Linkage Study Plan. Within 42 months of the effective date of this permit, the Permittee shall submit to EPA and NHDES a Phosphorus Linkage Study Final Report that includes: (1) results of the monitoring conducted for the study; (2) interpretations of phosphorus linkages to response variables; and (3) a recommended phosphorus target (concentration or load) for the receiving water to be applied under the appropriate seasonal and hydrologic conditions.

7. *The special condition and associated monitoring/study will not significantly affect the timing of phosphorus-related upgrades at the Rochester WWTP*. The WWTP would require a major capital upgrade to meet more stringent phosphorus limits. The present-day estimated cost of this upgrade is $18.3 million, and is likely to be significantly higher when constructed. This is a significant financial burden to the ratepayers of the City. For these reasons, it is estimated the City would require at least 10 years to plan, design, fund, construct, and bring online a new phosphorus removal system. Under the proposed schedule, the results of the Phosphorus Linkage Study would be available in time to inform the final phosphorus target prior to final design and construction of any related update. Hence, the proposed special condition would not significantly delay phosphorus reductions at the Rochester WWTP.

# Section 3: Proposed Ammonia Limits (Permit pp 2)

1. *In the draft permit, EPA proposes lowering the monthly limits for ammonia nitrogen*. The proposed limits are based on a mass balance under 7Q10 streamflow conditions. It would be more technically appropriate to use the 30Q10 streamflow with the chronic ammonia criterion, because that criterion is expressed as a 30-day average. New Hampshire is currently in a rulemaking process to consider revisions to permitting-related standards (Env-Wq 1705) including critical flows. We request that the draft permit utilize a streamflow for chronic ammonia that is consistent with DES' developing regulation.

2. *There is no reasonable potential that the existing limits would cause exceedance of acute criteria*: The table on page B-3 of the factsheet indicates that the existing permit limits have reasonable potential to exceed the acute ammonia criteria. We believe this is an error.

3. *Ammonia limit calculations should consider effluent variability*: The mass balance calculations in Appendix B appear useful for the RPA and for calculating the ammonia wasteload allocations (WLAs). However, it appears that EPA set the average monthly limit equal to the chronic WLA, without considering effluent variability. We request that EPA consider effluent variability in accordance with the *Technical Support Document for Water Quality Based Toxics Controls* (USEPA, 1991). Our own calculations[1] indicate that if this was done:

    - The existing winter monthly limit (7.7 mg/L) is protective.
    - The appropriate summer monthly limit is 2.8 mg/L instead of 2.0 mg/L

   These calculations are provided in Exhibit F.

# Section 4: WET Testing (Permit pp 3)

1. *The requirement to test effluent quality (hardness, ammonia, metals, and TOC) in conjunction with WET testing should be removed*. The City already monitors ammonia routinely and has a limit specifically set to prevent toxicity to aquatic life. USEPA has already determined that the Rochester WWTP has no reasonable potential to exceed toxic thresholds of metals. Given the lack of reasonable potential for metals toxicity, and lack of water quality standards for hardness and TOC, this testing would impose significant testing costs without a useful purpose. We also question USEPA authority to impose this chemical testing in the absence of reasonable potential. Such testing should be reserved for facilities that experience persistent WET test failures, as and part of standardized procedures such as toxicity identification evaluations (TIE) or toxicity reduction evaluations (TRE).

2. *The ambient monitoring requirements should be removed*. The requirement to test ambient water quality (hardness, ammonia, metals, TOC, DOC, pH, temperature, and total phosphorus) in conjunction with WET testing should be removed as a default requirement. As with the chemical

[1] Assumptions: Ammonia coefficient of variation of 2.5, probability basis of 0.95, 8 samples/month, statistics based on achieving chronic criterion as 30-day (not 4-day) average.

effluent monitoring associated with the WET test, this monitoring imposes a significant cost without a useful purpose, and we question USEPA's authority to impose monitoring requirements for constituents without reasonable potential of criteria exceedances. USEPA has already concluded that there is no reasonable potential for the facility to exceed metals criteria. USEPA's aluminum criteria are actually less stringent than New Hampshire's at the typical water quality of the Cocheco River (pH $\approx$ 6.6; hardness $\approx$ 25 mg/L, DOC > 4 mg/L). Hence, there would be no reasonable potential for aluminum exceedances even if NH adopted the USEPA criteria. Phosphorus monitoring may be beneficial, but should be conducted separately in accordance with the QAPP developed for the phosphorus linkage study recommended in these comments.

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# Exhibit A: Visual Algal Survey of the Cocheco River

(Brown and Caldwell, 2016)

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**Technical Memorandum**

Subject: Visual Algal Survey of the Cocheco River

Date: May 31, 2016

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# Executive Summary

This technical memorandum describes a visual algal survey that the City of Rochester, NH (the City) sponsored in August 2015 to characterize attached algae conditions in the non-tidal Cocheco River between Rochester, NH and Dover, NH. The visual algal survey used the viewing bucket survey method of Maine's Department of Environmental Protection (Maine) *Protocols for Sampling Algae in Wadeable Rivers*, *Streams, and Freshwater Wetlands* (MDEP, 2014). The great majority of the surveyed river area had relatively little attached algae, due to a combination of factors such as high depth, riparian shade, and dark water color. At the six locations where it was practical to perform the visual algal survey, the most common bottom conditions were a transparent algal layer, very thin (<1 mm) algal mat, and/or rooted plants. Overall, algal accumulations were relatively low. Of the six stations, four had an overall visual algal score of 1 (out of 5), and two had an overall visual algal score of 2 (out of 5), where a score of 1 represents <10% algal coverage and a score of 5 represents >75% algal coverage. The station upstream of the City of Rochester—where phosphorus concentrations are very low—also had similar algae and macrophyte conditions as downstream stations, suggesting that algal and macrophyte conditions are primarily controlled by non-nutrient factors. Macrophytes are relatively common in the non-tidal Cocheco River and do not impair recreational uses. Regardless, most macrophytes are able to obtain nutrients from sediments, and are not typically responsive to point or nonpoint source nutrient controls (WDNR, 2012).

A small proportion of the river surface experiences relatively dense growths of duckweed, which is part of the natural flora, and is common to relatively stagnant waters in New Hampshire (NH DES, 2007). The duckweed growths occur in relatively short (250-400 ft) segments where dam backwater effects have created ideal hydraulic conditions for duckweed accumulation. Overall, the area of dense duckweed accumulation represented only a small proportion (2-3%) of the river surface between Rochester and Dover. A review of the scientific literature indicates that duckweed growth is primarily controlled by temperature and light, and can maintain typical growth rates even under relatively low nutrient concentrations.

# Section 1: Introduction

This technical memorandum describes a visual algal survey that the City of Rochester, NH sponsored in August 2015 to characterize algal conditions in the non-tidal Cocheco River. The City operates a wastewater treatment facility (WWTF) that discharges to the Cocheco River, approximately 13 river miles upstream of the City of Dover. The river becomes tidal in downtown Dover at the Central Ave. dam. This segment of the Cocheco River is categorized as a Class B water. New Hampshire's water quality standards (Env-Wq 1703.14) includes a narrative nutrient standard that states that "Class B waters shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring." Like all surface waters in New Hampshire, the river's designated uses include aquatic life support and recreation.

New Hampshire's standard procedure for evaluating the potential for nutrient impairment involves the use of chlorophyll-*a* as an indicator of "excessive algal growth" (NHDES, 2015), in conjunction with numeric criteria for parameters such as dissolved oxygen (DO). Recent (2010-2014) chlorophyll-*a* and DO data provide no indication that the non-tidal Cocheco River is impaired by nutrients. Although the available chlorophyll-*a* data confirm the lack of excessive planktonic (i.e., suspended) algae in the non-tidal Cocheco River, the City also desired information on the form and extent of attached (e.g., periphytic) algae. Therefore, the 2015 visual algal survey was performed to determine the occurrence (or lack thereof) of attached algal growth. Due to the highly subjective nature of what levels of algal growth might be deemed "excessive", Brown and Caldwell (BC) employed a standardized, reproducible procedure developed by the State of Maine. This technical memorandum identifies the method and results of the visual algal survey, and also provides some interpretations of algal and plant-related conditions in the non-tidal Cocheco River.

# Section 2: Methods

The visual algal survey used the viewing bucket survey method of Maine's *Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands* (MDEP, 2014) at six stations in the non-tidal Cocheco River. The Maine protocol was selected because New Hampshire agencies had not released a visual algal assessment protocol at the time of study design. The Maine protocol is also appropriate for wadeable stream environments in New Hampshire, and similar to the USEPA protocol. The six algal survey stations are displayed on Figure 1 and listed in Table 1. Of these six stations, one (Station 1 - Cocheco River downstream of Little Falls Bridge Rd) is upstream of the WWTF outfall, and the remaining five stations are downstream of the WWTF outfall. At other locations along the Cocheco River, the BC field team simply noted that the viewing bucket survey was not performed because the stream conditions were unsuitable for the accumulation of attached algae. These stations are also noted on Figure 1.

**Table 1. Algal Survey Locations**

| Station | Description | Time and Location Data | | |
|---|---|---|---|---|
| | | Date/Time of Survey | Latitude | Longitude |
| 1 | Cocheco R. downstream of Little Falls Bridge Rd | 8/26/15 9:00 | 43.33915 | -70.99647 |
| 2 | Cocheco R. downstream of Rochester WWTF outfall | 8/26/15 11:15 | 43.251806 | -70.96201 |
| 3 | Cocheco R. near England Rd | 8/26/15 12:05 | 43.247077 | -70.95658 |
| 4 | Cocheco R. near Covered Bridge Rd | 8/26/15 14:30 | 43.221786 | -70.94436 |
| 5 | Cocheco R. downstream of Watson Rd dam | 8/26/15 16:15 | 43.213413 | -70.92149 |
| 6 | Cocheco R. downstream of Whittier Rd | 8/27/15 8:30 | 43.204806 | -70.89309 |

The visual algal survey was performed on August 26-27, 2015 by an environmental scientist with expertise in freshwater algae (Clifton Bell) and an environmental engineer with training in field methods (Colin O'Brien). These days were considered suitable because they occur during the growing season, and because there had been no major stormflow/scour event (>100 cfs) within the last 30 days, according to stream flow data from USGS gage 01072800 (Cocheco River near Rochester, NH). At each station, three cross-sectional transects were established perpendicular to the direction of streamflow. A viewing bucket was used to characterize the substrate and algal/plant conditions at three locations along each transection, for a total of nine locations per station. At each location along the transect, the viewing bucket was immersed in the water, and the substrate/algal/plant condition was recorded at each of 16 points of a 4" x 4" grid on the bottom of the viewing bucket. At each grid point, the conditions were described using one of the following descriptors derived from MDEP (2014):

- Macro 1 – a filament or other macroalga that is between 1 and 5 cm long (filaments <1 cm long are counted as part of the periphyton mat, such as Mat 2 or Mat 3)
- Macro 2 – a filament or other macroalga that is ≥5 cm and <15 cm long
- Macro 3 – a filament or other macroalga that is ≥15 cm long
- Mat 0 – substrate rough or slightly slimy with no visible algae

- Mat 1 – a thin layer of algae is visually evident, underlying rock is still visible
- Mat 2 – periphyton mat from 0.5-1 mm thick is evident, underlying rock is covered and can no longer be seen (may include filamentous algae <1cm long)
- Mat 3 –periphyton mat between 1-5 mm thick is evident
- Mat 4 – periphyton mat between 5 mm-2 cm thick is evident
- Mat 5 – periphyton mat >2 cm thick is evident
- Sand/Clay/Mud – unconsolidated substrate such as sand or mud
- Plant – an aquatic plant or plant-like macroalga
- Moss – a moss
- Crust – a crust-forming algae (may be black, red, or green)
- Sewage fungus – a filamentous bacteria.
- Sponge – a freshwater sponge

Results from each station were summarized by the calculation of a "visual algal score" according to the key shown in Table 2. A water quality sonde was used to record field parameters (DO, pH, specific conductance, water temperature, and turbidity) at each station. Other information recorded for each station included the stream width and approximate streamflow velocity. Photographs were taken at each station.

**Table 2. Key to Visual Algal Score**

| Score | Description |
|---|---|
| 0 | Conditions unsuitable for accum. of attached algae; survey not performed |
| 1 | ≤10% coverage by macroalgae or algal mats greater than 1 mm thick |
| 2 | 10-25% coverage by macroalgae or algal mats greater than 1 mm thick |
| 3 | 25-50% coverage by macroalgae or algal mats greater than 1 mm thick |
| 4 | 50-75% coverage by macroalgae or algal mats greater than 1 mm thick |
| 5 | >75% coverage by macroalgae or algal mats greater than 1 mm thick |

## Section 3: Results and Discussion

Attachment A is a table of the station characteristics, including water quality measurements. Table 3 provides the estimated percent area of each major substrate/algal/plant condition at each station. The percentages of moss, crust, sewage fungus, and sponge are not noted on the table because they were 0% for all stations. Attachment B provides the breakdown of the percentages for each location along each transect at each station. Finally, Table 4 provides the overall visual algal score at each station.

| Table 3. Summary of Algal Survey Results By Station | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Macro | | | Mat | | | | | | Sand Clay Mud | Macro-phyte |
| | 1. 1-5 cm long | 2. 6-15 cm long | 3. >15 cm long | 1. no visible layer | 2. transparent layer | 3. <1 mm thick, opaque | 4. 1-5 mm thick | 5. 5 mm - 2 cm thick | 6. >2 cm thick | | |
| 1 | 13% | 0% | 0% | 3% | 15% | 10% | 2% | 0% | 0% | 33% | 20% |
| 2 | 1% | 1% | 0% | 6% | 14% | 8% | 3% | 0% | 0% | 23% | 44% |
| 3 | 0% | 0% | 0% | 17% | 44% | 3% | 0% | 0% | 0% | 6% | 30% |
| 4 | 9% | 0% | 0% | 0% | 22% | 50% | 3% | 0% | 0% | 8% | 8% |
| 5 | 1% | 2% | 8% | 13% | 56% | 17% | 0% | 0% | 0% | 0% | 3% |
| 6 | 19% | 1% | 0% | 5% | 35% | 16% | 0% | 0% | 0% | 1% | 24% |

| | Table 4. Overall Visual Algal Scores by Station | |
|---|---|---|
| Station | Score | Description |
| 1 | 2 | 10-25% coverage by macroalgae or algal mats greater than 1 mm thick |
| 2 | 1 | ≤10% coverage by macroalgae or algal mats greater than 1 mm thick |
| 3 | 1 | ≤10% coverage by macroalgae or algal mats greater than 1 mm thick |
| 4 | 1 | ≤10% coverage by macroalgae or algal mats greater than 1 mm thick |
| 5 | 1 | ≤10% coverage by macroalgae or algal mats greater than 1 mm thick |
| 6 | 2 | 10-25% coverage by macroalgae or algal mats greater than 1 mm thick |

The great majority of the surveyed river area had relatively little attached algae, and so most locations were simply assigned a visual algal score of zero ("conditions unsuitable for accumulation of attached algae; survey not performed"). This was due to a combination of factors that make most of the non-tidal Cocheco River unsuitable for accumulation of attached algae. These factors include:

- Depths >3 ft in many locations.
- High riparian tree canopy that reduces light availability (see Photo 1).
- Noticeably dark water color, presumably from natural sources (e.g., tannic acids), that also reduces light availability (Photo 1).
- In some places, a sandy or silty substrate that is not suitable for periphytic attachment.

Photo 1 – Cocheco River near England Road

At the six locations where it was practical to perform the visual algal survey, the most common bottom conditions were a transparent algal layer (Photo 2), very thin (<1 mm) algal mat (Photo 3), and/or macrophytes (rooted plants; Photo 4, Table 3).

Photo 2 - Transparent Algal Layer

Photo 3 - Very thin (<1mm) algal mat

Photo 4 - Macrophytes (rooted plants)

However, overall algal accumulations were relatively low; of the six stations, four had an overall visual algal score of 1, and two had an overall visual algal score of 2 (Table 4). Macrophytes are relatively commonly in the non-tidal Cocheco River, as four of the six stations had 20-44% coverage by macrophytes. Macrophytes are able to obtain nutrients from sediments, and are not typically responsive to point or nonpoint source nutrient controls (WDNR, 2012). In the judgment of the BC survey team, the macrophytes in the Cocheco

River appeared as natural flora (although some may be invasive species) and did not represent an impairment of recreational uses. Overall the aesthetics of the river were very good.

Photo 5 – Cocheco River near Watson Road

It is noteworthy that of the two locations that had a visual algal score of 2, one was the station upstream of the WWTF outfall and the City of Rochester (Station 1 - Cocheco R. downstream of Little Falls Bridge Rd). This station also had moderate coverage (20%) by macrophytes (Photo 6). Based on two grab samples collected in September and October 2015, the total phosphorus concentration at this station is 0.01 mg/L or less (elec. comm., D. Green, City of Rochester, 9/11 and 10/13/2015). This suggests that the algae and macrophyte distribution in the tidal Cocheco River is primarily controlled by non-nutrient factors.

Photo 6 – Algae and macrophytes on the Cocheco River near Covered Bridge Road, upstream of the City of Rochester

Although the focus of this survey was on attached algae, the BC survey team noted some short sections of the non-tidal Cocheco River that had relatively dense accumulations of duckweed (Photo 7). These patches primarily occurred in very slow-moving (almost stagnant) water between just upstream of Covered Bridge Road and the Watson Bridge dam. In this section, the field team noted three locations where duckweed covered much of the surface of the river, and each patch was 250- 400 feet long. Some duckweed had also accumulated behind the Watson Bridge, Sterling, and Central Ave. (Dover) dams, presumably transported from upstream. Overall, the area of dense duckweed accumulation represented only a small proportion (2-3%) of the river surface between Rochester and Dover.

Duckweed is part of the natural flora of New Hampshire water bodies, and is common in lakes, ponds, and other stagnant waters throughout the state (NH DES, 2007). In the non-tidal Cocheco, duckweed appears to be favored by dam backwater effects that create ideal hydraulic conditions for duckweed accumulation. The spatial pattern of duckweed occurrence is consistent with advective transport from upstream segments and accumulation in the most stagnant locations. Under this hydraulic regime, it would not be necessary to have atypically-high rates of *in situ* duckweed growth in order for short segments of visible duckweed to develop in the summer months.

Duckweed growth is also favored by summer water temperatures and light availability. The scientific literature suggests that if temperature, light, and hydraulic conditions are favorable, duckweed can maintain high growth rates even under low nutrient concentrations (Hasan and Chakrabarti, 2009; McCann, 2016). As stated by Leng and others (1995):

> As a generalization, duckweed growth is controlled by temperature and sunlight more than nutrient concentrations in the water. At high temperatures, duckweeds can grow rapidly down to trace levels of P and N nutrients in water.

Similarly, Luond (1980) found that duckweed growth rates were similar across a wide range of nutrient concentrations, and that growth was not inhibited until phosphorus concentrations were less than or equal to 0.017 mg/L. These findings suggest that it is probably not practical to impose strong nutrient limitations on duckweed in the Cocheco River, and that short segments of higher duckweed density are likely to persist in the summer barring a major change to the hydraulic regime (e.g., dam removal).

Photo 7 – Duckweed in dam backwater (Cocheco Rover near Covered Bridge Road)

## Section 4: Conclusions

Based on the data collected during the visual algal survey, the fresh water portion of the Cocheco River is not impaired by bottom algal growth. The river's depth, shading, and other factors are not conducive to widespread algal accumulations. Rooted macrophytes are common in the Cocheco River; including areas where nutrients are very low, and do not impair recreational uses. Dam backwater effects have created several extremely slow-moving mini-segments (250-400 ft long) of the river that are prone to duckweed accumulation. Additional field investigations would be required to determine the sources and controls on the duckweed. However, areas of dense duckweed accumulate represent only 2-3% of the river surface between Rochester and Dover.

## References

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# Attachment A: Station Characteristics

| Station | Description | Location Data | | | Stream Data | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Date/Time | Latitude | Longitude | Wetted Width (ft) | Bank Width (ft) | Depth (cm) | Velocity (cm/s) | DO (ppm) | Temperature (°C) | pH | Turbidity | Water Color | Canopy Cover | Substrate | Habitat |
| 1 | Cocheco R. down-stream of Little Falls Bridge Rd | 8/26/15 9:00 | 43.33915 | -70.99647 | 57 | 62 | 30 | 30 | 6.27 | 21.5 | 6.20 | Clear | 1-Slight | Partly Shaded | 50% Boulders 10% Cobble 10% Gravel 10% Sand 10% Silt | 100% Riffles |
| 2 | Cocheco R. down-stream of Rochester WWTF outfall | 8/26/15 11:15 | 43.251806 | -70.96201 | 52 | 60 | 70 | 20 | 8.15 | 23.1 | 6.71 | Clear | 0-Clear | Partly Shaded | 40% Boulders 10% Cobble 30% Gravel 20% Sand | 50% Riffles 50% Runs |
| 3 | Cocheco R. near England Rd | 8/26/15 12:05 | 43.247077 | -70.95658 | 45 | 50 | 30 | 75 | 8.20 | 22.6 | 6.74 | Slightly Turbid | 1-Slight | Partly Shaded | 30% Boulders 20% Cobble 30%Gravel 10% Sand 10% Silt | 100% Riffles |
| 4 | Cocheco R. near Covered Bridge Rd | 8/26/15 14:30 | 43.221786 | -70.94436 | 110 | 116 | 50 | 30 | 7.15 | 22.7 | 6.58 | Turbid | 0-Clear | Partly Shaded | 50% Boulders 25% Cobble 20% Gravel 5% Sand | 25% Riffles 75% Runs |
| 5 | Cocheco R. down-stream of Watson Rd dam | 8/26/15 16:15 | 43.213413 | -70.92149 | 119 | 125 | 40 | 30 | 8.56 | 24.9 | 6.89 | Clear | 0-Clear | Open | 75% Boulders 15% Cobble 10% Gravel | 25% Riffles 75% Runs |
| 6 | Cocheco R. down-stream of Whittier Rd | 8/27/15 8:30 | 43.204806 | -70.89309 | 183 | 195 | 50 | 40 | 8.70 | 21.6 | 6.87 | Clear | 0-Clear | Open | 80% Bedrock 10% Boulders 10% Sand | 50% Riffles 50% Runs |

# Attachment B: Algal Survey Result by Transection and Location

**Station 1: Rochester, NH - Cochecho River - Little Falls Bridge Rd., Downstream of Bridge**

| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 73% | 27% | 0% | 0% | 0% | 0% |
| 43467 | 9% | 0% | 0% | 18% | 9% | 9% | 0% | 0% | 0% | 55% | 0% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 0% | 64% | 0% | 0% | 0% | 0% | 9% | 27% | 0% | 0% | 0% | 0% |
| 43497 | 0% | 0% | 0% | 0% | 20% | 0% | 30% | 0% | 0% | 40% | 10% | 0% | 0% | 0% | 0% |
| 43498 | 80% | 0% | 0% | 0% | 10% | 0% | 0% | 0% | 0% | 10% | 0% | 0% | 0% | 0% | 0% |
| 43499 | 0% | 0% | 0% | 0% | 0% | 9% | 18% | 0% | 0% | 0% | 73% | 0% | 0% | 0% | 0% |
| 43525 | 0% | 0% | 0% | 9% | 9% | 9% | 0% | 0% | 0% | 73% | 0% | 0% | 0% | 0% | 0% |
| 43526 | 27% | 0% | 0% | 0% | 18% | 18% | 0% | 0% | 0% | 36% | 0% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 0% | 8% | 50% | 8% | 0% | 0% | 0% | 33% | 0% | 0% | 0% | 0% |

**Station 2: Rochester, NH - Cochecho River - Downstream Outfall, Upstream Launch Point**

| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 0% | 0% | 0% | 55% | 18% | 0% | 0% | 0% | 0% | 9% | 18% | 0% | 0% | 0% | 0% |
| 43467 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 82% | 18% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 27% | 73% | 0% | 0% | 0% | 0% |
| 43497 | 0% | 0% | 0% | 0% | 27% | 45% | 27% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43498 | 0% | 0% | 0% | 0% | 82% | 18% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43499 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 27% | 73% | 0% | 0% | 0% | 0% |
| 43525 | 0% | 0% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 27% | 64% | 0% | 0% | 0% | 0% |
| 43526 | 9% | 9% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 82% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 27% | 73% | 0% | 0% | 0% | 0% |

| Station 3: Rochester, NH - Cochecho River - England Road Site, Downstream of Launch Point | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 0% | 0% | 0% | 45% | 36% | 0% | 0% | 0% | 0% | 18% | 0% | 0% | 0% | 0% | 0% |
| 43467 | 0% | 0% | 0% | 27% | 64% | 9% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 18% | 82% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43497 | 0% | 0% | 0% | 9% | 73% | 9% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 0% | 0% |
| 43498 | 0% | 0% | 0% | 0% | 55% | 9% | 0% | 0% | 0% | 0% | 36% | 0% | 0% | 0% | 0% |
| 43499 | 0% | 0% | 0% | 9% | 55% | 9% | 0% | 0% | 0% | 27% | 0% | 0% | 0% | 0% | 0% |
| 43525 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 0% |
| 43526 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 36% | 27% | 0% | 0% | 0% | 0% | 9% | 27% | 0% | 0% | 0% | 0% |

| Station 4: Dover, NH - Cochecho River - Covered Bridge Road, Upstream | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 0% | 0% | 0% | 0% | 8% | 50% | 17% | 0% | 0% | 0% | 25% | 0% | 0% | 0% | 0% |
| 43467 | 10% | 0% | 0% | 0% | 10% | 80% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 0% | 27% | 64% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 0% | 0% |
| 43497 | 9% | 0% | 0% | 0% | 9% | 45% | 9% | 0% | 0% | 9% | 18% | 0% | 0% | 0% | 0% |
| 43498 | 30% | 0% | 0% | 0% | 30% | 30% | 0% | 0% | 0% | 10% | 0% | 0% | 0% | 0% | 0% |
| 43499 | 27% | 0% | 0% | 0% | 0% | 73% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43525 | 9% | 0% | 0% | 0% | 9% | 73% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 0% | 0% |
| 43526 | 0% | 0% | 0% | 0% | 73% | 0% | 0% | 0% | 0% | 0% | 27% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 0% | 36% | 36% | 0% | 0% | 0% | 27% | 0% | 0% | 0% | 0% | 0% |

| Station 5: Rochester, NH - Cochecho River - Watson Rd. Dam, Downstream of Dam | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 9% | 0% | 0% | 18% | 73% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43467 | 0% | 0% | 0% | 0% | 36% | 64% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 0% | 73% | 27% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43497 | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43498 | 0% | 0% | 0% | 0% | 55% | 45% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43499 | 0% | 0% | 0% | 64% | 36% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43525 | 0% | 18% | 73% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 9% | 0% | 0% | 0% | 0% |
| 43526 | 0% | 0% | 0% | 27% | 55% | 18% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 9% | 73% | 0% | 0% | 0% | 0% | 0% | 18% | 0% | 0% | 0% | 0% |

| Station 6: Dover, NH - Cochecho River - Whittier Rd. | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect/Sample | Macro | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Crust | Sewage Fungus | Sponge |
| | 1-5 cm long | 6-15 cm long | >15 cm long | no visible layer | transparent layer | <1 mm thick, opaque | 1-5 mm thick | 5 mm - 2 cm thick | >2 cm thick | | | | | | |
| 43466 | 45% | 0% | 0% | 0% | 0% | 55% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43467 | 0% | 0% | 0% | 27% | 18% | 0% | 0% | 0% | 0% | 0% | 55% | 0% | 0% | 0% | 0% |
| 43468 | 0% | 0% | 0% | 0% | 55% | 9% | 0% | 0% | 0% | 0% | 36% | 0% | 0% | 0% | 0% |
| 43497 | 82% | 0% | 0% | 0% | 0% | 18% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43498 | 0% | 0% | 0% | 0% | 45% | 0% | 0% | 0% | 0% | 0% | 55% | 0% | 0% | 0% | 0% |
| 43499 | 0% | 0% | 0% | 0% | 18% | 18% | 0% | 0% | 0% | 9% | 55% | 0% | 0% | 0% | 0% |
| 43525 | 42% | 8% | 0% | 0% | 8% | 42% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43526 | 0% | 0% | 0% | 0% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 43527 | 0% | 0% | 0% | 10% | 80% | 0% | 0% | 0% | 0% | 0% | 10% | 0% | 0% | 0% | 0% |

# Exhibit B: 2016 Field Investigations of the Cocheco River and Regional Waters

(Brown and Caldwell, 2017)

# 2016 Field Investigations of the Cocheco River and Regional Waters

Prepared for

City of Rochester, New Hampshire

May 2017

# 2016 Field Investigations of the Cocheco River and Regional Waters

Prepared for

City of Rochester, NH

May 2017

Brown AND Caldwell

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# List of Abbreviations

| | |
|---|---|
| BC | Brown and Caldwell |
| cm | Centimeter |
| NHDES | New Hampshire Department of Environmental Services |
| DO | Dissolved Oxygen |
| MDEP | Maine Department of Environmental Protection |
| MassDEP | Massachusetts Department of Environmental Protection |
| mg/L | Milligrams per Liter |
| NPDES | National Pollutant Discharge and Elimination System |
| TKN | Total Kjeldahl Nitrogen |
| TMDL | Total Maximum Daily Load |
| ug/L | Micrograms per Liter |
| USEPA | U.S. Environmental Protection Agency |
| WWTF | Wastewater Treatment Facility |

# Executive Summary

This report provides the methods and results of three major types of environmental monitoring that were performed by Brown and Caldwell on behalf of the City of Rochester during the 2016 growing season. The primary goal of the monitoring was to document the water quality, algal, and plant conditions of the Cocheco River and regional reference sites during the 2016 growing season. A related goal was to determine whether field data provided any evidence that nutrient (phosphorus and nitrogen) discharges from the City's wastewater treatment facility were adversely affecting the river. The 2016 field effort included three different types of monitoring:

- Water quality monitoring and visual/photographic surveys of the **non-tidal** Cocheco River from upstream of Rochester to Dover. The monitoring focused on the Cocheco River from upstream of Rochester to Dover, and included water quality sampling, photographic surveys, and viewing bucket surveys of algal growth
- Water quality monitoring and visual/photographic surveys of the **tidal** Cocheco River and other regional tidal waters. The purpose of this monitoring was to document water quality and algal conditions/coverage (including macroalgae), and quantify the associated nutrient concentrations. Regional tidal waters were also evaluated for comparison to the tidal Cocheco River.
- Water quality monitoring and visual/photographic surveys of the **regional non-tidal** waters. The purpose of this monitoring was to support a comparison of the condition in the non-tidal Cocheco River with other regional waters, with regard to both plant conditions and nutrient concentrations.

The effort also included a review of the scientific literature regarding the nutrient-related controls on plant and macroalage growth. Major results and conclusions of the 2016 monitoring include the following:

1. *The scientific literature indicates that rooted aquatic plants are unlikely to respond to external nutrient controls, and is inconclusive on the potential response of floating plants and macroalgae in the Cocheco River*. The literature review performed for this effort (described in Section 2 of this report) demonstrated that rooted aquatic plants can obtain nutrients from both the water column and sediment, and are much more likely to be limited by habitat and light availability than nutrients. The literature provided mixed conclusions on the potential to control duckweed growth with nutrient reduction. Some studies indicated that—given favorable light, temperature, and hydrologic conditions—duckweed can grow at relatively high rates even at relatively low nutrient concentrations. Under this condition, duckweed would not be expected to be sensitive to changes in phosphorus loading to the system. Other studies note decreases in duckweed growth rates below moderate threshold nutrient concentrations. The potential for nutrient limitation (or lack thereof) of marine macroalgae is not easily predicted by water column nutrient concentrations.
2. *Algal growth in the non-tidal Cocheco River was low to moderate in 2016, and with no apparent relation to phosphorus concentrations*. Monitoring in 2016 confirmed the result from 2015 that attached algal growth was low to moderate in the non-tidal Cocheco River. The growth potential was not related to phosphorus concentrations, as evidence by the fact that visual algal scores

upstream of the Rochester WWTF (where phosphorus concentrations are low) were similar to or higher than those downstream of the discharge.

3. *Floating plant coverage in the non-tidal Cocheco was relatively low in 2016, and did not respond to interannual changes in phosphorus concentrations*. Floating plant coverage was slower to develop in 2016 than in 2015, as evidenced by the fact that very little duckweed was observed during the August 2016 field visit. Floating plant coverage was more visible during the September 2016 field visit, but the areas of high density were still limited to just a few (as in 2015) short segments in stagnant waters; i.e., dam backwaters, and were not at levels that would impair beneficial uses of the river. Phosphorus concentrations were not a factor in the interannually variability in duckweed growth, because lower stream flows in 2016 actually caused the median phosphorus concentrations to be higher in 2016 than in 2015.
4. *Many regional non-tidal sites had similar or higher levels of plant growth than the Cocheco River, despite a lack of point source nutrient inputs*. The great majority of regional non-tidal water bodies examined had abundant aquatic vegetation, regardless of the absence of wastewater inputs or other obvious anthropogenic nutrient sources. There was no obvious relation between total phosphorus concentration and plant growth, which is consistent with observations from the Cocheco River.
5. *The tidal Cocheco River had favorable water quality in summer 2016, with no indications of algal-related use impairments*. Water quality sampling on the tidal Cocheco River indicated favorable conditions for dissolved oxygen and pH. Cyanobacteria were very low in most samples, and cyanotoxins were non-detectable in all samples. There was no visual indication of harmful algal blooms. Overall, the sampling confirmed that the tidal Cocheco River is a moderately productive estuarine segment with a benign algal community and no nutrient-related use impairments.
6. *During the September 2016 survey, macroalgae was common in the Cocheco River and other regional tidal waters, but most locations had relatively low levels of overall coverage*. Macroalgae such as sea lettuce and seaweed were observed at many locations in the tidal Cocheco River, Piscataqua River, and Portsmouth Harbor. However, macroalgal coverage was low (<15%) at most locations, and not at levels that would impair aquatic life or recreation uses. Visual surveys reveal that macroalgae can accumulate to high densities at specific locations (e.g. tidal wracks), but photographs of only the high-density spots should not be interpreted as representative of the typical coverage. Portsmouth Harbor had locations of high macroalgae cover, despite the fact that nutrient concentrations in the Harbor tend to be significantly lower than at upstream locations in the estuary.

# Section 1
# Introduction

The City of Rochester (City) discharges both stormwater and treated wastewater effluent to the Cocheco River, and has a vested interest in understanding the water quality and biological status of this water body. Organizations such as the Great Bay Municipal Coalition and Piscataqua River Estuary Program have put a great deal of effort into understanding water quality dynamics of the Great Bay system and associated tidal waters. Similarly, the New Hampshire Department of Environmental Services (NHDES) performs various types of monitoring of both the non-tidal Cocheco River and downstream tidal waters. While participating in these efforts, the City has also desired more detailed documentation on the condition of the non-tidal and tidal segments of the Cocheco River. This report describes the methods and results of City-sponsored monitoring performed by Brown and Caldwell (BC) during the 2016 growing season on the Cocheco River, upper Piscataqua River, and other regional sites. Nutrient-related response variables (e.g. algae, plants) are of special interest due to ongoing discussions with the NHDES and the U.S. Environmental Protection Agency (USEPA) regarding the City's wastewater treatment facility (WWTF) National Pollutant Discharge Elimination System (NPDES) permit, the Municipal Separate Storm Sewer System (MS4) permit and impaired waters (303(d)) listing issues.

## 1.1 Description of Receiving Water and Previous Monitoring Efforts

The Cocheco River is formed in northern Strafford County and passes through the Town of Farmington prior to entering the City of Rochester. The river continues approximately 13 river miles downstream to the City of Dover, where it becomes a tidal estuary. The tidal portion of the Cocheco River extends another 3.5 miles downstream where it joins the Piscataqua River estuary, which flows on past the Great Bay system and into the Portsmouth Harbor system.

NHDES uses chlorophyll-*a* concentrations as an indicator of potential eutrophication in both fresh and saline waters (NHDES, 2015). Water quality monitoring by NHDES has shown that chlorophyll-*a* concentrations are consistently low (<15 ug/L) in the non-tidal Cocheco River. Chlorophyll-*a* is periodically elevated in the tidal segment of the Cocheco River, as would be expected for a productive upper estuarine segment. However, evaluation of both fixed station data and continuous monitoring data indicated that the exceedance rate of the tidal chlorophyll-*a* threshold (20 ug/L) was less than 10 percent (Storer, 2015). The available dissolved oxygen (DO) and pH data for the 2016 303(d) listing cycle indicate generally favorable conditions in both the non-tidal and tidal segments of the Cocheco River. USEPA representatives have noted areas of plant/duckweed growth in the non-tidal Cocheco River, and also collected photographs of macroalgae in the tidal Cocheco and upper Piscataqua River in 2014. Most of the information provided by USEPA could be characterized as anecdotal rather than quantitative, and of uncertain representativeness in time and space.

The City subsidized a visual algal survey of the non-tidal Cocheco in the 2015 growing season (Brown and Caldwell, 2016). This study concluded that algal growth rates were relatively low in most of the non-tidal Cocheco due to a combination of water depth and low light conditions. Rooted macrophytes were relatively abundant both upstream and downstream of the City of Rochester's wastewater treatment facility (WWTF) outfall, and the surveyors also noted short (250-400 ft) segments of duckweed accumulation in dam backwaters between Rochester and Dover.

Monitoring performed to-date has been useful for documenting generally favorable conditions in the Cocheco River. It has also provided a baseline understanding of the actual plant/algal occurrence in the river. However, there is still insufficient information to characterize seasonal or interannual variations in factors such as duckweed or macroalgal growth, or understand whether such growths are nutrient limited. The City's 2016 monitoring was intended to build upon the previous efforts and address data gaps.

## 1.2 Scope and Organization of Report

This report provides the methods and results of three major types of monitoring that the City performed during the 2016 growing season:

1. *Water quality monitoring and visual/photographic surveys of the non-tidal Cocheco River from upstream of Rochester to Dover*. The purpose of this monitoring was to document algal and plant conditions/coverage in 2016 and quantify the associated nutrient concentrations, focused on the Cocheco River from upstream of Rochester to Dover.
2. *Water quality monitoring and visual/photographic surveys of the tidal Cocheco River and other regional tidal waters.* The purpose of this monitoring was to document water quality and algal conditions/coverage (including macroalgae) in 2016, and quantify the associated nutrient concentrations. Regional tidal waters were also evaluated for comparison to the tidal Cocheco River.
3. *Water quality monitoring and visual/photographic surveys of the regional non-tidal waters*. The purpose of this monitoring was to support a comparison of the condition in the non-tidal Cocheco River with other regional waters, with regard to both plant conditions and nutrient concentrations.

Section 2 presents literature regarding the role of nutrients in controlling different types of algal/plant growth, which is important background information for the interpretation of conditions on the Cocheco River. Section 3 of this report documents the methods for the monitoring categories identified, and Section 4 summarizes the results. Finally, Section 5 provides the major interpretations/conclusions drawn from the 2016 monitoring results. Examples of questions to be addressed include the following:

- What was the nature and spatial extent of algae/plant growth in the Cocheco River in 2016, and how did it compare to conditions in 2015?
- Were the prevailing algae/plant conditions indicative of designated use attainment in 2016?
- Are algae/plant conditions in the Cocheco River similar to other regional sites?
- Based on available information, would it be expected that algae/plant levels in the Cocheco River would respond to external nutrient controls?

## Section 2

# Review of Nutrient Controls on Plant and Macroalgae Growth

New Hampshire's rivers, lakes, and estuaries contain a wide variety of aquatic plants, including both native and introduced (e.g. exotic) species. In tidal settings, rooted plants such as eelgrass are considered indicators of system health, and higher areal coverage/density is considered desirable by environmental managers. Plants and algae are also important components of healthy freshwater systems. However, high density growths of rooted or floating plants can sometimes be considered undesirable, especially if they contain a high proportion of exotic taxa. New Hampshire's water quality standards discuss the concept of "excessive plant growth" (e.g. Env-Wq 1702.15). However, like most states, New Hampshire lacks a precise definition of what constitutes "excessive" growth, and the judgment could be highly subjective.

NHDES maintains an Exotic Species Program that monitors the location of documented exotic plant infestations. This program also provides educational resources on control techniques for dense plant growths, such as mechanical harvesting, herbicide application, dredging, and biological controls[1]. As this list indicates, most proven techniques for aquatic plant control involve physical, chemical, or biological removal of the plants. However, in a limited number of settings, regulatory agencies have focused on nutrient reduction as an intended means to control freshwater plant accumulations. For example, the Massachusetts Department of Environmental Protection (MassDEP) developed nutrient total maximum daily loads (TMDLs) for the Assabet and Nashua Rivers, primarily intending to reduce accumulations of both rooted and floating plants such as duckweed. The ability of these TMDLs to actually affect plant growths in still in question.

The feasibility of using external (point/nonpoint source) nutrient controls to control freshwater plant growths merits close scientific investigation. This is because nutrients are only one factor that potentially limit plant growth, and in any specific settings, nutrients may not be the factor that controls the overall biomass accrual potential. Some plants only experience nutrient limitation[2] at extremely low concentrations, such that background nutrient concentrations are sufficient to support high growth rates. Others have nutrient acquisition strategies (e.g. luxury consumption) to avoid nutrient limitations, and thus may be more limited by factors such as light, temperature, substrate, habitat availability, and hydrology. In such settings, costly nutrient controls would achieve little environmental effect. Conversely, nutrient controls might actually reduce undesirable plant growths in some settings.

This section presents a literature review of the relations between nutrient availability and the growth rates of several plant types. Separate subsections are devoted to rooted aquatic plants (i.e., attached to a substrate), floating (i.e., not attached to a substrate) plants, and marine macroalgae. The discussion includes a review of both scientific literature and regulatory case studies. The results of this literature review will be used to support future scientific interpretations of the conditions in the Cocheco River.

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[1] See http://des.nh.gov/organization/divisions/water/wmb/exoticspecies/management.htm

[2] The term "nutrient limitation" describes a condition whereby the plant or algal growth rate is controlled (or "limited") by nutrient availability.

## 2.1 Rooted Aquatic Plants

Rooted aquatic plants include a large number of aquatic plants native to New Hampshire rivers (e.g. waterweed, coontail, wild celery) as well as exotic species (e.g. variable milfoil, curly-leaf pondweed). Variable milfoil is the most common exotic species in New Hampshire's lakes and ponds, and has established itself in many waters across the state, including the Cocheco River.

Different species of rooted plants have different survival requirements in terms of temperature, light, hydrologic conditions, substrate types, and nutrient concentrations. Most aquatic macrophytes prefer still or slow-moving water and grow faster under higher temperatures. According to Leibig's Law of the Minimum, plant growth is controlled not by the sum of the resources available, but by the scarcest resource; i.e., the limiting factor. For example, if a plant had sufficient nutrients, temperature, and available substrate to grow at its maximum physiological rate, but little light, it would be said to be light-limited. In this circumstance, nutrient availability could change over a wide range of concentrations without significantly affecting the plant growth rate. Conversely, plants that experienced favorable conditions for all parameters except nutrient availability would be nutrient-limited.

Different species of plants have different preferences regarding light conditions. Plants such as milfoil prefer high light levels and can growth rapidly up in the water column to reach such conditions near the surface. In dense stands, the leaves of individual plants will overlap each other, causing "self-shading" which can limit the total biomass accrual potential. Hence, light limitation can occur even if no external shading is provided.

In some settings, state agencies have concluded that nutrient controls are not sensitive to water column nutrient concentrations. For example, Wisconsin Department of Natural Resources (2012) states that rooted aquatic plants are able to obtain nutrients from both the water column and sediments, and are not typically responsive to short-term fluctuations in water column nutrient concentrations. MassDEP (2002) points out that milfoil infestations can occur in both oligotrophic (low nutrient) and eutrophic (high nutrient) lakes. Unlike plants in terrestrial settings, subaquatic macrophytes receive a continuous supply of nutrients from upstream sources. By a mechanism known as "luxury consumption", plants can store nutrients in their tissues to support future growth (Shardendu and others, 2012), and thus can take advantage of temporarily high nutrient concentrations in flowing waters to support growth when nutrient concentrations are lower.

When developing a nutrient TMDL for Stoneman Lake, the Arizona Department of Environmental Quality (2000) applied a model that explicitly simulated the ability of rooted plants (including milfoil) to uptake nutrients from both the sediment and water column. Results indicated that milfoil would consistently be limited by light (self-shading) rather than by nutrients, and that it was not practical to impose a nutrient limitation. Hence, the TMDL focused on other lake management measures, such as lake volume control.

A stream in Washington state (Clarks Creek) experienced high densities of the native plant *Elodea*, which in turn caused high diurnal fluctuations of dissolved oxygen concentrations. Modeling using QUAL2Kw demonstrated a very low sensitivity of the *Elodea* to changes in nutrient availability; rather, the plant was more limited by light and habitat availability (Washington Department of Ecology, 2014). As a result, the local municipality's control strategy focused on physical removal of the plant and increasing riparian shade. Nutrient controls are also being pursued on a watershed scale, but without the expectation that they will have a direct impact on *Elodea* growth.

Despite the physiological challenges of imposing nutrient limitations on rooted macrophytes, some states have pursued TMDLs on this basis. For example, in 2000, the Utah Department of Environmental Quality developed a nutrient TMDL for East Canyon Creek, Utah with the goal of controlling stream macrophytes. After stringent point source nutrient controls were imposed, no appreciable changes in macrophyte density were observed (Hall and Hall, 2007). More recent monitoring (Hampshire, 2015) confirms that macrophytes are still abundant in the stream, and not experiencing significant nutrient limitations. Implementation of riparian shading now appears to be a more viable control strategy.

Because rooted plants can obtain nutrients from the sediment, one control strategy involves dredging nutrient-laden sediments from the water body. This can be temporarily effective because it removes the mature plants, seed beds, and nutrient-rich sediments in one operation. Dredging is very expensive (NHDES cites $16,000-$32,000 per acre), and it is unclear how much benefit is derived from removing nutrients versus removing the plant and seed beds. The literature review revealed no case studies where dredging provided a long-term solution for macrophyte infestations, as plants tend to return within 5-10 years. In addition, the propagation of some species such as milfoil actually seems to be favored by disturbance. As stated by Smith and Barko (1990) regarding Eurasian milfoil:

> Eradication of this particular species, with a demonstrated ability to reproduce from fragments, is rarely if ever likely to succeed…Existing control techniques are short-lived and expensive…

In summary, watershed nutrient controls may be a recommended strategy for prevention of some types of eutrophication, but the literature provides little evidence that it is viable control measure for rooted plants. As stated in an assessment of Millville Lake, NH (Aquatic Control Technology, 2015):

> Watershed/nutrient abatement strategies have little or no effect on the growth of rooted vegetation species, as these plants derive the bulk of their nutrient requirements directly from the bottom sediments. However, watershed and nutrient abatement strategies should be considered, where applicable, for long-term management and improvement of water quality.

## 2.2 Floating Plants

Floating plants such as duckweed and watermeal are part of the natural flora of New Hampshire water bodies, and are common in lakes, ponds, and slow-moving rivers throughout the state (NHDES, 2007). Unlike rooted macrophytes, these plants have no true stems and the roots (if present) are free-hanging, so they must obtain nutrients from the water column. Because they grow at the water surface, floating plants are not affected by light attenuation through the water column. However, they can be sensitive to external shading and also limited by crowding; i.e., by the available surface area of a water body. Floating plants cannot accumulate in fast-moving water, and so in rivers tend to occur in marginal areas of the relatively quiescent waters behind dams, either grown in place or transported from upstream. Duckweed (*Lemna* species) is the particular focus of this literature review because it has been observed in the Cocheco River.

Although duckweed can grow within a wide range of temperatures, the plants grow faster under warm and sunny conditions (Skillicorn and others 1993). Optimum temperature for maximum growth of most groups lies between 17.5 and 30 ºC (Culley and others, 1981; Gaigher and Short, 1986). Driever and others (2004) found that duckweed growth rates were affected by temperature, but that crowding (i.e., available surface area) was the most important growth limitation in ditches. Similarly, Demmirezen and others (2007) found that duckweed biomass production was inhibited by an increase in plant density, which they speculated may have been due to lower temperatures and lower nutrients within duckweed mats.

The scientific literature suggests that if temperature, light, and hydraulic conditions are favorable, duckweed can maintain high growth rates even under low nutrient concentrations (Hasan and Chakrabarti, 2009; McCann, 2016). As stated by Leng and others (1995):

> As a generalization, duckweed growth is controlled by temperature and sunlight more than nutrient concentrations in the water. At high temperatures, duckweeds can grow rapidly down to trace levels of P and N nutrients in water.

Similarly, Luond (1980) found that duckweed growth rates were similar across a wide range of nutrient concentrations, and that growth was not inhibited until phosphorus concentrations were less than or equal to 0.017 mg/L. Duckweeds are hyperaccumulators of phosphorus and can use internally stored phosphorus for growth when it is no longer available (Novak and Chan, 2003). As a result, duckweed growth rates are more sensitive to internal reservoirs of nutrients than to ambient water column concentrations. For example, Kufel and others (2012) found that duckweed growth was not accurately modeled by the Monod formulation, which primarily uses external nutrient concentrations. Rather, the Droop model—that uses internal cellular nutrient concentrations—gave a much better fit to growth measurements.

Gerard and Triest (2014) found no difference in duckweed growth rates between eutrophic (30-100 ug/L phosphorus) and mesotrophic (10-30 ug/L phosphorus) conditions. Rather, oligotrophic (0-10 ug/L phosphorus) conditions were required to significantly reduce growth rates. Njambuya and others (2011) found that the growth rate of one duckweed species (*Lemna minor*) did not significantly vary between low, medium, and high nutrient concentrations, whereas the growth rates of another species (*Lemna minuta*) varied modestly between these three conditions. Duckweed prefers ammonia nitrogen ($NH_4$-N) as a source of nitrogen and will remove ammonia preferentially, even in the presence of relatively high nitrate concentrations (Hasan and Chakrabarti, 2009).

In contrast to studies cited above, other studies have found that that the N and P uptake rates of duckweeds continued to increase as nutrient concentrations increased to very high levels. For example, Culley and others (1978), working in dairy waste lagoons, achieved doubled production from 2 to 4 days at P concentrations in excess of 35 mg/L. Hasan and Chakrabarti (2009) report that the “optimal” nutrient concentrations for N and P uptake (not necessarily growth rate) was 4-8 mg/L for dissolved inorganic phosphorus and 7-12 mg/L for ammonia nitrogen. This same reference reported that reduced growth in some species only occurs if P drops below 0.017 mg/L or N drops to trace levels.

Lasfar and others (2007) found that duckweed’s (*Lemna minor*) intrinsic growth rate was essentially constant over ranges of 1-20 mg/L P and 3-120 mg/L N, but decreased rapidly below 1 mg/L. Cedergreen and Madsen (2002) determined that duckweed (*Lemna minor*) relative growth rates increased between three different nitrogen treatment levels (0.14, 1.40, and 7 mg/L N). Landesmen and others (2005) measured duckweed (*Lemna obscura*) biomass accumulation at a range of supplied nitrogen levels (0, 3.9, 8.9, 13.9, 28.5 and 54.6 mg/L TN). Although they found that growth rates were highest in the 13.9 mg/L treatment level, growth rates were also significant even in the treatment with no supplied nitrogen.

Huebert and Shay (1991) measured similar duckweed (*Lemna trisulca*) growth rates across a range of P concentrations (0.23 -7.4 mg/L), and found reduced growth rates when N fell below about 0.4 mg/L. Fulton and others (2009) observed phosphorus limitation of duckweed (*Lemna gibba*) in streams with P concentrations of about 0.008 mg/L, although growth rates were only slightly higher at P concentrations of 0.020 – 0.100 mg/L.

State agencies and USEPA Region 1 have pursued stringent point source phosphorus controls for several New England river systems, in part to control duckweed (*Lemna minor*) and rooted plants. The Assabet River TMDL modeling used algae as a surrogate for total plant biomass (MassDEP, 2004), and did not explicitly simulate the nutrient acquisition dynamics of floating or rooted plants. Monitoring has shown that phosphorus concentrations in the Assabet River have indeed decreased by 38-50 percent since the implementation of point-source phosphorus controls in 2012 (Savoie and others, 2016). However, as of the date of this report, regulatory agencies had not yet documented whether duckweed coverage had responded to nutrient reductions.

In summary, floating plants such as duckweed have more potential to respond to external nutrient reduction than rooted plants, due to the requirement to obtain nutrients from the water column.

However, the scientific literature provides a wide range of values regarding the nutrient concentrations that would actually limit duckweed growth rates. Many studies indicate that—given favorable light, temperature, and hydrologic conditions—duckweed can grow at relatively high rates even at relatively low nutrient concentrations. Other studies note decreases in duckweed growth rates below moderate threshold nutrient concentrations. Even low to moderate growth rates may produce visible accumulations of duckweed in impoundments under warm (summer), stable (low) flow conditions—particularly where the downstream transport of duckweed causes accumulation of duckweed behind dams. It is probably not practical to make predictions of duckweed responses based solely on changes in water column nutrient concentrations. Rather, it would be necessary to perform more detailed modeling analyses that considers the effects of hydrologic conditions, luxury consumption, and longitudinal variations in nutrient availability.

## 2.3 Macroalgae

Macroalgae is a generic term for various multicellular algae capable of growing in macroscopic forms. These algae are sometimes referred to using the even more generic term "seaweed". Macroalgae are a natural component of the flora of coastal environments. However, increased growths of macroalgae have been associated with eutrophication of coastal waters (Teichberg and others, 2010), and they have also sometimes been cited as a factor in the loss of submerged aquatic vegetation (Cloern, 2001). A representative macroalgal genus is *Ulva*, commonly known as sea lettuce. This green algal taxon grows in flat, ruffled layers in the littoral and sublittoral zones of coastal areas. Although it is typically attached to its substrate (by a structure known as a holdfast), it does not have roots and so must obtain nutrients from the water column or from direct sediment nutrient fluxes to the overlying macroalgae.

As with other flora types, tissue nutrient concentrations in macroalgae are a better predictor of growth potential than water column nutrient concentrations. For example, Sjoo and Mork (2009) state the following:

> Coastal marine ecosystems often display little correlation between dissolved nutrient concentrations and the productivity of primary producers, as productivity also depend on physical and biogeochemical fluxes, physiological morphological attributes of the producers, water turbulence and other environmental factors… nutrients in the water column seldom represent the actual nutrient loading, as losses may occur due to gaseous transformation, binding to sediment, trapping in interstitial spaces and uptake by primary producers.

Poor correlations between water column nutrient concentrations and macroalgae growth have also been specifically attributed to the ability of macroalgae to store nutrients (i.e., luxury consumption). For these reasons, most researchers have studied the potential for nutrient limitation by evaluating macroalgal tissue concentrations rather than ambient water concentrations.

Teichberg and others (2010) found that *Ulva* growth rates were higher at coastal sites with higher dissolved inorganic nitrogen concentrations, over a range of 0.030 – 1.4 mg/L N. Teichberg and others (2010) also conducted nutrient enrichment experiments with *Ulva* at sites in both the US and Europe. Most of the sites showed small (<10 percent) increases in *Ulva* growth rates with nutrient enrichment, suggesting only modest levels of nutrient limitation. However, some sites showed >30 percent increase in *Ulva* growth rate with enrichment of either N or P.

Moustafa and others (2014) found that relative growth rates of *Ulva* species increased when ammonia-nitrogen concentrations were increased from 0.2 mg/L to 0.4 mg/L, but did not increase further when ammonia-nitrogen concentrations were further increased to 0.8 mg/L. The authors observed no significant differences in *Ulva* relative growth rates as nitrate-nitrogen concentrations were increased over a range of 3 – 52 mg/L.

Pedersen and Borum (1996) found that growth rates of *Ulva lactuca* increased in response to nitrogen enrichment from less than 0.3 mg/L to over 5 mg/L ammonia nitrogen. However, this study did not examine intermediate levels of nutrient enrichment, and *Ulva* growth rates did not respond to phosphorus enrichment. The authors concluded that fast-growing macroalgae required up to 30 times the internal nitrogen requirements as slower-growing algae, which explains why the faster-growing taxa (including *Ulva*) has larger growth responses to nutrient enrichment.

In mesocosm experiments or coastal marine environments, Taylor and others (1995) found that nitrogen enrichment actually caused macroalgae to decline, apparently due to increased shading from phytoplankton. Villares and Carballeira (2004) found that *Ulva rigida* was nutrient-limited in four coastal embayments, as evidenced by higher growth rates under higher internal tissue nutrient concentrations. It was not determined whether nitrogen or phosphorus was the limiting nutrient.

Bjornsater and Wheeler (1990) found that for *Ulva fenestrata*, tissue N:P ratios less than 16 were indicative of N-limitation, tissue N:P ratios of 16–24 was optimal for growth, and tissue N:P ratio of greater than 24 was indicative of P-limitation. Working in a Danish fjord, Lyngby and others (1999) determined that tissue nutrient concentrations were highly variable between years, such as *Ulva lactuca* was either nitrogen limited, phosphorus limited, or not nutrient limited. Van Alstyne (2016) determined the *Ulva lactuca* in a northeastern Pacific embayment were seasonally nitrogen-limited, and that small nutrients inputs could release macroalage from nitrogen limitation. Wallace and Gobler (2014) concluded that *Ulva rigida* was usually light-limited rather than nutrient-limited in a eutrophic urban estuary (Jamaica Bay, NY).

In summary, although macroalgal growth rates can sometimes increase due to coastal nutrient enrichment, the actual response would depend on a variety of site-specific factors. Fast-growing taxa such as *Ulva* can be favored over other primary producers when conditions allow them to accumulate high concentrations of nutrients in tissues. However, macroalgae do not experience strong nutrient limitations in all settings. The potential for nutrient limitation (or lack thereof) of *Ulva* is not easily predicted by water column nutrient concentrations. Rather, tissue nutrient concentrations are a superior predictor of growth potential, and depend on many factors other than water column concentrations.

## Section 3

# Field Sampling Locations and Methods

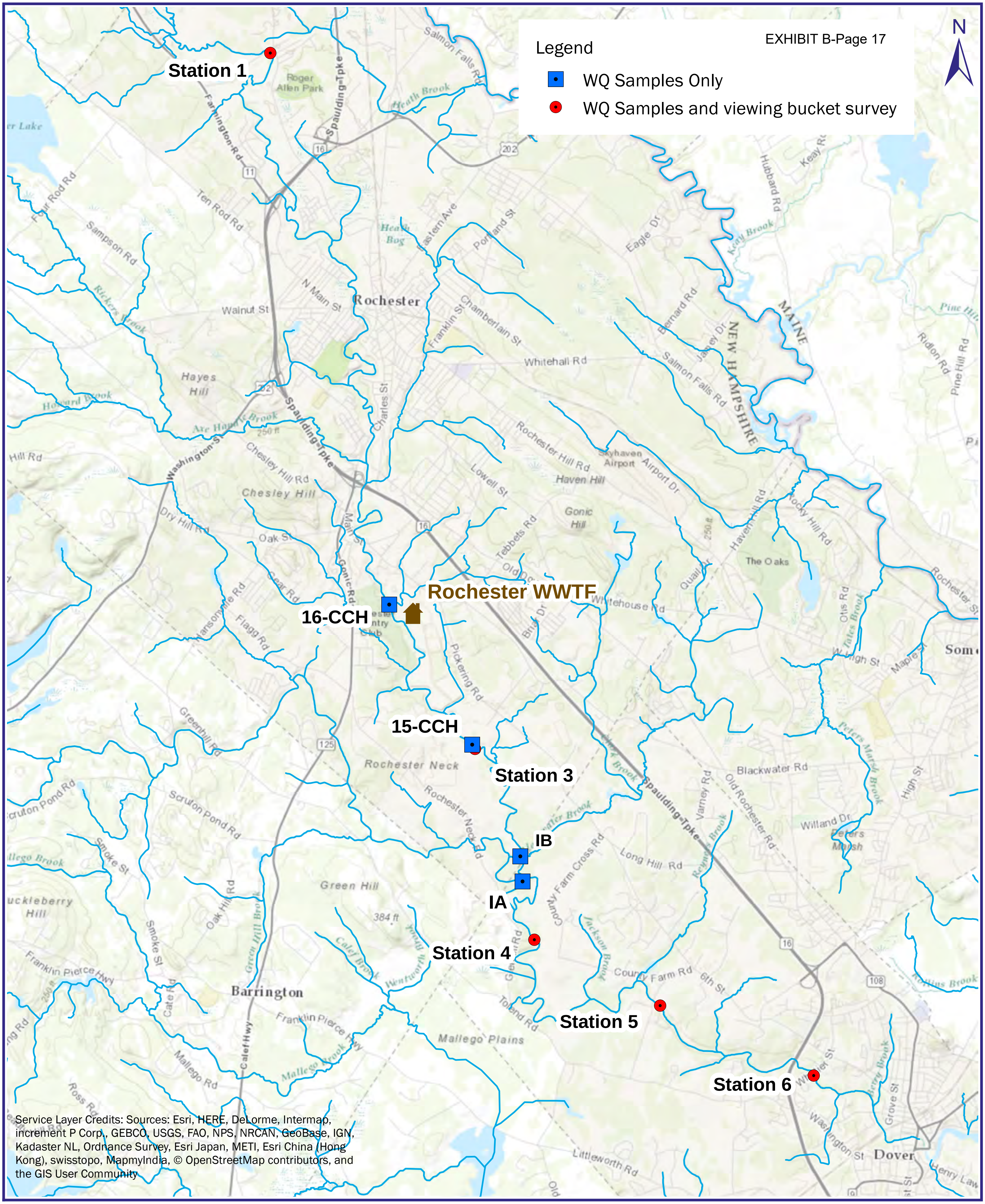
Field survey activities were conducted to assess the aerial and longitudinal extent, as well as the typical form and occurrence, of algae (including subaquatic and floating macrophytes) in the Cocheco River. As described in this section, BC employed standardized, reproducible procedures developed by federal and/or state agencies for the characterization studies. Different assessment methods were selected for the non-tidal and tidal portions of the Cocheco River to account for the ecological conditions of each segment. Water quality samples were collected at some locations to support a comparison of plant/algal condition with ambient nutrient concentrations. The field surveys also included extensive photographic documentation of plant/algal conditions. The field monitoring schedule was selected to coincide with the regional growing season. Further details of the methods employed for each portion of the river are presented in the sections below.

Algal survey activities were conducted under the direction of BC staff comprised of an environmental scientist with expertise in freshwater algae; field activities were performed by an environmental scientist with expertise in freshwater vegetation identification and survey methods and an environmental engineer with training and experience in field methods.

## 3.1 Non-Tidal Cocheco River

The non-tidal study portion of the Cocheco River includes a winding, approximately 18-mile river segment that starts upstream of the Town of Farmington, flows through the City of Rochester and extends to Dover, New Hampshire, where the Cocheco and Salmon Falls Rivers combine to form the Piscataqua River. The 18-mile non-tidal study segment was evaluated to assess the aerial and longitudinal extent, as well as the typical form and occurrence, of algae. Visual surveys of algal growth (including subaquatic and floating macrophytes) were conducted at five representative stations along the non-tidal study portion of the Cocheco River. The field study was conducted from August 3$^{rd}$ to 4$^{th}$, 2016, and again from September 21$^{st}$ to 22$^{nd}$, 2016 in order to obtain a comparative data set. Field stations were established at locations determined to be physically accessible, as well as have characteristics generally representative of the ecological conditions identified along the majority of the Cocheco River.

Details of the algal survey field activities completed for the non-tidal portion of the Cocheco River are presented in the following sections. The non-tidal study portion of the Cocheco River, as well as survey stations, are shown on Figure 3-1 on the following page.

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Viewing Bucket Survey Locations – August 3rd - 4th, 2016

Figure 3-1. Viewing Bucket Survey and Water Quality Monitoring Locations on the Non-Tidal Cocheco River

Source Citation

0 0.5 1

Miles

### 3.1.1 Water Quality Sampling

Water quality sampling was conducted to document field conditions and provide a basis of comparison of water quality conditions between sites.

Surface water samples were collected at five locations, as shown on Figure 3-1. The viewing bucket station numbering is identical to that presented in the 2015 monitoring report (Brown and Caldwell, 2016). However, a viewing bucket survey was not performed at Station 2 in 2016 due to the proximity to Station 3. Water samples were submitted to Eastern Analytical, Inc. (EAI) under chain of custody for chemical analysis. Water samples were analyzed for ammonia-nitrogen, total phosphorus, total nitrogen, total Kjeldahl nitrogen (TKN), and nitrate/nitrite. Samples were collected using nitrile gloves to prevent contamination of the 5-gallon sample bucket that was rinsed with distilled water between samples. Samples were then poured into their respective sample bottle, put on ice in a cooler, and collected by a certified lab courier within 24 hours.

**Table 3-1. Water Quality Sample and Algal Survey Locations**

| Station | Description | Time and Location Data | | | |
|---|---|---|---|---|---|
| | | Date of Survey 1 | Date of Survey 2 | Latitude | Longitude |
| 1 | Cocheco R. downstream of Little Falls Brdg. Rd | 08/03/16 | 09/21/16 | 43.339023 | -70.996547 |
| 3 | Cocheco R. near England Rd | 08/03/16 | 09/21/16 | 43.247055 | -70.956191 |
| 4 | Cocheco R. near Covered Bridge Rd | 08/04/16 | 09/22/16 | 43.221812 | -70.944594 |
| 5 | Cocheco R. downstream of Watson Rd dam | 08/04/16 | 09/21/16 | 43.213440 | -70.921392 |
| 6 | Cocheco R. downstream of Whittier Rd | 08/04/16 | 09/21/16 | 43.204608 | -70.893176 |
| *15-CCH* | Downstream of Outfall | N/A | 09/21/2016 | 43.247586 | -70.956745 |
| *16-CCH* | Upstream of Outfall | N/A | 09/21/2016 | 43.266008 | -70.972458 |
| IA | Upstream of Isinglass Confluence | N/A | 09/22/2016 | 43.232899 | -70.947520 |
| IB | Downstream of Isinglass Confluence | N/A | 09/22/2016 | 43.229541 | -70.947105 |

### 3.1.2 Visual/Photograph Evaluation

A qualitative visual assessment of the river was conducted to supplement information collected at the monitoring stations. BC personnel navigated the complete study portion of the river by canoe. Date and time-stamped photographs were collected for the majority of the watercourse and immediately adjacent banks. Field personnel collected photographs and recorded general observations of ecological conditions, including plant communities, specific plants/macrophytes identified, descriptions of dense accumulations of macrophytes and incidental observations of wildlife. Photographs and field notes were also collected for other features of interest, such as bank slopes, changes in ecological communities, locations of pipe outfalls and locations of trash/debris accumulation.

In addition to still photographs, video recordings of subaquatic conditions were collected of select areas of the river. Video recordings were also collected for randomly selected areas to document general conditions, or where an anomaly (e.g. area of dense macrophyte growth, localized pool, outfall discharge location) warranted further subsurface evaluation.

Video footage was collected using a GoPro® camera/video recorder. Key points of interest were located in the field using the GPS Tour mobile application accessed via an iPhone® smartphone with built in camera.

### 3.1.3 Viewing Bucket Surveys

Visual surveys of algal growth were conducted at representative stations along the Cocheco River using the viewing bucket survey method outlined in the *New Hampshire Department of Environmental Services (NHDES) Protocols for Benthic Algal Surveys* (NHDES, 2013). Portions of the methodology outlined in Maine's *Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands* (MDEP, 2014) were also applied in order to maximize consistency and alignment with the algal survey completed by BC in 2015. The NHDES and MDEP protocols were selected based on the appropriateness for wadeable stream environments. Field stations were established at locations deemed to be physically accessible and have ecological characteristics generally identified along the majority of the study portion of the Cocheco River, based on a review of available aerial imagery. Areas that were inaccessible (i.e., private property, physical barriers) or dissimilar to general stream conditions (i.e., outfall pipe locations, areas of accumulated trash/debris) were omitted as potential survey stations.

A viewing bucket survey was completed at each station established along the study portion of the Cocheco River. Five stations were evaluated from August 3rd to 4th, 2016, and again from September 21st to 22nd, 2016. Of the five stations, one (Station 1 - Cocheco River downstream of Little Falls Bridge Road) is upstream of the urban Rochester area and upstream of the WWTF outfall. The remaining four stations are downstream of the urban Rochester area and the WWTF outfall. The algal survey station locations are summarized in Table 3-1 and illustrated on Figure 3-1.

Site location and stream characteristic data were collected for each station, including stream identification, site identification, date, time, streamflow velocity, stream width, sunlight conditions and general description of the ecological community. At each station, three cross-sectional transects were established perpendicular to the direction of streamflow, with transects spaced at approximately 10 feet. Transects were temporarily marked in the field using a flexible tape measure. A viewing bucket was used to characterize the substrate and assess algal/plant conditions at six viewing locations along each transect, for a total of eighteen locations per station. The viewing bucket consisted of an approximate 5-gallon capacity plastic bucket, on the bottom of which was secured a clear plastic viewing window marked with a 16-point grid pattern with grid points spaced at 1-inch by 1-inch square intervals.

Visual assessments were initiated at the downstream transect, beginning at river right, and progressed upstream in order to minimize influence from sediment disturbed during access. At each of the 18 viewing locations, the viewing bucket was immersed in the water and the substrate/algal/plant conditions were recorded for each grid point. At each grid point, the conditions were described using one of the following descriptors derived from the NHDES and MDEP protocols:

- Macro 1 – A filament or other macroalga that is between 1 and 5 cm long (filaments <1 cm long is counted a part of the periphyton mat, such as mat 2 or mat 3)
- Macro 2 – A filament or other macroalga that is $\geq$5 cm and <15 cm long
- Macro 3 – A filament or other macroalga that is $\geq$15 cm
- Mat 0 – Substrate rough or slightly slimy with no visible algae
- Mat 1 – A thin layer of algae is visually evident, underlying rock is still visible
- Mat 2 – Periphyton mat from 0.5–1 mm thick is evident, underlying rock is covered and can no longer be seen (may include filamentous algae <1 cm long)
- Mat 3 – Periphyton mat between 1-5 mm thick is evident
- Mat 4 – Periphyton mat between 5mm – 2 cm thick is evident

- Mat 5 – Periphyton mat >2 cm thick is evident
- Sand/Clay/Mud – Unconsolidated substrate such as sand or mud
- Plant – An aquatic plant or plant-like macroalga
- Moss – A moss
- Crust – A crust-forming algae (may be black, red, or green)
- Sewage fungus – A filamentous bacterium (despite the name "fungus")
- Sponge – A freshwater sponge

Observation data was recorded on algal abundance field data forms.

A rating was assigned to each descriptor (Table 3-2) corresponding to the absence or abundance of plant/algae growth observed. The rating increases as the abundance of the growth increases.

**Table 3-2. Assignment of Algal Ratings**

| Score | Descriptor |
|---|---|
| 0 | Sand/Clay/Mud, Mat 0 |
| 1 | Crust, Macro 1, Mat 1 |
| 2 | Plant, Moss, Macro 2, Mat 2 |
| 3 | Macro 3, Mat 3 |
| 4 | Mat 4 |
| 5 | Mat 5 |

An overall score was developed for each of the five non-tidal stations to assess the relative abundance of macroalgae along the study portion of the river. A relative percentage was first developed for each descriptor by adding the total quantity of observations for each descriptor across all 18 viewing stations. The total sum was weighted against the total number of grid points monitored for the station (i.e., 288). This percentage calculated for each descriptor was then multiplied by the assigned descriptor score (presented in Table 3-2). An average of all descriptor scores for the station was calculated to derive an overall algal abundance score for each station. This rating and scoring approach is consistent with NHDES methodology, as shown in NHDES workbooks that compile its own 2016 viewing bucket survey results from the Cocheco River.

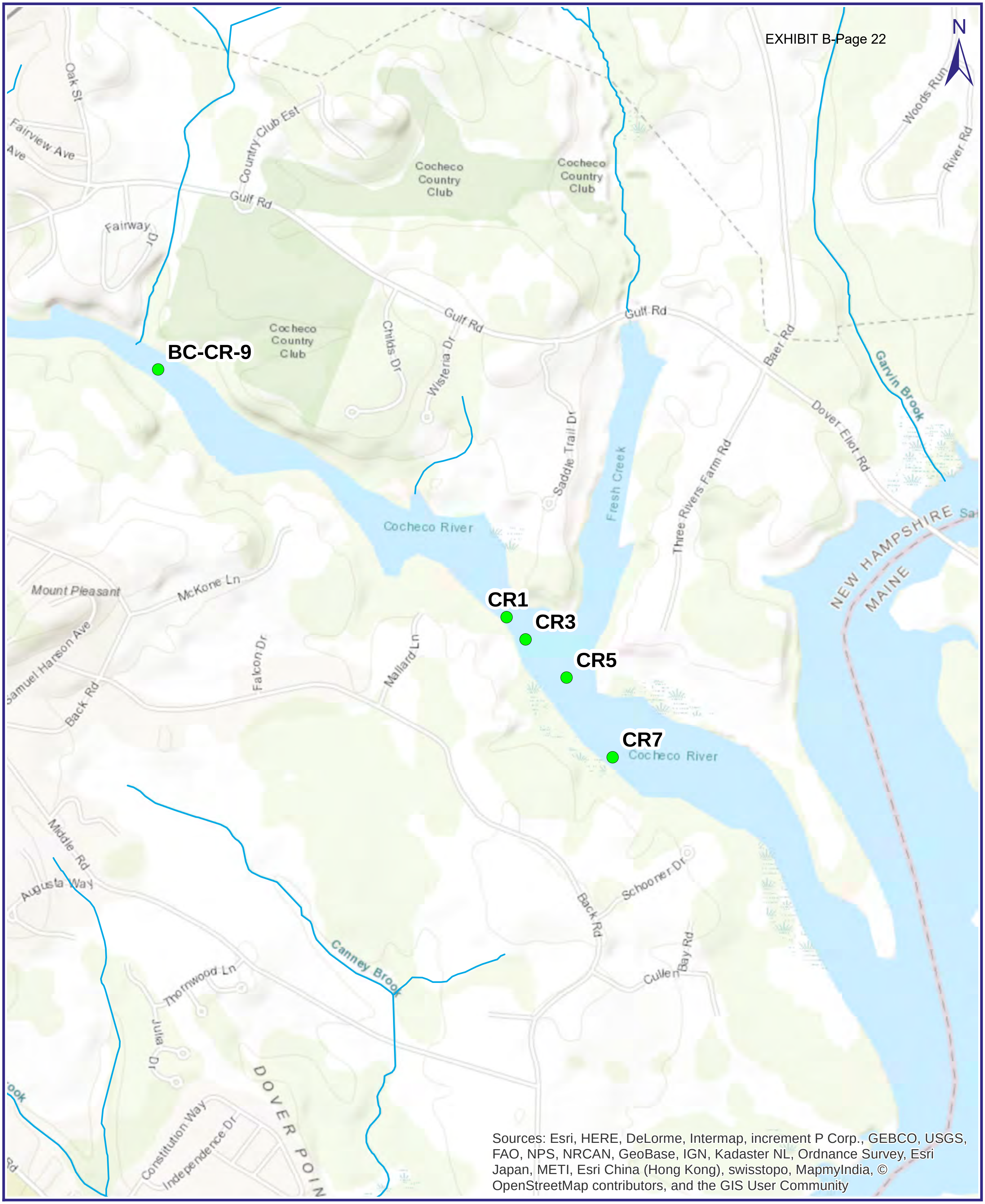
## 3.2 Tidal Cocheco River and Regional Tidal Waters

The tidal segment of interest includes an approximately 18-mile segment of the lower Cocheco River and upper Piscataqua River in Dover, New Hampshire (Figure 3-2). Qualitative and quantitative visual surveys of algal growth were conducted along the tidal study portion of the Cocheco River/upper Piscataqua River to assess the aerial/longitudinal extent, typical form and occurrence of algae. Details of the tidal segment field activities are presented in the following sections.

### 3.2.1 Water Quality and Phytoplankton Sampling

Water quality sampling was conducted to document field conditions and provide a basis of comparison of water quality between sites.

Surface water samples were collected at five locations (refer to Figure 3-2). Sample locations CR-1, CR-3, CR-5 and CR-7 were previously established by the NHDES and sample location BC-CR-9 was established by BC. Water samples were submitted to EAI under chain of custody for chemical analysis. Water samples were analyzed for ammonia-nitrogen, total phosphorus, total nitrogen, TKN, nitrate/nitrite, and chlorophyll-a. Chlorophyll-a samples were not corrected for pheophytin and so are not discussed further in this report. Selected samples were also analyzed for algal taxonomy and the cyanotoxins microcystin-LR and anatoxin-a. Samples were collected and stored using the same protocols as for the non-tidal sampling program. Phytoplankton samples in the tidal waters required a shorted hold time and were delivered to the courier on the same day as sample collection.

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Tidal Station Sampling Locations
August 2nd & September 23rd, 2016

Figure 3-2. Tidal Station Sampling Locations

### 3.2.2 Visual/Photograph Evaluation

A qualitative visual assessment of the river was conducted to supplement information collected at the tidal monitoring stations. The assessment was conducted on August 2, 2016, and again on September 1, 2016 and September 23, 2016 in order to obtain comparative data sets. BC personnel navigated the complete study portion of the river by a motorized boat operated by a qualified captain. Date and time-stamped photographs were collected for the majority of the study segment of the watercourse and immediately adjacent banks. Field personnel collected photographs and recorded general observations of ecological conditions, including plant communities, specific plants/macrophytes identified, descriptions of dense accumulations of macrophytes and incidental observations of wildlife. Photographs and field notes were also collected for other features of interest, such as bank slopes, changes in ecological communities and observations recorded at intersections of the Cocheco River with other water bodies.

In addition to still photographs, video recordings of subaquatic conditions were collected of select areas of the river. Video recordings were collected for randomly selected areas to document general conditions, or where an anomaly (e.g. area of dense macrophyte growth) warranted further subsurface evaluation.

Photographs and video recordings were collected using the same protocols as for the non-tidal sampling program.

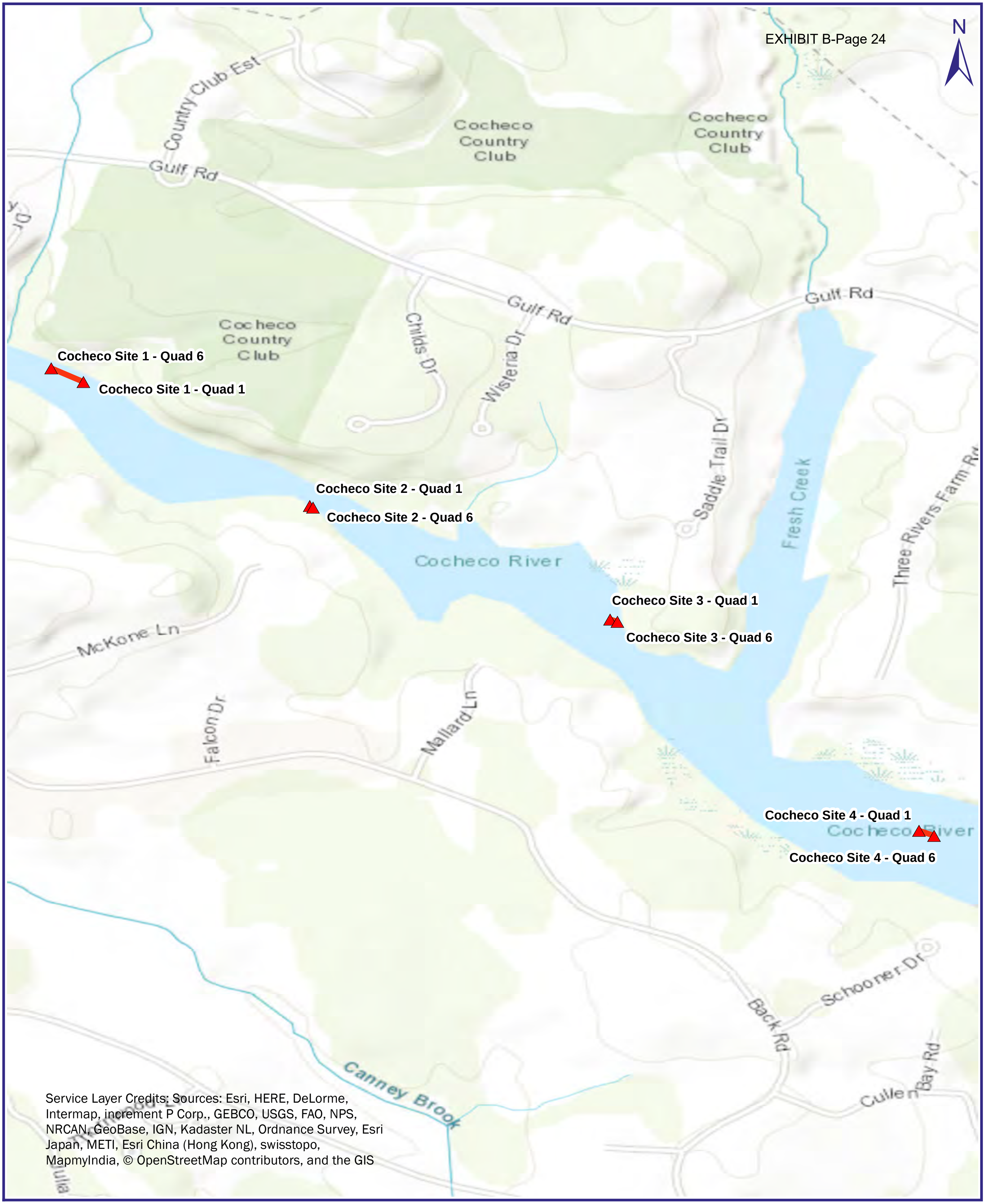
Photograph collection was conducted at, or as close as possible to, the photograph stations established by USEPA Region 1 on September 11, 2014 as presented in the "*Draft – 2014 Macroalgae in the Lower Tidal Cocheco River and Upper Piscataqua*" in order to provide a basis of comparison with the USEPA study.

### 3.2.3 Macroalgae Survey

BC performed field monitoring to document macrophyte occurrence at the following 11 representative stations from September 13th through 16th, 2016:

- 4 stations in the tidal region of the lower Cocheco River,
- 4 stations in the tidal region of the upper Piscataqua River, and
- 3 additional reference stations.

Reference stations were selected in Portsmouth Harbor based on a similarity in conditions to the tidal Cocheco River and Piscataqua River. Monitoring stations along the tidal portion of the Cocheco River/Piscataqua River were positioned at approximately 1,000 to 2,500–foot intervals on alternating riverbanks (e.g. east bank, west bank). Station locations are illustrated on Figure 3-3, Figure 3-4, and Figure 3-5 below.

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Macroalgae Survey Transects - Lower Cocheco River
September 13th - September 16th, 2016

Figure 3-3. Macroalgae Survey Transects – Lower Cocheco River


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Macroalgae Survey Transects – Upper Piscatqua River
September 13th - September 16th, 2016

0 0.075 0.15
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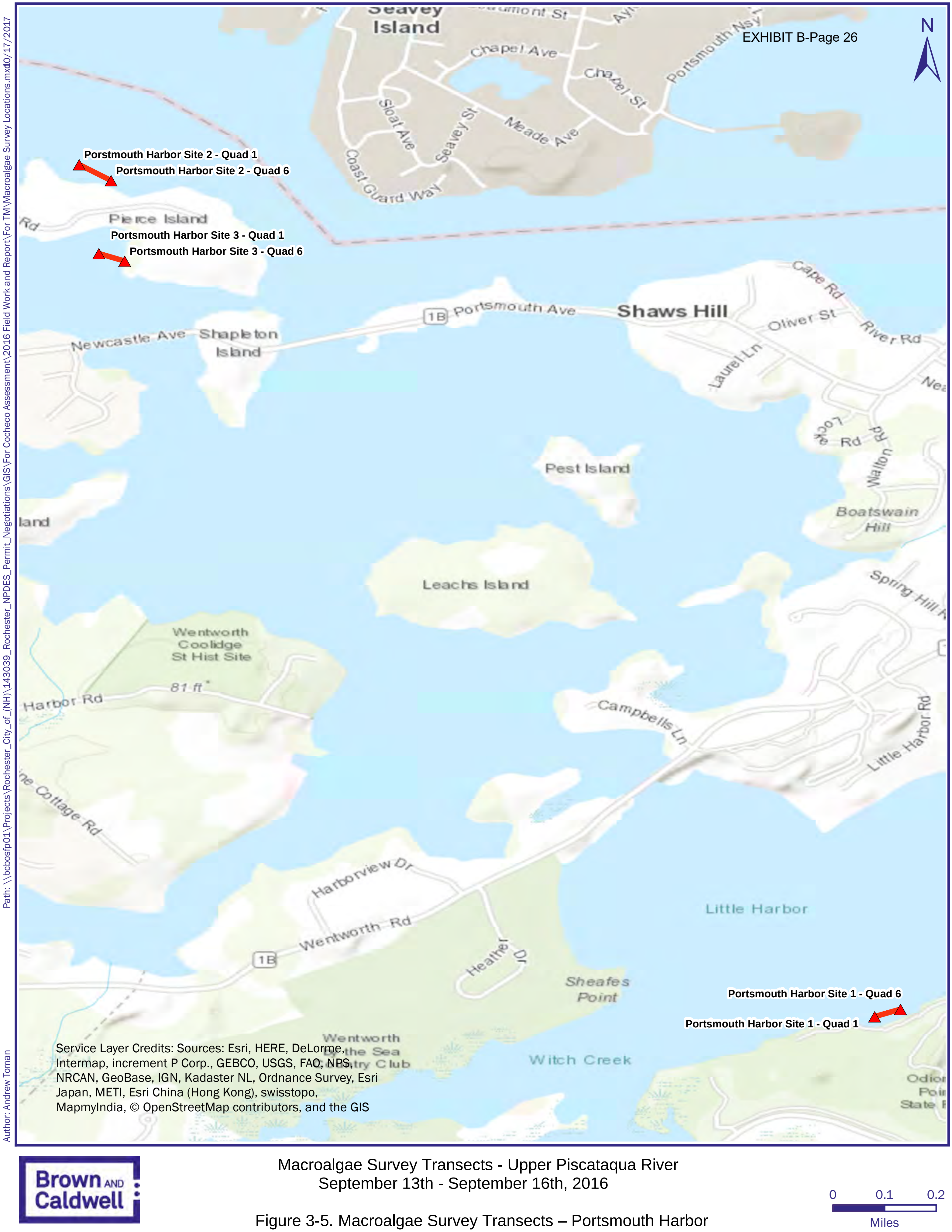
Figure 3-4. Macroalgae Survey Transects – Upper Piscatqua River

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Macroalgae Survey Transects - Upper Piscataqua River
September 13th - September 16th, 2016

Figure 3-5. Macroalgae Survey Transects – Portsmouth Harbor

The macroalgal assessment methodology is based on portions of the standardized methods outlined in the 2013 *NHDES Protocols for Benthic Algal Surveys*, with appropriate modifications drawn from other federal or state agency-approved assessment protocols to accommodate watercourse conditions (e.g. deep water, wide watercourse). A quadrat method was applied at each survey station to assess and document the presence of visible algal features, such as scums, mats or major discolorations (or lack thereof), estimate percent aerial cover and assess a rank value characterizing the extent of algae. Survey activities were conducted at low tide to maximize visibility of the river substrate.

Following collection of general station location information, a transect was established on the riverbank between the mean low tide and mean high tide elevations. The transect was positioned parallel to the water line/shoreline and extended to a length deemed to be physically accessible and representative of the subsegment being evaluated (i.e., transects lengths measure approximately 100 feet to 300 feet). Six quadrat locations were positioned at equal distances along the transect (Quad 1 through Quad 6). Refer to the figures above for the locations of the upstream (Quad 1) and downstream (Quad 6) transect end points at each station. Quadrat locations were temporarily marked in the field using a flexible tape measure. Quadrats measured 36 inches by 36 inches square and were subdivided into 16 viewing units (similar to the viewing bucket method, but larger in viewing scale) for a total of 96 viewing units per stations. Visual assessments were initiated at the downstream transect and progressed upstream. At each of the 6 viewing quadrats, the quadrat structure (36-inch square grid constructed of wooden yard sticks) was positioned on the bank surface and the dominant macrophyte species were identified within each grid unit. At each grid point, conditions were documented by recording the macrophyte (e.g. milfoil, sea weed) and/or plant (e.g. *Spartina*) and then visually estimating the percent aerial cover for each. An average percent cover was calculated for each quadrat and each station in order to estimate the extent of algal accumulation for each station.

Water quality measurements were collected at each station for major field parameters, similar to the methods and parameters described for the non-tidal water quality monitoring described in Section 3.1.1. Photographs were also collected at each monitoring location and of each sampling quadrat. Some monitoring stations and photograph collection was conducted at, or as close as possible to, the photograph stations established by USEPA Region 1 on September 11, 2014 as presented in the "*Draft – 2014 Macroalgae in the Lower Tidal Cocheco River and Upper Piscataqua*" for some stations in order to provide a basis of comparison with the USEPA study. Other station locations were selected to provide an analysis that was representative of the characteristics observed throughout the Tidal Cocheco and upper Piscataqua River. Regional locations, within Portsmouth Harbor, were also selected to allow for a representative characterization of that area. Banking slope, sunlight, soil composition (visual observation), water depth, and proximity to typical low tide depth were some additional factors that were considered in the field when selecting macroalgae sites. The results of the survey are discussed in Section 4.

## 3.3 Regional Non-Tidal Waters

A qualitative visual assessment and water quality sampling of regional non-tidal waterbodies was conducted to support a comparison of conditions identified in the study portion of the non-tidal Cocheco River to conditions at other sites, including those with lower nutrient concentrations. Regional survey sites were selected based on physically accessibility and similarity of ecological and hydraulic conditions to the non-tidal study portion of the Cocheco River. The NHDES "Exotic Aquatic Plant Infestations in New Hampshire" (July 2015) publication was used to identify regional locations experiencing exotic aquatic plant infestations for reference to conditions on the Cocheco River. To the extent practical, regional sites were selected at locations within or near the Cocheco River watershed, but not located on segments where water quality would be expected to be strongly influenced by effluent from wastewater treatment plants. Areas that were inaccessible (i.e., private property, physical barriers) were omitted as survey stations.

Visual assessment of algal growth was conducted at 17 regional non-tidal waterbody sites (Figure 3-6; Table 3-3) on August 30 and 31, 2016. Observations of general and ecological conditions were recorded for each regional site, including assessment of the ecological community structure, plant identification, sunlight conditions, visual estimate of algal location and extent on water surface, identification of dominant algae, incidental observations of wildlife and other discerning features if identified (e.g. rock outcrops, erosional features, trash/debris, outfalls).

**Table 3-3. Regional Non-Tidal Evaluation Sites**

| Site ID | Site Name | Sample Date |
|---|---|---|
| Site 1 | Fire protection pond off of Christmas Lane | 08/30/16 |
| Site 3 | Berry's River Reservoir | 08/30/16 |
| Site 4 | Berry's River, Crown Point Road | 08/30/16 |
| Site 6 | Baxter Lake | 08/30/16 |
| Site 9 | Barnstead Parade Dam | 08/30/16 |
| Site 10 | Brundle Pond | 08/30/16 |
| Site 11 | Snecook Lakes | 08/30/16 |
| Site 12 | Locke Lake | 08/30/16 |
| Site 13 | Jones Pond | 08/30/16 |
| Site 14 | Club Pond | 08/30/16 |
| Site 15 | Scrunton Pond Road | 08/31/16 |
| Site 16 | Oyster River, Mill Pond | 08/31/16 |
| Site 17 | Long Marsh Brook, off of Long Marsh Road | 08/31/16 |
| Site 18 | Lamprey River | 08/31/16 |
| Site 20 | Waldron Mill Pond | 08/31/16 |
| Site 21 | Jones Brook | 08/31/16 |
| Site 22 | Spaulding Pond | 08/31/16 |


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Figure 3-6. Regional Non-Tidal Waterbody Sites

Details of the algal survey field activities completed for the non-tidal portion of the Cocheco River are presented in the following sections.

### 3.3.1 Water Quality Sampling

Water quality samples were collected at 12 of the 17 regional survey locations. The remaining five sites could not be sampled due to access restrictions. Water samples were submitted to EAI under chain of custody for chemical analysis. Water samples were analyzed for ammonia-nitrogen, total phosphorus, total nitrogen, TKN, and nitrate/nitrite. Samples were collected using the same sampling protocols as used for the tidal and non-tidal sections of the Cocheco River. A discussion of analytical results is presented in Section 4.

### 3.3.2 Visual/Photograph Evaluation

Visual assessment of algal growth was conducted at 17 regional non-tidal waterbody sites. Some sites were not accessible because they were on private property. Field personnel collected photographs and observations of general and ecological conditions for each regional site, including assessment of the ecological community structure, plant identification, sunlight conditions, visual estimate of algal location and extent on water surface, identification of dominant macrophytes, incidental observations of wildlife and other discerning features if identified (e.g. rock outcrops, erosional features, trash/debris, outfalls). Date and time-stamped photographs were collected at each regional site.

Photographs and video recordings were collected using the same protocols as for the tidal and non-tidal sampling program for the Cocheco River.

## Section 4

# Results of Field Investigations

The results of the field survey activities completed along the study portion of the Cocheco River are presented in the sections below. Due to the large amount of information that was collected, this section provides concise tabular and graphical summaries of results for the three major study areas (non-tidal Cocheco, tidal Cocheco, and regional non-tidal). More detailed data compilations are provided in the appendices. Whereas Section 4 summarizes the monitoring results, Section 5 builds upon these and the literature review of Section 2 to reach major scientific interpretations relevant to management.

## 4.1 Non-Tidal Cocheco River

This subsection summarizes results for the water quality sampling, visual/photographic evaluation, and viewing bucket surveys that were performed in the non-tidal segment of the Cocheco River. See Section 3 for details on field and laboratory methods.

### 4.1.1 Water Quality Sampling

Water quality sampling results are presented in Table 4-1 on the following page. The overall spatial pattern in total phosphorus and total nitrogen concentration was similar: very low concentrations upstream of the City of Rochester (Station 1), a marked increase below the WWTF outfall (Station 3), and generally decreasing concentrations downstream to Dover (Stations 4, 5, and 6). The downstream decrease in nutrient concentrations is presumably caused by a combination of dilution, settling, and biological uptake. Interestingly, by Station 6, total phosphorus concentrations are nearing levels upstream of the WWTF outfall. Nutrient concentrations also decreased below the Isinglass River confluence, showing the dilution effect of that stream.

| Station | Sample Date | Orthophos-phorus (mg/L as P) | Ammonia (mg/L as N) | Total Phosphorus (mg/L) | Total Nitrogen (mg/L) | TKN (mg/L) | Nitrate+ Nitrite (mg/L as N) |
|---|---|---|---|---|---|---|---|
| Station 1 (Upstream of Rochester) | 8/3/2016 | 0.003 | 0.050 | 0.009 | < 0.5 | < 0.5 | 0.06 |
| Station 3 (near England Rd) | 8/3/2016 | 0.013 | < 0.05 | 0.051 | 3.00 | 0.6 | 2.40 |
| Station 4 (near Covered Bridge Rd) | 8/4/2016 | 0.009 | 0.050 | 0.044 | 3.20 | 1.4 | 1.80 |
| Station 5 (downstream of Watson Rd dam) | 8/4/2016 | 0.004 | 0.060 | 0.032 | 1.03 | 0.6 | 0.43 |
| Station 6 (downstream of Whittier Rd) | 8/4/2016 | 0.007 | 0.050 | 0.025 | 1.05 | 0.6 | 0.45 |
| Station 1 (Upstream of Rochester) | 9/21/2016 | 0.004 | < 0.05 | 0.008 | 0.59 | 0.5 | 0.09 |
| Station 16-CCH (Upstream of Outfall) | 9/21/2016 | 0.006 | < 0.05 | 0.027 | 1.53 | 1.2 | 0.33 |
| Station15-CCH (Downstream of Outfall) | 9/21/2016 | 1.200 | < 0.05 | 1.200 | 3.40 | 0.9 | 2.50 |
| Station 3 (near England Rd) | 9/21/2016 | 1.200 | < 0.05 | 1.300 | 3.10 | 0.6 | 2.50 |
| Station IA (Upstream of Isinglass Confluence) | 9/22/2016 | 1.200 | < 0.05 | 1.200 | 2.20 | < 0.5 | 2.20 |
| Station IB (Downstream of Isinglass Confluence) | 9/22/2016 | 0.610 | < 0.05 | 0.620 | 1.60 | 0.5 | 1.10 |
| Station 4 (near Covered Bridge Rd) | 9/22/2016 | 0.740 | < 0.05 | 0.760 | 1.70 | 0.6 | 1.10 |
| Station 5 (downstream of Watson Rd dam) | 9/22/2016 | 0.006 | 0.070 | 0.039 | 2.20 | 0.9 | 1.30 |
| Station 6 (downstream of Whittier Rd) | 9/21/2016 | 0.004 | < 0.05 | 0.018 | 1.72 | 0.8 | 0.92 |

Table 4-1. Water Quality Sampling Results – Non-Tidal Cocheco River

### 4.1.2 Visual/Photograph Evaluation

The non-tidal study segment is generally characterized by moderate to steeply sloped banks (i.e., approximately 20 to 90 percent) occupied by mature, mixed deciduous-coniferous woodland with a well-developed canopy. Upper slopes (viewed from watercourse) appear to generally contain thin woody growth in the understory, or a relatively open understory and leaf-litter groundcover. Generally, a thick overgrowth of woody shrub and herbaceous vegetation occupies the toe of streambank, with growth often extending over the water surface. Due to the moderate/steep bank slopes, the ordinary high-water mark of the river is distinctive. Localized scour holes and/or sediment bars occur periodically within the watercourse, particularly where the river bends or where a downed tree(s) in the river course has impeded streamflow.

The visual survey indicated that the study portion of the Cocheco River is characterized by two types of segments: free-flowing segments of shallow to moderate depth, and slower-moving, deeper segments that are primarily associated with dam backwaters. The upper segments of the study area (Photograph 1) are narrower and have more shade than the lower segments (Photographs 8-9), which are wide enough to receive sunlight even in the presence of riparian buffers. Most of the banks and beds along the study segment were observed to be vegetated. Few portions of the river bed were observed to be devoid of vegetation; the substrate in these areas were generally comprised of sand, sediment or accumulated organic matter (e.g. partially or undecomposed leaf litter, wood debris).

The dominant species observed along the course are summarized in the Table 4-2. The plant distribution was variable by depth and water velocity. Emergent plants such as pickerelweed and smartweed primarily occurred in shallow areas (<0.75 ft depth) adjacent to the riverbank or shoals. Rooted, submerged macrophytes such as milfoil and pondweed occurred in areas of moderate depth (0.75- 4 feet) with moving water (Photographs 3 & 6).

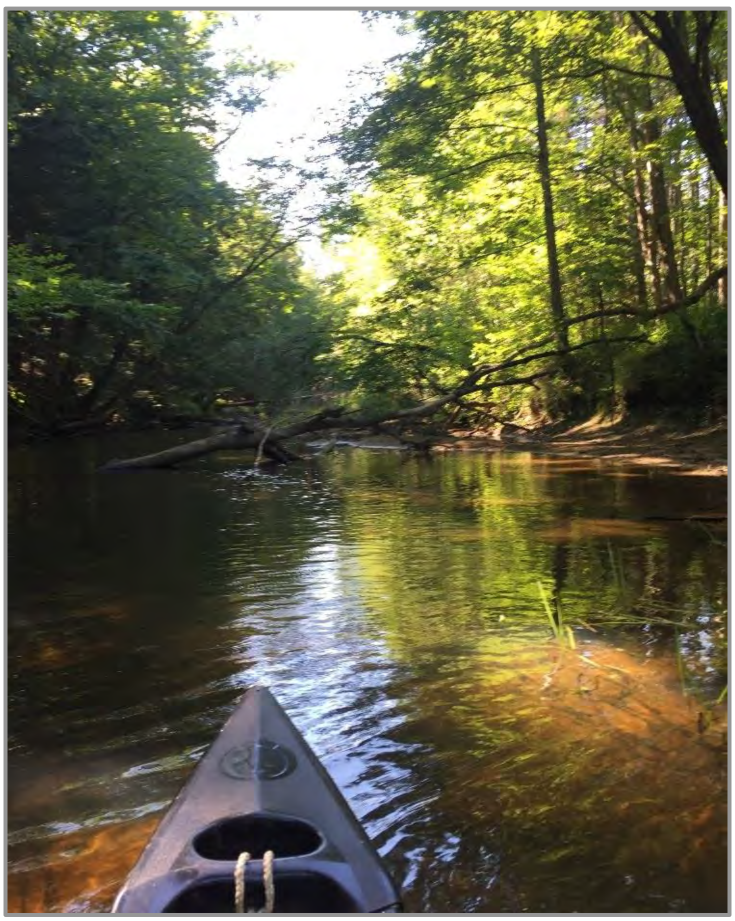
**Table 4-2. Summary of Vegetation Observed Along Non-Tidal Cocheco River During Visual Assessment**

| Common Name | Botanical Name | Growth Habit Within Littoral Zone |
|---|---|---|
| Burreed | *Sparganium americanum* | Emergent Plant |
| Burreed | *Sparganium eurycarpum* | Emergent Plant |
| Pickerelweed | *Pontedaria cordata* | Emergent Plant |
| Smartweed | *Polygonum and Persicaria species* | Emergent Plant |
| Floating Pondweed | *Potamogeton nutans* | Rooted, Upper Leaves Floating |
| Milfoil | *Myriophyllum species* | Rooted, Submerged |
| Duckweed | *Lemna minor* | Floating |
| Watermeal | *Wolffia species* | Floating |

As observed in summer 2015, aquatic vegetation was very common both upstream and downstream of the Rochester WWTF discharge. Station 1 (Cocheco River downstream of Little Falls Bridge Road) is located upstream of both the discharge and the urban area of the City. This site had both emergent and submerged vegetation in similar abundance as observed in many downstream locations (Photographs 4 and 5). Phosphorus concentrations at Station 1 were very low (0.008 – 0.009 mg/L; Table 4-1). In general, there was no spatial correlation observed between plant growth or phosphorus concentrations or any other water quality parameters in the Cocheco River. Rather, the plant distribution was more strongly associated with water depth and velocity as discussed above.

The occurrence of floating plants (duckweed and watermeal) was relatively low in August 2016. Whereas duckweed covered 250-400 ft segments in dam backwaters in summer 2015 (Brown and Caldwell, 2016), in August 2016 it was primarily restricted to very small patches in littoral waters (Photograph 2) and dam backwaters. Duckweed occurrence in September 2016 was slightly higher than during the August 2016 field visit, but it was still restricted to a narrow fringe in some littoral zones and short (100-200 ft) segments in dam backwaters (Photograph 10).

It is not clear why floating plants were slower to develop and less extensive in 2016 than in 2015. One major difference between the two years is that streamflows were lower in 2016 due to drought. For example, the average September-July streamflow in the Cocheco River near Rochester (USGS gage 01072800) was 27 cfs in 2015, but only 7 cfs in 2016. In theory, lower streamflows might be expected to favor duckweed/watermeal growth by creating more quiescent conditions and providing less dilution of wastewater-derived nutrient concentrations. Sampling by City staff demonstrated that median summer total phosphorus concentrations below the Rochester WWTF outfall (Station 15-CCH) were generally higher in summer 2016 than summer 2015, as would be expected given the lower streamflows in 2016. Hence, any differences in floating plant coverage between 2016 and 2015 were clearly not due to differences in phosphorus availability. Another possibility is that the moderate streamflows actually stimulate duckweed growth more than lower streamflows, or that the higher streamflows simply cause more visible occurrence of floating plants by transporting it downstream to locations where it accumulates (e.g. dam backwaters).



Photograph 1. (08/03/16) – View looking south along non-tidal Cocheco River at typical fallen snags and woody debris observed at intervals along the river.

Photograph 2. (08/03/16) - Typical duckweed occurrence observed along the non-tidal Cocheco River in August 2016. Typical growth of subaquatic rooted macrophytes is visible in the photograph.

Photograph 3. (09/21/16) - Typical view of subaquatic macrophyte growth observed within the littoral zone of the non-tidal Cocheco River.

### 4.1.3 Viewing Bucket Surveys

Water depths measured at viewing bucket survey stations (Figure 3-1) along the non-tidal portion of the Cocheco River were generally recorded to be 0.75 to 4 feet, and streamflow velocities were measured at approximately 0.2 to 2 feet per second. Table 4-3 provides a summary of the results from the first and second surveys conducted during the summer of 2016. Viewing bucket results from the August and September 2016 events were similar overall. The most common types of coverage were thin (≤1 mm) to moderate (1- 5 mm) mats of algae and strands of filamentous algae less than 15 cm long. It should be emphasized that viewing bucket survey locations were shallower than the great majority of the study reach. Benthic algae is likely to be higher at the viewing bucket survey locations than in most Cocheco River locations, due to higher light at the river bottom in shallow locations. Hence, most of the study reach had lower amounts of filamentous algae than the viewing bucket locations.

**Table 4-3. Summary of Algal Survey Results By Station**

**Survey 1 – 8/3/2016 – 8/4/2016**

| Station | Macroalgae | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Algal Crust |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. < 5 cm | 2. > 5cm & <15 cm | 3. =15 cm | 0. no visible layer | 1. transparent layer | 2. 0.1 - 1.0 mm Thick | 3. 1 - 5 mm Thick | 4. 5 mm - 2 cm Thick | 5. > 2 cm Thick | | | | |
| 1 | 0% | 16% | 26% | 6% | 14% | 16% | 12% | 0% | 0% | 7% | 3% | 0% | 0% |
| 3 | 0% | 0% | 0% | 19% | 24% | 5% | 0% | 0% | 0% | 16% | 36% | 0% | 0% |
| 4 | 0% | 50% | 3% | 0% | 2% | 5% | 13% | 0% | 0% | 9% | 0% | 18% | 0% |
| 5 | 5% | 51% | 0% | 0% | 4% | 9% | 21% | 0% | 0% | 0% | 8% | 0% | 0% |
| 6 | 24% | 4% | 0% | 0% | 59% | 10% | 1% | 0% | 0% | 0% | 2% | 0% | 0% |

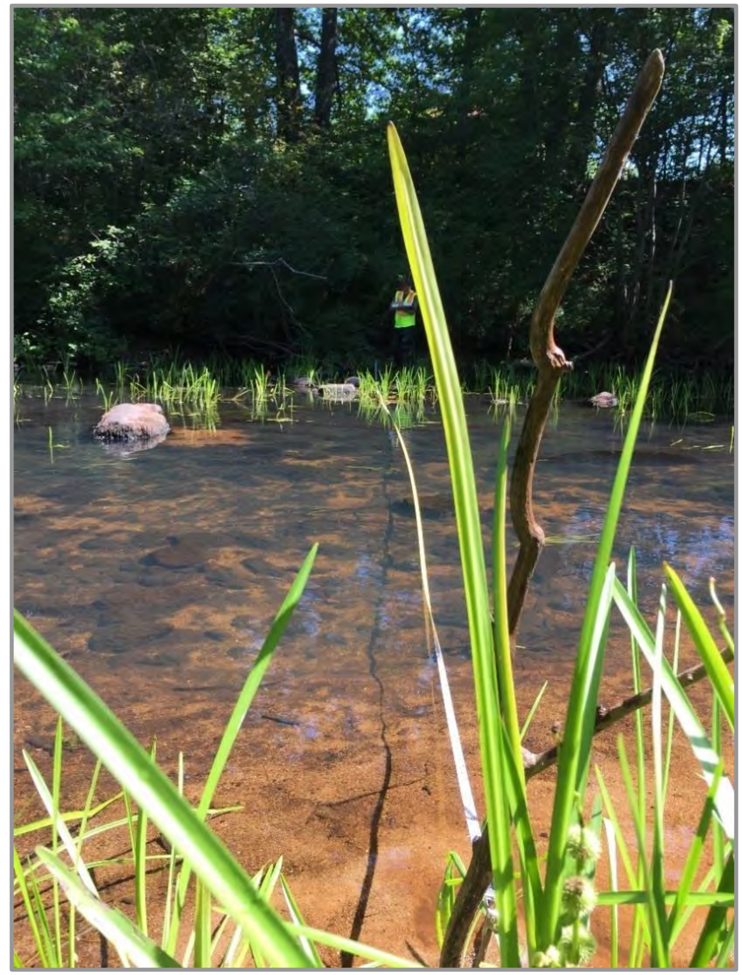
**Survey 2 – 9/21/2016 – 9/22/2016**

| Station | Macroalgae | | | Mat | | | | | | Sand Clay Mud | Plant | Moss | Algal Crust |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1. < 5 cm | 2. > 5cm & <15 cm | 3. =15 cm | 0. no visible layer | 1. transparent layer | 2. 0.1 - 1.0 mm Thick | 3. 1 - 5 mm Thick | 4. 5 mm - 2 cm Thick | 5. > 2 cm Thick | | | | |
| 1 | 0% | 59% | 0% | 0% | 2% | 22% | 13% | 0% | 0% | 2% | 1% | 0% | 0% |
| 3 | 7% | 12% | 0% | 16% | 30% | 17% | 5% | 0% | 0% | 9% | 5% | 0% | 0% |
| 4 | 0% | 63% | 0% | 0% | 0% | 5% | 32% | 0% | 0% | 0% | 1% | 0% | 0% |
| 5 | 0% | 50% | 0% | 0% | 4% | 28% | 18% | 0% | 0% | 0% | 0% | 0% | 0% |
| 6 | 17% | 2% | 1% | 16% | 33% | 21% | 9% | 0% | 0% | 2% | 0% | 0% | 0% |

Table 4-4 provides the overall visual algal scores that we assigned to each station by assessing the viewing bucket survey results. The scale of the scoring metric ranges from 0.0 to 4.0, but have no specific thresholds or regulatory interpretation; rather, they are simply a convenient way to summarize survey results into a single value for comparison of sites. As shown in Table 4-4, the Cocheco River viewing bucket survey sites could be characterized as having low (0—1) to moderate (1—2) algal coverage. There was no obvious pattern in the scores related to longitudinal location along the river or phosphorus concentrations. Station 1—which is located upstream of Rochester and had relatively low (0.008 – 0.009 mg/L) phosphorus concentrations—had a visual algal score that was higher than the first station (3) downstream of the Rochester WWTF outfall, and comparable to that of other stations downstream.

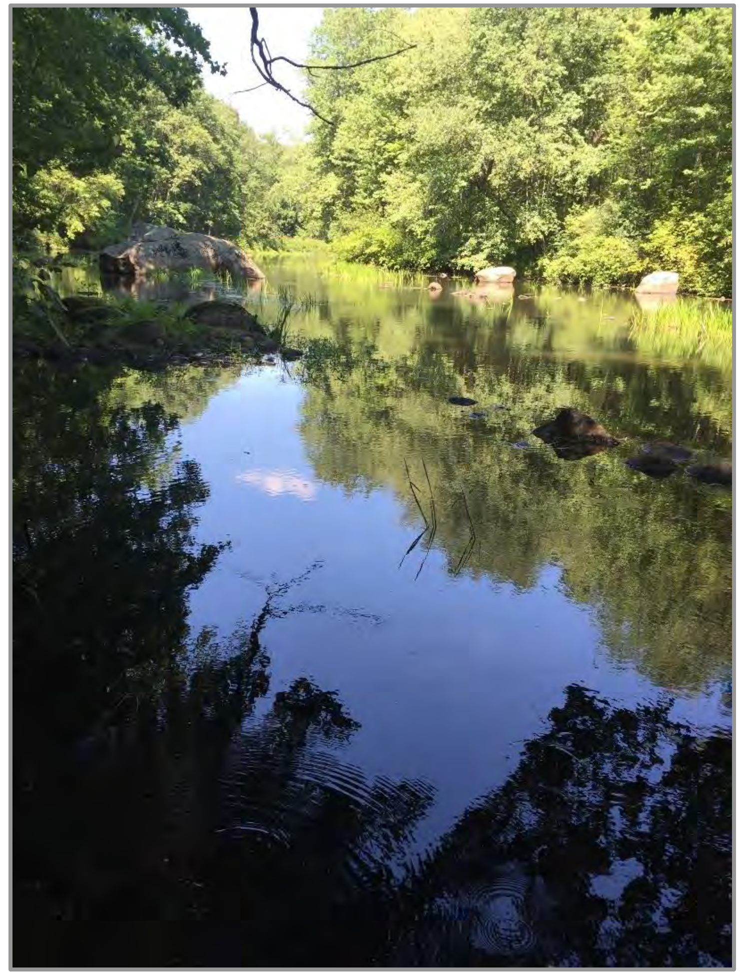
| Table 4-4. Overall Visual Algal Scores by Station [Based on of Scale of 0.0 to 4.0] | | |
|---|---|---|
| Station | Visual Algal Score | |
| | Survey 1 (Aug 3-4, 2016) | Survey 2 (Sep 21-22, 2016) |
| 1 | 2.0 | 2.1 |
| 3 | 1.1 | 1.2 |
| 4 | 2.0 | 2.3 |
| 5 | 2.1 | 2.1 |
| 6 | 1.2 | 1.2 |

Photograph 4. (08/03/16) - View of non-tidal Cocheco River Station 1 looking upstream (north). Existing beaver dam visible in photograph background (below bridge).



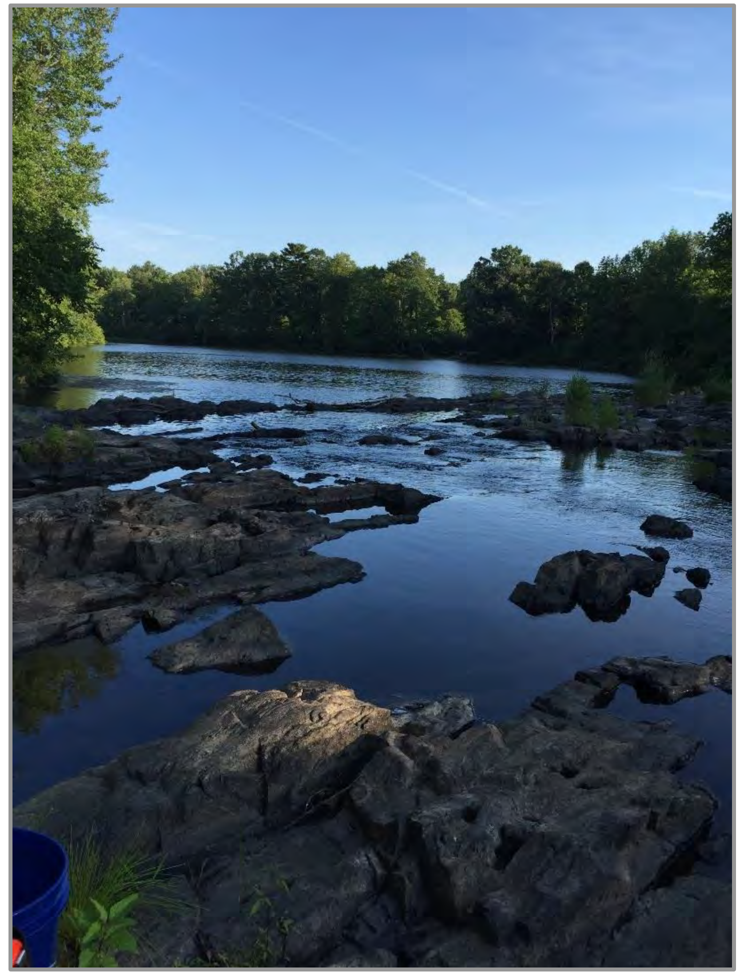
Photograph 5. (08/03/16) - View of non-tidal Cocheco River looking east at a typical Station 1 viewing bucket transect.

Photograph 6. (08/03/16) – View of non-tidal Cocheco Station 3 looking upstream (north).

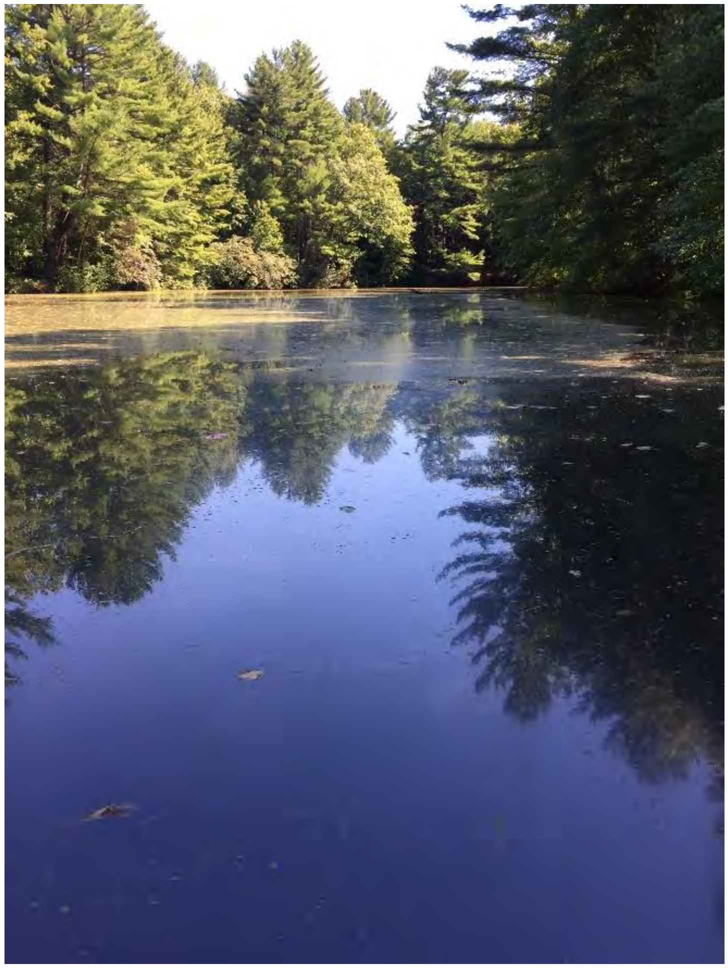


Photograph 7. (08/04/16) – View of non-tidal Cocheco River Station 4 looking upstream (north).

Photograph 8. (08/04/16) – View of non-tidal Cocheco Station 5 looking downstream (south).



Photograph 9. (08/04/16) – View of non-tidal Cocheco Station 6 looking downstream (south).



Photograph 10. (9/23/2017) – Duckweed in quiescent backwater of Watson Dam.

## 4.2 Tidal Cocheco River and Regional Tidal Waters

As described in Section 3, an 18-mile tidal study segment of the Cocheco River and upper Piscataqua River was evaluated to assess the aerial and longitudinal extent, as well as the typical form and occurrence, of algae. In addition, a visual assessment of regional tidal water bodies within the Cocheco River/Piscataqua River watershed were evaluated for comparison. The results of the visual assessment and sampling completed to support the tidal study segment assessment are presented below.

### 4.2.1 Water Quality Sampling

The results from the tidal water quality sampling are summarized in Tables 4-5, 4-6, and 4-7 and correspond to the locations identified on Figure 3-2. Water quality conditions were generally favorable during both the August and September 2016 field visits. No violations of DO, pH, or ammonia criteria were observed. The cyanotoxins microcystin-LR and anatoxin-a were non-detectable in all samples.

Algal taxonomic analysis (Table 4-8) revealed that the dominant algal groups in most samples were the diatoms and a class of green algae (*Chlorophyceae*). Cyanobacteria, golden algae (*Chrysophyceae*), and another class of green algae (*Charophyceae*) were minor components or were largely absent in most samples. The exception was a single sample collected from Station CR-5 on September 1, 2016 in which cyanobacteria were the dominant group. However, cyanotoxins were not detected in this sample. Overall, the algal community could be characterized as benign and typical of an upper estuary segment, without evidence of harmful algal blooms or other phytoplankton-related impairments of beneficial uses.

| Table 4-5. Water Quality Sampling Results – Tidal Cocheco River | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | Sample Date | Sample Time - finish (24 hr) | Ortho Phosphate-P (mg/L) | Ammonia - N (mg/L) | Total Phosphorus - P (mg/L) | Total Nitrogen (mg/L) | TKN (mg/L) | Nitrate/ Nitrite-N (mg/L) | Total Suspended Solids (mg/L) |
| CR-1 | 8/2/16 | 11:05:00 | 0.120 | -- | -- | <1 | <1 | <0.05 | 8 |
| CR-3 | 8/2/16 | 11:25:00 | 0.110 | -- | -- | <1 | <1 | 0.08 | 7 |
| CR-5 | 8/2/16 | 11:54:00 | 0.140 | -- | -- | <1 | <1 | 0.07 | 6 |
| CR-1 | 9/1/16 | 11:24:00 | 0.140 | < 0.05 | 0.040 | 1.06 | 1 | 0.06 | 8 |
| CR-5 | 9/1/16 | 11:09:00 | 0.140 | < 0.05 | 0.120 | 2.06 | 2 | 0.06 | 8 |
| BC-CR-9 | 9/1/16 | 11:52:00 | 0.140 | < 0.05 | 0.080 | 1.00 | 1 | < 0.05 | 7 |
| CR-1 | 9/23/16 | 11:12:00 | 0.100 | 0.050 | 0.060 | -- | < 1 | 0.17 | 9 |
| CR-5 | 9/23/16 | 11:30:00 | 0.110 | 0.080 | 0.070 | -- | < 1 | 0.11 | 12 |
| BC-CR-9 | 9/23/16 | 11:00:00 | 0.100 | 0.070 | 0.050 | -- | < 1 | 0.19 | 7 |

| Table 4-6. Field Monitoring Results – Tidal Cocheco River | | | | | | |
|---|---|---|---|---|---|---|
| Sample ID | Sample Date | Water Temp. (°C) | pH | Diss. Oxygen (mg/L) | Spec. Cond. (mS/cm) | Turbidity (NTU) |
| CR-1 | 8/2/16 | 23.3 | 7.5 | 6.5 | 89.2 | -- |
| CR-3 | 8/2/16 | 23.3 | 7.6 | 6.6 | 9.9 | -- |
| CR-5 | 8/2/16 | 23.0 | 7.6 | 7.1 | 9.9 | -- |
| CR-1 | 9/1/16 | 22.7 | 8.0 | 6.8 | 41.1 | 1.4 |
| CR-5 | 9/1/16 | 22.7 | 8.0 | 6.8 | 41.6 | 1.5 |
| BC-CR-9 | 9/1/16 | 23.3 | 8.1 | 8.2 | 39.2 | 1.4 |
| CR-1 | 9/23/16 | | 7.7 | 10.0 | 25 | 36.1 |
| CR-5 | 9/23/16 | 21.1 | 7.6 | 10.3 | 23 | 2.1 |
| BC-CR-9 | 9/23/16 | 20.3 | 7.6 | 9.3 | 35 | 71 |

| Table 4-7. Algal Taxonomy and Algal Toxin Results – Tidal Cocheco River | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample ID | Sample Date | Total Cell count (cells / mL) | Cyanobacteria (cells/mL) | Chlorophyceae (cells / mL) | Bacillariophyceae (cells / mL) | Chrysophyceae (cells / mL) | Charophyceae (cells / mL) |
| CR-1 | 8/2/2016 | 50 | <1 | 4 | 22 | 0 | 24 |
| CR-3 | 8/2/2016 | 56 | <1 | 4 | 20 | 0 | 32 |
| CR-5 | 8/2/2016 | 24 | <1 | 8 | 10 | 0 | 6 |
| DUP-1 | 8/2/2016 | 20 | <1 | 8 | 12 | 0 | <1 |
| CR-5 | 9/1/2016 | 32,458 | 30,788 | 1,650 | 20 | 0 | 0 |
| CR-1 | 9/1/2016 | 1682 | 24 | 1,550 | 108 | 0 | 0 |
| BC-CR-9 | 9/1/2016 | 91,206 | <1 | 91,150 | 56 | 0 | 0 |
| DUP-1 | 9/1/2016 | 1,560 | <1 | 1416 | 144 | 0 | 0 |
| DUP | 9/23/2016 | 2,292 | <1 | 548 | 1,744 | 0 | 0 |
| CR-1 | 9/23/2016 | 4,204 | 284 | 372 | 3,408 | 140 | 0 |
| CR-5 | 9/23/2016 | 2,772 | <1 | 1000 | 1,772 | 0 | 0 |
| BC-CR-9 | 9/23/2016 | 5,192 | <1 | 3,290 | 1,844 | 58 | 0 |

| Table 4-8. Algal Taxonomic Analysis | | | |
|---|---|---|---|
| Station | Date | Microcystin-LR (µg/L) | Anatoxin-a (µg/L) |
| CR-1 | 8/2/2016 | <0.15 | <0.05 |
| CR-3 | 8/3/2016 | <0.15 | <0.05 |
| CR-5 | 8/3/2016 | <0.15 | <0.05 |
| CR-1 | 9/1/2016 | <0.15 | <0.05 |
| CR-5 | 9/1/2016 | <0.15 | <0.05 |
| BC-CR-9 | 9/1/2016 | <0.15 | <0.05 |
| CR-1 | 9/23/2016 | <0.15 | <0.05 |
| CR-5 | 9/23/2016 | <0.15 | <0.05 |
| BC-CR-9 | 9/23/2016 | <0.15 | <0.05 |

### 4.2.2 Visual/Photo Evaluation

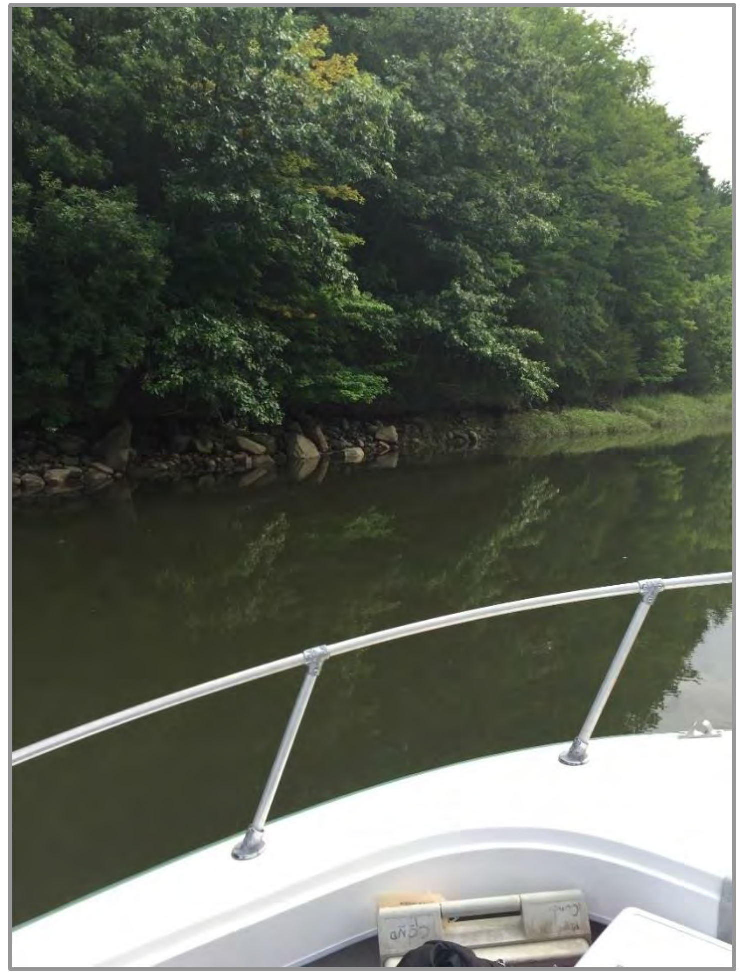
The visual survey indicated that the most upstream portions of the tidal Cocheco River are similar to the downstream non-tidal portions of the Cocheco River with respect to general habitat. Upstream is characterized by moderately to steeply sloped banks, some of which consist of a shear rock outcrop with visible moss lines and/or water staining indicating the high-water mark. Vegetation includes mature, mixed deciduous-coniferous woodland. The tidal study segment is wider than the non-tidal segment, therefore, the overstory canopy is not closed over the water. However, vegetation does extend over the high-water line in most areas along the banks. The woodland appears to be more heavily dominated by deciduous trees vs. conifers compared to the non-tidal study area.

As the lower Cocheco transitions to the Piscataqua River, the channel becomes progressively wider, bank slopes become more level, residential development increases and the vegetation community becomes occupied with more open, maintained lawn areas and narrow bands of mudflats vegetated primarily with herbaceous plants and grasses (e.g. *Spartina* species) at the toe of bank slopes. The focus of this assessment was to qualitatively evaluate the aerial and longitudinal extent, as well as the typical form and occurrence, of macroalgae. As such, a comprehensive inspection or inventory of emergent plants along the banks/riparian corridor was not completed.

The visual survey generally indicated that macroalgae depositions occurred at equal frequency and accumulations were of similar size throughout the tidal Cocheco and upper Piscataqua Rivers.

The results of the survey identified sea lettuce (*Ulva lactuca*) and seaweed (*Ascophyllum nodosum*) as the dominant macroalgal species in the tidal study segment. Sea lettuce was observed much more frequently compared to seaweed. The most common occurrence of these macroalage was as small, sparse patches in shallow subtidal zones (0-5 feet deep) (Photographs 20, 23, and 24) and as deposits on tidal flats (Photographs 17, 18, 19, 22, and 24). Many of the deposits on tidal flats occurred as tidal wracks, which had the effect of concentrating the macroalgae locally. Approximate measurements were collected of algae depositions observed on the river banks at low tides. Accumulations typically measured 5 to 15 feet wide (a few at 50 to 70 feet wide) and 75 to 300 feet long (a few at 500 or 1,000 feet long). In a few locations, sea lettuce was observed floating at the surface in boat wakes (Photograph 14), but most locations did not have floating macroalgae (Photographs 11, 12, 13, and 15). Due to the sparseness of the macroalgae in subtidal zones, the overall biomass could visually be characterized as low in most locations in both the Cocheco and upper Piscataqua Rivers. The densest accumulations of macroalgae on tidal flats were similar in appearance to those photographs by USEPA in 2014, but these were simply the most visible accumulations, and not necessarily representative of most locations. Many tidal flats had some visible macroalage but relatively low density and/or areal coverage (Photographs 17, 18, 20), and the typical amount of macroalage was low relative to the 2014 USEPA photographs.

Photograph 11. (08/02/16) - View of tidal Lower Cocheco River at the upstream starting point of the study segment.



Photograph 12. (08/02/16) - Typical view of tidal riverbank. Banks were observed to be occupied by mudflats at low tide, salt grass and other aquatic plants along the littoral fringe and occasional rock outcrops.
Banks are generally forested above the river high water line.

Photograph 13. (08/02/16) - Typical view of tidal Cocheco River study segment.

Photograph 14. (08/02/16) - View of floating Sea Lettuce (*Ulva lactuca*) observed trailing in a motorboat wake.

Photograph 15. (08/02/16) - Typical view of tidal riverbank. Banks were observed to be occupied by mudflats at low tide, salt grass and other aquatic plants along the littoral fringe and occasional rock outcrops. Banks are generally forested above the river high water line. A private dock associated with a residential home is frequently observed along the study segment.

Photograph 16. (08/02/16) - Typical view of residential property and private dock located along tidal Cocheco River.

Photograph 17. (09/01/16) – Cocheco River.
(Photograph location is proximate to EPA Photograph 12 collected in 2014)

Photograph 18. (09/01/16) – Cocheco River. (Photograph location is proximate to EPA Photograph 12 collected in 2014)

Photograph 19. (09/01/16) – Cocheco River.
(Photograph location is proximate to EPA Photograph 14 collected in 2014)

Photograph 20. (09/01/16) – Cocheco River. (Photograph location is proximate to EPA Photograph 14 collected in 2014)

Photograph 21. (09/01/16) – Mouth of Cocheco River. (Photograph location is proximate to EPA Photographs 17 and 24 collected in 2014)

Photograph 22. (09/01/16) – Mouth of Cocheco River. (Photograph location is proximate to EPA Photographs 17 and 24 collected in 2014)

Photograph 23. (09/01/16) – Mouth of Cocheco River. (Photograph location is proximate to EPA Photographs 17 and 24 collected in 2014)

Photograph 24. (09/01/16) – Upper Piscataqua River. (Photograph location is proximate to EPA Photograph 37 collected in 2014)

Photograph 25. (09/01/16) - Upper Piscataqua River. (Photograph location is proximate to EPA Photograph 37 collected in 2014)

Photograph 26. (09/01/16) - Upper Piscataqua River. (Photograph location is proximate to EPA Photograph 56 collected in 2014)

Photograph 27. (09/01/16) - Upper Piscataqua River. (Photograph location is proximate to EPA Photograph 56 collected in 2014)

### 4.2.3 Macroalgae Surveys

Quantitative field monitoring was conducted at 11 representative stations in the tidal region of the lower Cocheco River, upper Piscataqua River and Portsmouth Harbor reference sites. Station locations are shown on Figures 3-3 through 3-5.

**Table 4-9. Summary of Macroalgae Survey Transect Results**

| | % Cover Sea Lettuce | % Cover Seaweed | % Unknown Macrophyte |
|---|---|---|---|
| Portsmouth Harbor - Site 1 | 0.0 | 0.6 | 0.1 |
| Portsmouth Harbor - Site 2 | 2.0 | 0.0 | 0.0 |
| Portsmouth Harbor - Site 3 | 0.3 | 0.0 | 0.0 |
| Cocheco River - Site 1 | 0.0 | 0.0 | 0.0 |
| Cocheco River - Site 2 | 0.3 | 0.0 | 0.0 |
| Cocheco River - Site 3 | 0.3 | 0.0 | 0.0 |
| Cocheco River - Site 4 | 0.2 | 0.0 | 0.0 |
| Piscataqua River - Site 5 | 34.5 | 0.0 | 0.0 |
| Piscataqua River - Site 6 | 13.2 | 0.4 | 0.0 |
| Piscataqua River - Site 7 | 0.5 | 0.0 | 0.0 |
| Piscataqua River - Site 8 | 7.1 | 0.4 | 0.0 |

The results of the field study indicate that macroalgae occurrence in the Lower Cocheco River was generally low at the time of the September 2016 field survey. While small amounts of sea lettuce were observed, other types of seaweed were largely absent from the transect locations. Based on the form and occurrence observed, the presence of sea lettuce may result in part from plant debris migrating upstream during tidal fluctuations or within the flow of motorboat wakes, and not necessarily or entirely rooted growth. Sea lettuce anchored to a holdfast (e.g. soil or woody debris) was only observed in the Piscataqua River. Occurrence of sea lettuce was observed to increase moderately and occurrence of seaweed was observed to increase slightly in the downstream Upper Piscataqua River.

The results of the September 2016 regional macroalgae site evaluation indicate that macroalgae growth (including sea lettuce and seaweed) was ubiquitous throughout the Cocheco River and Piscataqua River watersheds, but was low in overall biomass and coverage. Low to moderate sea lettuce was observed at regional sites, including deposits along the shoreline and anchored to a holdfast. Seaweed occurrence was also commonly observed, as both deposits and anchored to riverbeds or by holdfast to debris (e.g. brick, stone). Some of the highest accumulations of seaweed occurred in Portsmouth Harbor (Photograph 42), deposited by the tide, despite the relatively low nutrient concentrations in the low portion of this estuarine system. Given the low to moderate level of macroalgae, there was no indication that it impaired beneficial uses of the system.

Photograph 28. (09/16/16) - Cocheco River Site 1: View looking downstream (from Quadrat 1 toward Quadrat 6).

Photograph 29. (09/16/16) - Cocheco River Site 1: View of typical monitoring quadrat (Quad 2).

Photograph 30. (09/13/16) - Cocheco River Site 2: View looking upstream (from Quadrat 6 toward Quadrat 1).

Photograph 31. (09/13/16) - Cocheco River Site 3: View looking upstream (from Quadrat 6 toward Quadrat 1).

Photograph 32. (09/13/16) - Cocheco River Site 4: View looking downstream (from Quadrat 1 toward Quadrat 6).

Photograph 33. (09/13/16) - Cocheco River Site 4: Typical Sea Lettuce (*Ulva lactuca*) observed anchored to holdfast in proximity of Site 4 transect.

Photograph 34. (09/14/16) - Seaweed accumulation (anchored by holdfast) observed in tidal Cocheco River (proximate to Site 7).

Photograph 35. (09/14/16) - Piscataqua River Site 5: View looking upstream (from Quadrat 6 toward Quadrat 1).

Photograph 36. (09/14/16) - Piscataqua River Site 6: View looking downstream (from Quadrat 1 toward Quadrat 6).

Photograph 37. (09/14/16) - Piscataqua River Site 6: View of typical monitoring quadrat (Quad 2).

Photograph 38. (09/14/16) - Piscataqua River Site 7: View looking upstream (from Quadrat 6 toward Quadrat 1).

Photograph 39. (09/14/16) - Piscataqua River Site 8: View looking upstream (from Quadrat 6 toward Quadrat 1).

Photograph 40. (09/15/16) - Portsmouth Harbor Site 1: View looking east (from Quadrat 1 toward Quadrat 6).

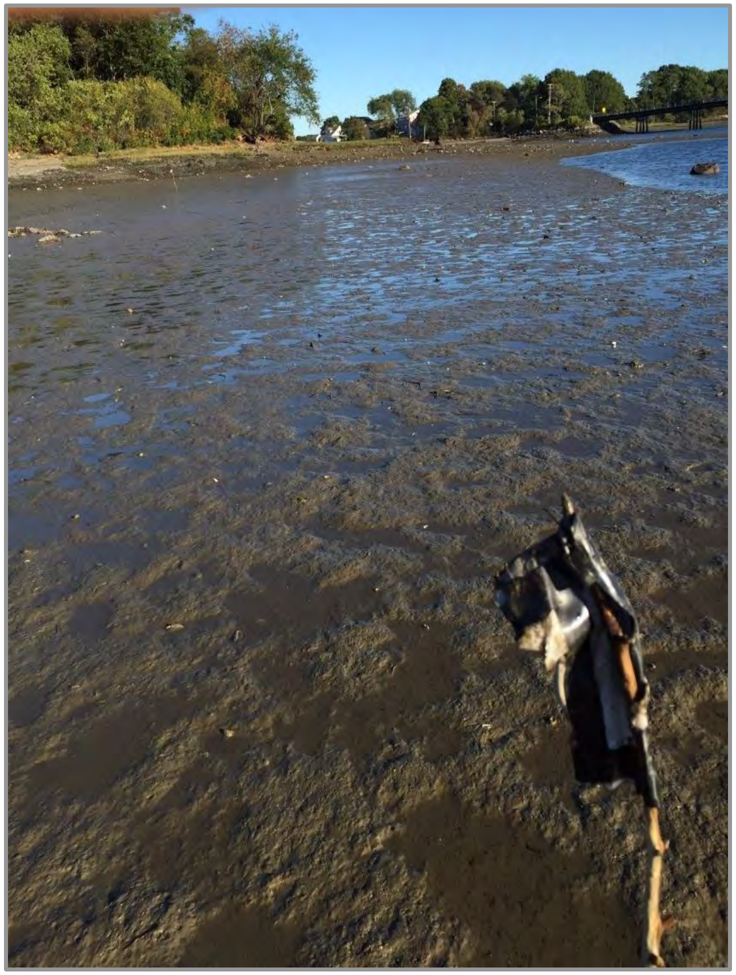
Photograph 41. (09/15/16) - Portsmouth Harbor Site 1: Subaquatic macrophyte (Sea Lettuce) growth observed anchored to holdfast at low tide.

Photograph 42. (09/15/16) - Portsmouth Harbor Site 1: Macrophyte (seaweed) accumulation on shoreline east of Site 1 transect. Seaweed was observed to be freely deposited on beach, as well as anchored by holdfast to shoreline rock and debris (e.g. weathered concrete).

Photograph 43. (09/15/16) - Portsmouth Harbor Site 2: View looking west (from Quadrat 6 toward Quadrat 1).

Photograph 44. (09/15/16) - Portsmouth Harbor Site 2: View of typical monitoring quadrat (Quad 4).


Photograph 45. (09/15/16) - Portsmouth Harbor Site 2: Macrophyte (Sea Lettuce) observed on shore at Site 2.



Photograph 46. (09/15/16) - Portsmouth Harbor Site 3: View looking east (from Quadrat 1 toward Quadrat 6).

Photograph 47. (09/15/16) - Portsmouth Harbor Site 2: Macrophyte (Sea Lettuce) observed proximate to transect.

# 4.3 Regional Non-Tidal Waters

An assessment was conducted at 17 regional non-tidal water bodies in southern New Hampshire (Figure 3-6). Sites were generally characterized by quiescent or slow-moving freshwater and riparian corridors heavily vegetated with mature, mixed deciduous-coniferous woodland, well-developed canopy and thick shrub/herbaceous plant growth along the banks.

## 4.3.1 Water Quality Sampling

Table 4-10 presents the nutrient sampling results for the regional sites. Results from the Cocheco River for August 2016 are included in the table for comparison. These results show that ammonia concentrations were low at most sites; otherwise, nutrient concentrations were highly variable between sites. Regional sites had nutrient concentrations that were both higher and lower than the Cocheco River.

**Table 4-10. Nutrient Concentrations at Regional Sites**

| Sample ID | Sample Date | Ortho Phosphate-P (mg/L) | Ammonia – N (mg/L) | Total Phosphorus – P (mg/L) | Total Nitrogen (mg/L) | TKN (mg/L) | Nitrate/Nitrite-N (mg/L) |
|---|---|---|---|---|---|---|---|
| Site 9 | 8/30/2016 | < 0.002 | < 0.05 | 0.012 | 0.90 | 0.9 | < 0.05 |
| Site 10 | 8/30/2016 | < 0.002 | < 0.05 | 0.013 | 0.95 | 0.9 | 0.05 |
| Site 11 | 8/30/2016 | < 0.002 | < 0.05 | 0.006 | 0.87 | 0.8 | 0.07 |
| Site 12 | 8/30/2016 | 0.003 | < 0.05 | 0.028 | 2.05 | 2 | 0.05 |
| Site 13 | 8/30/2016 | 0.008 | < 0.05 | 0.047 | 0.78 | 0.7 | 0.08 |
| Site 14 | 8/30/2016 | < 0.002 | < 0.05 | 0.096 | 1.40 | 1.4 | < 0.05 |
| Site 15 | 8/31/2016 | 0.003 | < 0.05 | 0.032 | 1.15 | 1.1 | 0.05 |
| Site 16 | 8/31/2016 | 0.044 | 0.110 | 1.400 | 13.08 | 13 | 0.08 |
| Site 17 | 8/31/2016 | 0.004 | 0.050 | 0.068 | 1.67 | 1.6 | 0.07 |
| Site 18 | 8/31/2016 | 0.003 | < 0.05 | 0.019 | 0.86 | 0.8 | 0.06 |
| Site 20 | 8/31/2016 | 0.003 | < 0.05 | 0.015 | 1.35 | 1.3 | 0.05 |
| Site 21 | 8/31/2016 | 0.005 | < 0.05 | 0.008 | 0.79 | 0.7 | 0.09 |
| Site 22 | 8/31/2016 | 0.077 | 0.660 | 0.100 | 1.80 | 1.5 | 0.30 |
| Cocheco Station 1 | 8/3/2016 | 0.003 | 0.050 | 0.009 | < 0.5 | < 0.5 | 0.06 |
| Cocheco Station 3 | 8/3/2016 | 0.013 | < 0.05 | 0.051 | 3.00 | 0.6 | 2.40 |
| Cocheco Station 4 | 8/4/2016 | 0.009 | 0.050 | 0.044 | 3.20 | 1.4 | 1.80 |
| Cocheco Station 5 | 8/4/2016 | 0.004 | 0.060 | 0.032 | 1.03 | 0.6 | 0.43 |
| Cocheco Station 6 | 8/4/2016 | 0.007 | 0.050 | 0.025 | 1.05 | 0.6 | 0.45 |

## 4.3.2 Visual/Photo Evaluation

In general, the investigation found that—like the Cocheco River—the great majority of sites had abundant aquatic vegetation, regardless of the absence of wastewater inputs. Several species were identified at both the regional site and along the Cocheco River. However, some notable differences in species composition and in growth habit were observed. Several species identified as native to New Hampshire

(NHDES, 2008) were observed in regional sites, including Yellow and White Water Lily, Floating Heart, Watershield, Duckweed and Watermeal. Although identified as native and known to provide various ecological benefits, these species were observed to be growing at very high densities. The areal extent of the communities observed may currently be impacting some sites through excessive shading via broad leaf structures covering the water surface (Water Lily, Floating Heart, Watershield) or by volume of plant material (Duckweed, Watermeal).

Purple Loosestrife was observed at three regional sites, but not identified along the study portion of the Cocheco River. Purple Loosestrife is identified by NHDES as a non-native, exotic plant. The identification of Purple Loosestrife at regional sites only may be in part to the more topographically level conditions of some site, as well as higher light conditions, lower water levels and slower moving water.

Cardinal flower, identified as native to New Hampshire and considered to be a wildflower of ecological value, was observed at one regional site and identified in 2 locations along the banks of the Cocheco River. All siting's consisted of only 2 or 3 plants.

Table 4-11 presents a categorization of the regional sites as having low, moderate, or high accumulations of three vegetation types: emergent, floating, and subaquatic rooted, based on visual observation. The total phosphorus concentrations measured at each site are also presented. About half the sites had high accumulations of subaquatic rooted macrophytes, over half (10 of 17) had high occurrence of emergent vegetation, and just slightly less than half (6 of 17) had high densities of floating macrophytes. This demonstrates that such growths are very common in the region and not dependent on point source nutrient inputs. In fact, some of the regional sites have much higher plant accumulations than the Cocheco River, despite a lack of point source nutrient inputs.

**Table 4-11. Summary of Macrophyte Observations for Regional Non-Tidal Sites**

| Site ID | Site Name | Observations of Macrophyte Growth Density[1] | | | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|
| | | Emergent Vegetation | Floating Macrophytes | Subaquatic Rooted Macrophytes | |
| Site 1 | Fire protection pond, off of Christmas Lane | High | High | Undetermined (visual obstruction) | -- |
| Site 3 | Berry's River Reservoir | High | Moderate | High | -- |
| Site 4 | Berry's River, Crown Point Rd | High | Low | Low | -- |
| Site 6 | Baxter Lake | Low | Low | Low | -- |
| Site 9 | Barnstead Parade Dam | Low | Low | High | 0.012 |
| Site 10 | Brundle Pond | High | Moderate | High | 0.013 |
| Site 11 | Snecook Lakes | Low | Low | Low | 0.006 |
| Site 12 | Locke Lake | Low | Low | Moderate | 0.028 |
| Site 13 | Jones Pond | High | High (in littoral zone) | High | 0.047 |
| Site 14 | Club Pond | High | High | Moderate | 0.096 |
| Site 15 | Scrunton Pond Road | High | High (in littoral zone) | High | 0.032 |
| Site 16 | Oyster River, Mill Pond | High | High | Undetermined (visual obstruction) | 1.400 |
| Site 17 | Long Marsh Brook, off of Long Marsh Road | High | Moderate | Moderate | 0.068 |
| Site 18 | Lamprey River | Low | High (in littoral zone) | High | 0.019 |

| Table 4-11. Summary of Macrophyte Observations for Regional Non-Tidal Sites | | | | | |
|---|---|---|---|---|---|
| Site ID | Site Name | Observations of Macrophyte Growth Density[1] | | | Total Phosphorus (mg/L) |
| | | Emergent Vegetation | Floating Macrophytes | Subaquatic Rooted Macrophytes | |
| Site 20 | Waldron Mill Pond | High | Low | High | 0.015 |
| Site 21 | Jones Brook | Low | Low | Low | 0.008 |
| Site 22 | Spaulding Pond | Moderate | Low | High | 0.100 |

1. Ranks are based on a visual estimate of areal extent of plant density observed within an approximately 10 foot x 10 foot area. Low: Growth density = Less than 25% areal coverage; Moderate: Growth density = 25% to 50% areal coverage; Significant: Growth density = Greater than 50% areal coverage.

Total phosphorus concentrations were highly variable between the regional sites. Two sites with low coverage of all three macrophyte types (Site 11 and Site 21) also had the lowest total phosphorus concentrations recorded (0.006 and 0.011 mg/L respectively). Otherwise, there was no obvious relation between total phosphorus concentration and plant growth. Sites such as 9, 10, 18 and 20 had relatively low (<0.020 mg/L) total phosphorus concentrations, but high coverage of one or more of the plant types. This is consistent with what was observed from the Cocheco River, where the type and amount of plant growth had little obvious relation with phosphorus concentration. These findings support the conclusion that even background concentrations of phosphorus are sufficient to support both floating and aquatic plant growth in the Cocheco River, and raise serious questions about whether phosphorus reductions would have any measured effects on plant growth in the system.

Photograph 48. (08/30/16) – Regional Site 1.

Photograph 49. (08/30/16) – Regional Site 1.

Photograph 50. (08/30/16) – Regional Site 3.

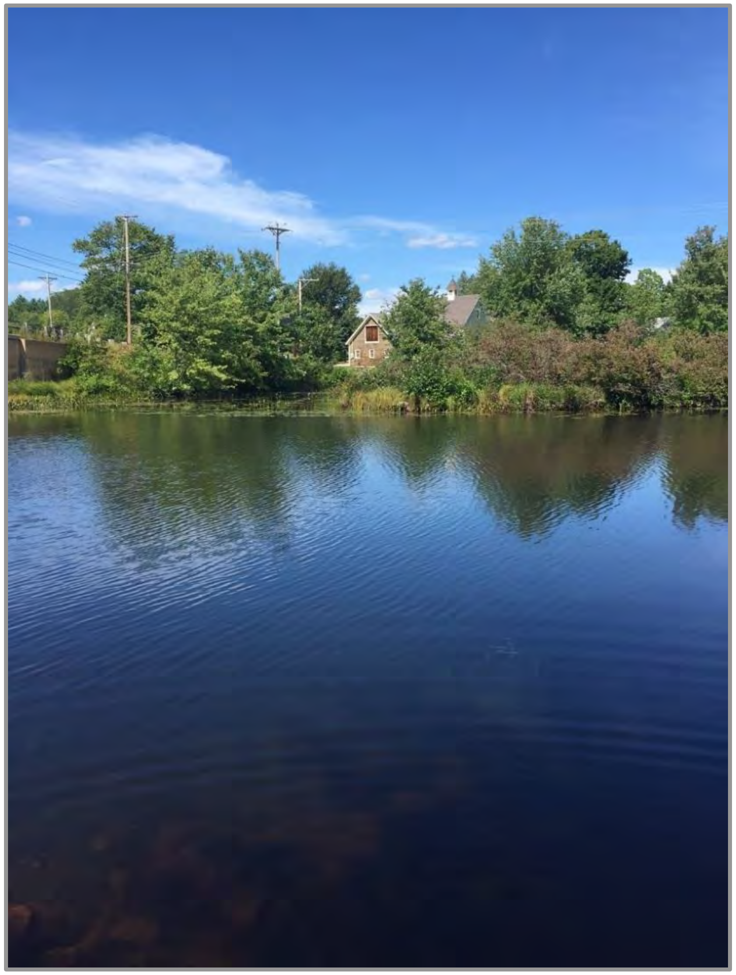
Photograph 51. (08/30/16) – Regional Site 3.

Photograph 52. (08/30/16) – Regional Site 4.

Photograph 53. (08/30/16) – Regional Site 4.

Photograph 54. (08/30/16) – Regional Site 6.

Photograph 55. (08/30/16) – Regional Site 6.



Photograph 56. (08/30/16) – Regional Site 9. Site is identified (by posted sign) by New Hampshire Exotic Species Program as containing an invasive aquatic plant.

Photograph 57. (08/30/16) – Regional Site 9.

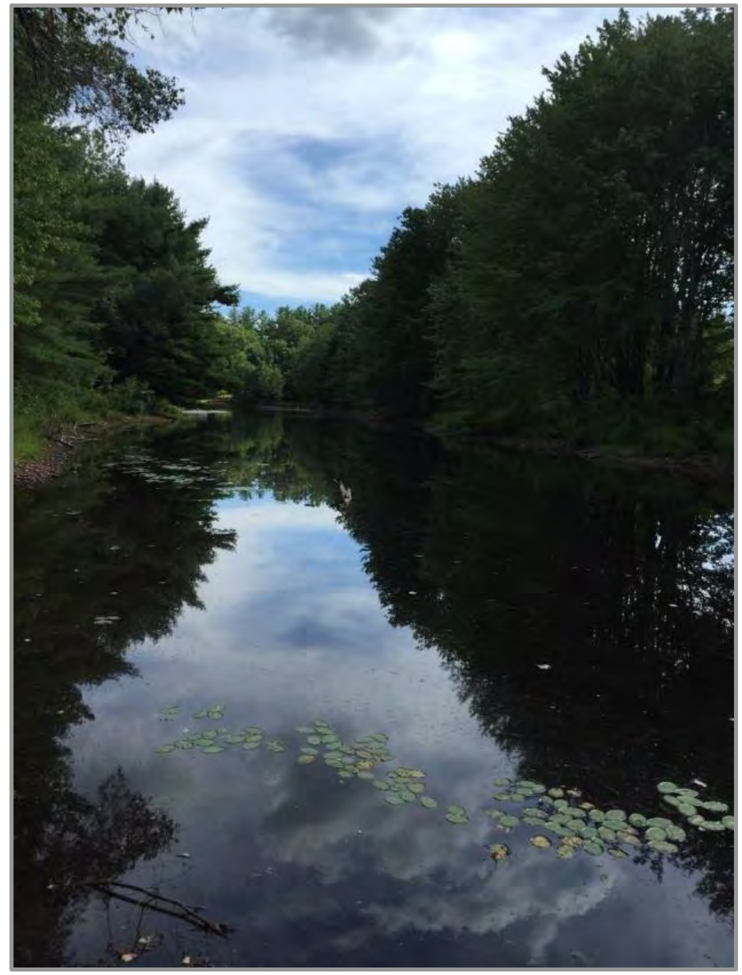
Photograph 58. (08/30/16) – Regional Site 10.

Photograph 59. (08/30/16) – Regional Site 10.

Photograph 60. (08/30/16) – Regional Site 11.

Photograph 61. (08/30/16) – Regional Site 11.

Photograph 62. (08/30/16) – Regional Site 11.



Photograph 63. (08/30/16) – Regional Site 12.

Photograph 64. (08/30/16) – Regional Site 12.

Photograph 65. (08/30/16) – Regional Site 13.

Photograph 66. (08/30/16) – Regional Site 13.

Photograph 67. (08/30/16) – Regional Site 13.

Photograph 68. (08/30/16) – Regional Site 14.

Photograph 69. (08/30/16) – Regional Site 15.

Photograph 70. (08/31/16) –Regional Site 15.

Photograph 71. (08/31/16) – Regional Site 16.

Photograph 72. (08/31/16) – Regional Site 16.

Photograph 73. (08/31/16) – Regional Site 17.

Photograph 74. (08/31/16) – Regional Site 18.

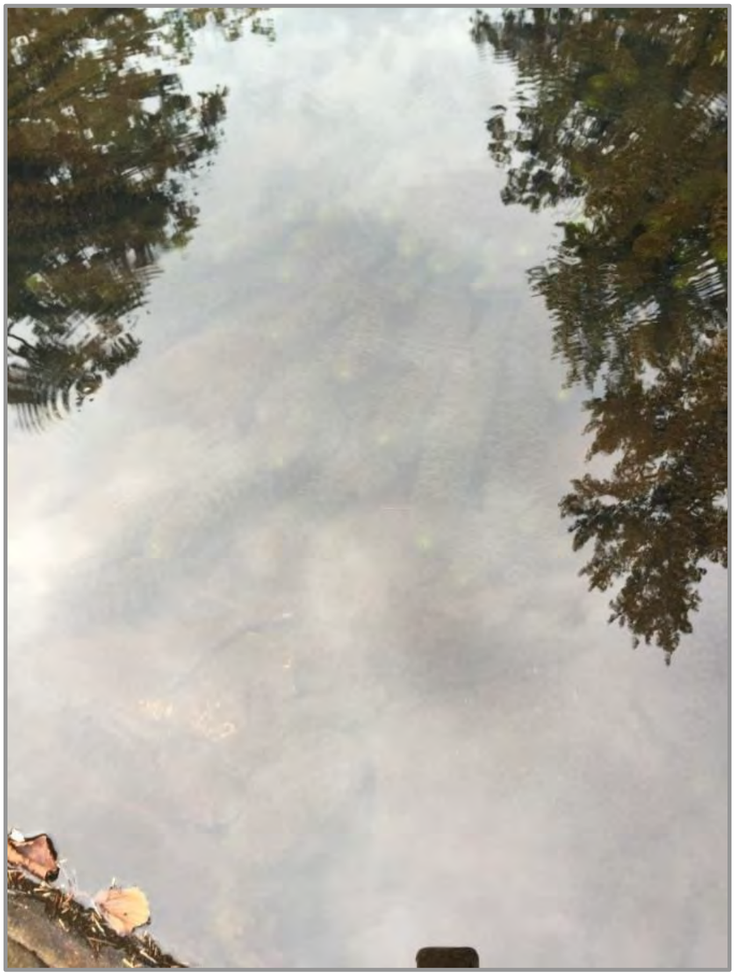
Photograph 75. (08/31/16) – Regional Site 20.

Photograph 76. (08/31/16) – Regional Site 20.

Photograph 77. (08/31/16) – Regional Site 21. Light floating or subaquatic rooted macrophyte growth observed.

Photograph 78. (08/31/16) – Regional Site 21.

Photograph 79. (08/31/16) – Regional Site 22.



Photograph 80. (08/31/16) – Regional Site 22.

## Section 5

# Conclusions

The 2016 monitoring effort resulted in a great deal of qualitative and quantitative information on the status of the non-tidal and tidal segments of the Cocheco River. In this concluding section, we identify the most important observations and interpretations that could be relevant to management.

1. *The scientific literature indicates that rooted aquatic plants are unlikely to respond to external nutrient controls, and is inconclusive on the potential response of floating plants and macroalgae in the Cocheco River*. The literature review performed for this effort (Section 2) demonstrated that rooted aquatic plants can obtain nutrients from both the water column and sediment, and are much more likely to be limited by habitat and light availability than nutrients. Even dredging of sediments only provides temporary reductions in plant growth, and can actually favor the spread of plants such as milfoil.

   The literature provided mixed conclusions on the potential to control duckweed growth with nutrient reduction. Many studies indicated that—given favorable light, temperature, and hydrologic conditions—duckweed can grow at relatively high rates even at relatively low nutrient concentrations. Under this condition, duckweed would not be expected to be sensitive to changes in phosphorus loading to the system. Other studies note decreases in duckweed growth rates below moderate threshold nutrient concentrations. In tidal waters, fast-growing macroalgae taxa such as *Ulva* can be favored over other primary producers when conditions allow them to accumulate high concentrations of nutrients in tissues. However, macroalgae do not experience strong nutrient limitations in all settings. The potential for nutrient limitation (or lack thereof) of *Ulva* is not easily predicted by water column nutrient concentrations. Rather, tissue nutrient concentrations are a superior predictor of growth potential, and depend on many factors other than water column concentrations.

2. *Algal growth in the non-tidal Cocheco River was low to moderate, and with no apparent relation to phosphorus concentrations*. Monitoring in 2016 confirmed the result from 2015 that attached algal growth was low to moderate in the non-tidal Cocheco River. Most of the river between Rochester and Dover is too deep and/or light-limited for attached algae to grow on the bottom. In a few shallower locations, attached algae can accumulate to moderate levels (i.e., scores of 1-2 on a 4-point scale). The growth potential was not related to phosphorus concentrations, as evidenced by the fact that visual algal scores upstream of the Rochester WWTF (where phosphorus concentrations are low) were similar to or higher than those downstream of the discharge.

3. *Floating plant coverage in the non-tidal Cocheco was relatively low in 2016, and did not respond to interannual changes in phosphorus concentrations*. Floating plant coverage was slower to develop in 2016 than in 2015, as evidenced by the fact that very little duckweed was observed during the August 2016 field visit. Floating plant coverage was more visible during the September 2016 field visit, but the areas of high density were still limited to just a few (as in 2015) to 100-250 ft segments in stagnant waters such as that behind Watson Dam, and did not impair beneficial uses. It is unclear why duckweed coverage was lower overall in 2016. Lower streamflow may have been a factor. Phosphorus concentrations were not a factor, because the

lower streamflows actually caused the median phosphorus concentrations to be higher in 2016 than in 2015.

4. *Many regional sites have similar or higher levels of plant growth than the Cocheco River, despite a lack of point source nutrient inputs*. The great majority of regional non-tidal water bodies examined had abundant aquatic vegetation, regardless of the absence of WWTF effluent inputs or other obvious anthropogenic nutrient sources. About half the sites had high accumulations of subaquatic rooted macrophytes, over half had high occurrence of emergent vegetation, and just slightly less than half had high densities of floating macrophytes. Two sites with low plant coverage of all three macrophyte types also had the lowest total phosphorus concentrations recorded (0.006 and 0.011 mg/L respectively). Otherwise, there was no obvious relation between total phosphorus concentration and plant growth, which is consistent with observations from the Cocheco River.
5. *The tidal Cocheco River had favorable water quality in summer 2016, with no indications of algal-related use impairments*. Water quality sampling on the tidal Cocheco River indicated favorable conditions for dissolved oxygen and pH. Cyanobacteria were low in most samples—including the single bloom sample—and cyanotoxins were non-detectable in all samples. There was no visual indication of harmful algal blooms. Overall, the sampling confirms that the tidal Cocheco River is a moderately productive estuarine segment with a benign algal community and with no nutrient-related use impairments.
6. *During the September 2016 survey, macroalgae was common in the Cocheco River and other regional tidal waters, but most locations had relatively low levels of overall coverage*. Macroalgae such as sea lettuce and seaweed is very common within coastal systems, and was observed at many locations in the tidal Cocheco River, Piscataqua River, and Portsmouth Harbor. However, macroalgal coverage was low (<15%) at most locations, and not at levels that would impair aquatic life or recreation uses. Visual surveys reveal that macroalgae can accumulate to high densities at specific locations (e.g. tidal wracks), but photographs of only the high-density spots should not be interpreted as representative of the typical coverage. Portsmouth Harbor had locations of high macroalgae cover, despite the fact that nutrient concentrations in the Harbor tend to be significantly lower than at upstream locations in the estuary.

## Section 6

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# Appendix A: Viewing Bucket Survey Data

8/3/2016 9:42

| |
|---|
| Station ID: Station 1 |
| Stream Name: Cocheco River |
| Town: Rochester, NH |
| Assessment Aesthetics: |

| |
|---|
| Personnel: M. Laselva, C. O'Brien |
| Recent and Current Streamflow Conditions: less than 1 ft/s . Flow meter indicated 0.3 ft/s |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 11 | 1 - 1 | | 7 | | | | | | | 2 | 5 | 2 | | | |
| 10.5 | 1 - 2 | | 1 | | | | | | | 6 | 7 | 2 | | | |
| 14 | 1 - 3 | | 4 | | | | | | | 1 | 6 | 5 | | | |
| 13 | 1 - 4 | | | | | | | | | | 1 | 5 | 10 | | |
| 11 | 1 - 5 | | | 3 | | | | 10 | | | | | 3 | | |
| 8 | 1 - 6 | | | | | | | | 16 | | | | | | |
| 10 | 2 - 1 | | 8 | | | | | | | 3 | 4 | 1 | | | |
| 11 | 2 - 2 | | | | | | | 4 | | | 3 | 3 | 6 | | |
| 8 | 2 - 3 | | | | | | | 1 | | | 2 | 9 | 4 | | |
| 6 | 2 - 4 | | | | | | | | | | 3 | 8 | 5 | | |
| 6 | 2 - 5 | | | | | | | | 16 | | | | | | |
| 6 | 2 - 6 | | | | | | | 12 | 4 | | | | | | |
| 10 | 3 - 1 | | 1 | | | | | | | 5 | 4 | 6 | | | |
| 12 | 3 - 2 | | | | | | | 8 | | 1 | 2 | 3 | 2 | | |
| 11 | 3 - 3 | | | | | | | 7 | 9 | | | | | | |
| 6 | 3 - 4 | | | 3 | | | | 5 | | | 2 | 1 | 5 | | |
| 3 | 3 - 5 | | | 2 | | | | | 14 | | | | | | |
| 3 | 3 - 6 | | | | | | | | 16 | | | | | | |

8/3/2016 14:01

| Station ID: Station 3 |
|---|
| Stream Name: Cocheco River |
| Town: Rochester, NH |
| Assessment Aesthetics: |

| Personnel: M. LaSelva, C. O'Brien |
|---|
| Recent and Current Streamflow Conditions: |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 6 | 1 - 1 | | 1 | 9 | | | | | | | 4 | 2 | | | |
| 7 | 1 - 2 | | | 11 | | | | | | | | 5 | | | |
| 8 | 1 - 3 | | 1 | 7 | | | | | | 3 | 4 | 1 | | | |
| 4 | 1 - 4 | | 2 | 5 | | | | | | 9 | | | | | |
| 3 | 1 - 5 | | 2 | | | | | 1 | | 9 | 4 | | | | |
| 2 | 1 - 6 | | 8 | | | | | | | 8 | | | | | |
| 3 | 2 - 1 | | | 16 | | | | | | | | | | | |
| 3 | 2 - 2 | | 1 | 15 | | | | | | | | | | | |
| 6 | 2 - 3 | | 2 | 9 | | | | | | | 4 | 1 | | | |
| 6 | 2 - 4 | | 4 | | | | | | | 6 | 5 | 1 | | | |
| 4 | 2 - 5 | | 1 | 5 | | | | | | 4 | 6 | | | | |
| 2 | 2 - 6 | | | | | | | | | | 16 | | | | |
| 5 | 3 - 1 | | | 16 | | | | | | | | | | | |
| 6 | 3 - 2 | | 6 | 6 | | | | | | 1 | 3 | | | | |
| 7 | 3 - 3 | | | 5 | | | | | | 3 | 8 | | | | |
| 6 | 3 - 4 | | 4 | | | | | | | 2 | 7 | 3 | | | |
| 4 | 3 - 5 | | 9 | | | | | | | 4 | 3 | | | | |
| 2 | 3 - 6 | | 4 | | | | | | | 7 | 5 | | | | |

| |
|---|
| Station ID: Station 4 |
| Stream Name: Cocheco River |
| Town: Rochester, NH |
| Assessment Aesthetics: |

| |
|---|
| Personnel: M. Laselva, C. O'Brien |
| Recent and Current Streamflow Conditions: Low stream velocity, flow level appears higher than previous year |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 4 | 1 - 1 | 12 | 6 | | 7 | | | | 3 | | | | | | |
| 16 | 1 - 2 | 24 | | | 4 | | | 2 | | | | | 10 | | |
| 35 | 1 - 3 | 38 | | | | | | | | | | | | | |
| 11 | 1 - 4 | 61 | 1 | | | | | 15 | | | | | | | |
| 10 | 1 - 5 | 72 | | | | | | 16 | | | | | | | |
| 27 | 1 - 6 | 86 | 6 | | | | | 10 | | | | | | | |
| 13 | 2 - 1 | 12 | 6 | | 10 | | | | | | | | | | |
| 25 | 2 - 2 | 24 | | | 1 | | | 6 | 3 | | | | 6 | | |
| 38 | 2 - 3 | 38 | | | | | | | | | | | | | |
| 13 | 2 - 4 | 61 | | | | | | 16 | | | | | | | |
| 8 | 2 - 5 | 72 | | | | | | 15 | | 1 | | | | | |
| 18 | 2 - 6 | 86 | | | | | | | | | 4 | 7 | 5 | | |
| 11 | 3 - 1 | 12 | 2 | 1 | 13 | | | | | | | | | | |
| 17 | 3 - 2 | 24 | | | 7 | | | 7 | | | | | 2 | | |
| 40 | 3 - 3 | 38 | | | | | | | | | | | | | |
| 15 | 3 - 4 | 61 | | | | | | 16 | | | | | | | |
| 10 | 3 - 5 | 72 | | | | | | 16 | | | | | | | |
| 19 | 3 - 6 | 86 | | | | | | 2 | | | 1 | 5 | 8 | | |

8/4/2016 17:05

| | |
|---|---|
| Station ID: Station 5 | Personnel: M. LaSelva, C. O'Brien |
| Stream Name: Cocheco River | Recent and Current Streamflow Conditions: 0.2 ft/s |
| Town: Dover, NH | |
| Assessment Aesthetics: | |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 4 | 1 - 1 | 7 | | | | | | 1 | | | | 7 | 8 | | |
| 10 | 1 - 2 | 14 | | | | | | 9 | | | | 1 | 6 | | |
| 9 | 1 - 3 | 21 | | | | | | 16 | | | | | | | |
| 16 | 1 - 4 | 28 | | | | | | 16 | | | | | | | |
| 15 | 1 - 5 | 35 | | 6 | | | | 10 | | | | | | | |
| 11 | 1 - 6 | 42 | 1 | | | | | 2 | | | 4 | 6 | 3 | | |
| 2 | 2 - 1 | 7 | | | | | 7 | 6 | 1 | | | 1 | 1 | | |
| 2 | 2 - 2 | 17 | | | | | 4 | 6 | | | 4 | 1 | 1 | | |
| 4 | 2 - 3 | 27 | | | | | | 14 | | | | | 2 | | |
| 10 | 2 - 4 | 37 | | | | | | 11 | | | | | 5 | | |
| 11 | 2 - 5 | 47 | | | | | | 11 | | | | 1 | 4 | | |
| 9 | 2 - 6 | 57 | | 16 | | | | | | | | | | | |
| 2 | 3 - 1 | 11 | | | | | 4 | 1 | | 1 | 3 | 3 | 4 | | |
| 6 | 3 - 2 | 18 | | | | | | 4 | | | | 4 | 8 | | |
| 8 | 3 - 3 | 26 | | | | | | 16 | | | | | | | |
| 13 | 3 - 4 | 36 | | | | | | 16 | | | | | | | |
| 11 | 3 - 5 | 45 | | | | | | 6 | | | | | 10 | | |
| 11 | 3 - 6 | 51 | | 2 | | | | 3 | | | | 2 | 9 | | |

| Station ID: Station 6 |
| --- |
| Stream Name: Cocheco River |
| Town: Dover, NH |
| Assessment Aesthetics: |

| Personnel: M. Laselva, C. O'Brien |
| --- |
| Recent and Current Streamflow Conditions: 1.5 ft/s |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 10 | 1 - 1 | 9 | | | | | 1 | 3 | | | 11 | | 1 | | |
| 12 | 1 - 2 | 21 | | | | | 7 | | | | 9 | | | | |
| 20 | 1 - 3 | 33 | | | | | 6 | | | | 10 | | | | |
| 17 | 1 - 4 | 45 | | | | | 11 | | | | 5 | | | | |
| 20 | 1 - 5 | 57 | | | | | 6 | | | | 9 | | 1 | | |
| 2 | 1 - 6 | 69 | | | | | | | | | 16 | | | | |
| 10 | 2 - 1 | 11 | | | | | | | | | 14 | 2 | | | |
| 18 | 2 - 2 | 22 | | | | | 1 | | | | 14 | 1 | | | |
| 23 | 2 - 3 | 33 | | | | | 7 | | | | 8 | | 1 | | |
| 20 | 2 - 4 | 44 | | | | | 11 | 2 | | | 3 | | | | |
| 19 | 2 - 5 | 55 | | 5 | | | | | | | 11 | | | | |
| 14 | 2 - 6 | 69 | | | | | | 4 | | | | 12 | | | |
| 9 | 3 - 1 | 11 | | | | | 5 | | | | 11 | | | | |
| 11 | 3 - 2 | 22 | | | | | | | | | 16 | | | | |
| 21 | 3 - 3 | 33 | | | | | | | | | 16 | | | | |
| 12 | 3 - 4 | 44 | | | | | | | | | 16 | | | | |
| 8 | 3 - 5 | 55 | | | | | 10 | 1 | | | 2 | 3 | | | |
| 14 | 3 - 6 | 69 | | | | | 3 | 2 | | | | 10 | 1 | | |

9/21/2016 8:20 9:24

| | |
|---|---|
| Station ID: Station 1 | Personnel: M. Laselva, C. O'Brien |
| Stream Name: Cocheco River | Recent and Current Streamflow Conditions: low velocity, higher water than previous visit |
| Town: Rochester, NH | |
| Assessment Aesthetics: | |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 12 | 1 - 1 | 7.5 | | | | | | 5 | | | | | 11 | | |
| 12 | 1 - 2 | 15 | 3 | | | | | 9 | | 1 | 1 | 2 | | | |
| 11 | 1 - 3 | 21 | 3 | | | | | 13 | | | | | | | |
| 8 | 1 - 4 | 28 | | | | | | 6 | | | | 10 | | | |
| 6 | 1 - 5 | 35 | | | | | | 16 | | | | | | | |
| 6 | 1 - 6 | 42 | | | | | | 8 | | | 1 | 5 | 2 | | |
| 10 | 2 - 1 | 8 | | | | | | 9 | | | | 2 | 5 | | |
| 13 | 2 - 2 | 15 | | | | | | 5 | | | | 10 | 1 | | |
| 10 | 2 - 3 | 22 | | | | | | 16 | | | | | | | |
| 9 | 2 - 4 | 29 | | | | | | 10 | | | | 4 | 2 | | |
| 8 | 2 - 5 | 36 | | | | | | 11 | | | 1 | 3 | 1 | | |
| 7 | 2 - 6 | 43 | | | | | | 16 | | | | | | | |
| 9 | 3 - 1 | 7 | | | | | | 10 | 1 | | | 4 | 1 | | |
| 10 | 3 - 2 | 14 | | | | | | 10 | | | | 1 | 5 | | |
| 11 | 3 - 3 | 21 | | | | | | 4 | | | | 8 | 4 | | |
| 5 | 3 - 4 | 28 | | | | | | 4 | | | | 7 | 5 | | |
| 5 | 3 - 5 | 35 | | 2 | | | | 14 | | | | | | | |
| 6 | 3 - 6 | 42 | | 2 | | | | 5 | | | 2 | 6 | 1 | | |

9/21/2016 14:42 15:10

| | |
|---|---|
| Station ID: Station 3 | Personnel: M. LaSelva, C. O'Brien |
| Stream Name: Cocheco River | Recent and Current Streamflow Conditions: higher flow, 2 ft/s |
| Town: Rochester, NH | |
| Assessment Aesthetics: | |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 3 | 1 - 1 | 6 | 6 | 2 | | | | | | 6 | | 2 | | | |
| 8 | 1 - 2 | 12 | 2 | | | | | 4 | | 2 | 5 | 2 | 1 | | |
| 7 | 1 - 3 | 18 | | | | | 6 | 7 | 1 | | | 1 | 1 | | |
| 6 | 1 - 4 | 24 | 2 | 2 | | | | | | 1 | 7 | 3 | 1 | | |
| 5 | 1 - 5 | 30 | | | | | | | | 4 | 3 | 9 | | | |
| 2 | 1 - 6 | 34 | 2 | | | | | | | 2 | 12 | | | | |
| 8 | 2 - 1 | 6 | 1 | | | | | | | 1 | 6 | 7 | 1 | | |
| 9 | 2 - 2 | 12 | 3 | 6 | | | | | | 2 | 4 | 1 | | | |
| 8 | 2 - 3 | 18 | 3 | 3 | | | | 2 | | 5 | 2 | 1 | | | |
| 5 | 2 - 4 | 24 | | | | | | 4 | | 1 | 4 | 4 | 3 | | |
| 4 | 2 - 5 | 30 | | | | | | | | | 5 | 7 | 4 | | |
| 2 | 2 - 6 | 36 | | | | | | | | 2 | 7 | 7 | | | |
| 5 | 3 - 1 | 6 | 4 | 1 | | | | 1 | | 3 | 3 | 3 | 1 | | |
| 7 | 3 - 2 | 12 | 2 | | | | 6 | 6 | | 1 | | 1 | | | |
| 7 | 3 - 3 | 18 | | | | | 6 | 7 | | | | 1 | 2 | | |
| 5 | 3 - 4 | 24 | | | | | 1 | 4 | | | 10 | 1 | | | |
| 3 | 3 - 5 | 30 | | | | | | | | 6 | 10 | | | | |
| 1 | 3 - 6 | 36 | | | | | | | | 9 | 7 | | | | |

9/22/2016 11:37 12:09

| | |
|---|---|
| Station ID: Station 4 | Personnel: M. Laselva, C. O'Brien |
| Stream Name: Cocheco River | Recent and Current Streamflow Conditions: Less than 0.5 ft/s flow, higher water levels |
| Town: Rochester, NH | |
| Assessment Aesthetics: | |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 14 | 1 - 1 | 7 | | | | | | 8 | | | | 1 | 7 | | |
| 18 | 1 - 2 | 14 | | | | | | 7 | | | | | 9 | | |
| 13 | 1 - 3 | 21 | | | | | | 6 | | | | 2 | 8 | | |
| 11 | 1 - 4 | 28 | | | | | | 12 | | | | | 4 | | |
| 11 | 1 - 5 | 35 | | | | | | 4 | | | | | 12 | | |
| 20 | 1 - 6 | 42 | | | | | | 6 | | | | 1 | 9 | | |
| 11 | 2 - 1 | 7 | | | | | | 10 | | | | | 6 | | |
| 14 | 2 - 2 | 14 | | | | | | 9 | | | | 1 | 6 | | |
| 11 | 2 - 3 | 21 | | 2 | | | | 8 | | | | 2 | 4 | | |
| 20 | 2 - 4 | 28 | | | | | | 14 | | | | | 2 | | |
| 21 | 2 - 5 | 35 | | | | | | 13 | | | | | 3 | | |
| 16 | 2 - 6 | 42 | | | | | | 8 | | | | | 8 | | |
| 12 | 3 - 1 | 7 | | | | | | 11 | | | | | 5 | | |
| 12 | 3 - 2 | 14 | | | | | | 15 | | | | | 1 | | |
| 9 | 3 - 3 | 21 | | | | | | 16 | | | | | | | |
| 28 | 3 - 4 | 28 | | | | | | 6 | | | | 6 | 4 | | |
| 30 | 3 - 5 | 35 | | | | | | 15 | | | | 1 | | | |
| 22 | 3 - 6 | 42 | | | | | | 12 | | | | | 4 | | |

9/21/2016 13:55 14:17

| | |
|---|---|
| Station ID: Station 5 | Personnel: M. LaSelva, C. O'Brien |
| Stream Name: Cocheco River | Recent and Current Streamflow Conditions: flow at 0.5 ft/s, rain 2 days ago |
| Town: Dover, NH | |
| Assessment Aesthetics: | |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 5 | 1 - 1 | 7 | | | | | | 15 | | | | 1 | | | |
| 7 | 1 - 2 | 15 | | | | | | 0 | | | 1 | 13 | 2 | | |
| 9 | 1 - 3 | 21 | | | | | | 4 | | | | 5 | 7 | | |
| 13 | 1 - 4 | 28 | | | | | | 10 | | | | 6 | | | |
| 11 | 1 - 5 | 35 | | | | | | 11 | | | 3 | 2 | | | |
| 11 | 1 - 6 | 42 | | | | | | 6 | | | | 1 | 9 | | |
| 4 | 2 - 1 | 7 | | | | | | 7 | | | | 3 | 6 | | |
| 4 | 2 - 2 | 14 | | | | | | 3 | | | 1 | 8 | 4 | | |
| 9 | 2 - 3 | 21 | | | | | | 5 | | | 1 | 10 | | | |
| 11 | 2 - 4 | 28 | | | | | | 4 | | | 3 | 5 | 4 | | |
| 14 | 2 - 5 | 35 | | | | | | 16 | | | | | | | |
| 9 | 2 - 6 | 42 | | | | | | 11 | | | | 4 | 1 | | |
| 6 | 3 - 1 | 7 | | | | | | 16 | | | | | | | |
| 8 | 3 - 2 | 14 | | | | | | 5 | | | 2 | 7 | 2 | | |
| 12 | 3 - 3 | 21 | | | | | | 6 | | | | 4 | 6 | | |
| 13 | 3 - 4 | 28 | | | | | | 16 | | | | | | | |
| 13 | 3 - 5 | 35 | | | | | | 9 | | | | 4 | 3 | | |
| 10 | 3 - 6 | 42 | | | | | | 0 | | | | 8 | 8 | | |

9/21/2016 1702

| |
|---|
| Station ID: Station 6 |
| Stream Name: Cocheco River |
| Town: Dover, NH |
| Assessment Aesthetics: |

| |
|---|
| Personnel: M. Laselva, C. O'Brien |
| Recent and Current Streamflow Conditions: flow 1 ft/s, higher water level |

| | | | | | | | Filamentous or Other Macroalgae | | | Periphyton mat Includes microalgae, detritus, decaying macroalgae, and silt. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 2 | 2 | 1 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| Water Depth (inches) | Transect | Tape (ft) | Clay, Sand, or Mud | Plant | Moss | Algal Crust | < 5 cm | > 5cm & <15 cm | = 15 cm | No Visible Layer | Thin Layer, Rock Still Visible | 0.1 - 1.0 mm Thick | 1 - 5 mm Thick | 5 mm - 2 cm Thick | > 2 cm Thick |
| 9 | 1 - 1 | 15 | | 1 | | | 3 | | | 5 | 3 | 2 | 2 | | |
| 8 | 1 - 2 | 28 | | | | | | | | | 16 | | | | |
| 15 | 1 - 3 | 42 | | | | | 3 | | | | 13 | | | | |
| 23 | 1 - 4 | 56 | | | | | 8 | | | | 5 | 3 | | | |
| 19 | 1 - 5 | 70 | | | | | 1 | 5 | | | 8 | 1 | 1 | | |
| 6 | 1 - 6 | 84 | | | | | 4 | | | | 1 | 7 | 4 | | |
| 14 | 2 - 1 | 12 | | | | | 2 | | | 4 | 2 | 5 | 3 | | |
| 12 | 2 - 2 | 24 | | | | | 1 | | | | 9 | 6 | | | |
| 10 | 2 - 3 | 36 | | | | | 4 | | | | | 12 | | | |
| 17 | 2 - 4 | 48 | | | | | 5 | | | | | 10 | 1 | | |
| 24 | 2 - 5 | 60 | | | | | 10 | | 2 | | | 4 | | | |
| 14 | 2 - 6 | 76 | | | | | | | | 4 | 6 | 3 | 3 | | |
| 13 | 3 - 1 | 14 | 3 | | | | | | | 2 | 10 | 1 | | | |
| 23 | 3 - 2 | 28 | 2 | | | | | | | 14 | | | | | |
| 19 | 3 - 3 | 42 | | | | | | | | 10 | 1 | 1 | 4 | | |
| 22 | 3 - 4 | 56 | 2 | | | | | | | 6 | 8 | | | | |
| 16 | 3 - 5 | 69 | | | | | 4 | | | | 5 | 1 | 6 | | |
| 8 | 3 - 6 | 82 | | | | | 3 | | | | 7 | 4 | 2 | | |

# Appendix B: Macroalgae Survey Results

| Date: | 9/15/2016 | |
|---|---|---|
| Station ID: PH -Site 1 | Start Time | End Time |
| Stream Name: Portsmouth Harbor | 15:07 | 15:20 |
| Town: Portsmouth, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.051953N, -70.722641E | 43.052161N, -70.721917E |

% Cover Sea lettuce Typical for all Quadrats at site 1

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | |
| 2 | 0 | 0 | 0 | 3 | 3% unknown macrophyte |
| 3 | 0 | 0 | 0 | 5 | 5% unknown macrophyte |
| 4 | 0 | 0 | 0 | 0 | |

% Cover Seaweed Typical for all Quadrats at site 1

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 3 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 4 | 0 | 0 | 2 |
| 3 | 5 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 1 |
| 2 | 1 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 2 | 0 |
| 2 | 0 | 0 | 0 | 2 |
| 3 | 1 | 1 | 20 | 20 |
| 4 | 5 | 5 | 0 | 0 |

| Date: | 9/15/2016 | |
|---|---|---|
| Station ID: PH - Site 2 | Start Time | End Time |
| Stream Name: Portsmouth Harbor | 16:19 | 16:48 |
| Town: Portsmouth, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.075838N, -70.744951E | 43.075391E, -70.744054 |

% Cover Sea lettuce Typical for all Quadrats at site 2

Quadrat 1 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 5 | 0 | 0 | 0 |
| 2 | 0 | 2 | 0 | 2 |
| 3 | 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 0 |
| 2 | 0 | 0 | 2 | 2 |
| 3 | 1 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 20 | 0 | 0 | 30 |
| 2 | 0 | 0 | 25 | 35 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 2 | 0 |

Quadrat 4 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 |
| 2 | 3 | 0 | 40 | 5 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 5 | 5 | 0 |

Quadrat 5 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 4 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 2

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 2 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/15/2016

| Station ID: PH - Site 3 | Start Time | End Time |
| --- | --- | --- |
| Stream Name: Portsmouth Harbor | 17:12 | 17:32 |
| Town: Portsmouth, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.073347N, -70.7443990E | 43.073131N, -70.743675E |

% Cover Sea lettuce Typical for all Quadrats at site 3

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 2 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 1 | 1 | 0 | 0 |

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 2 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 2 |
| 2 | 0 | 0 | 0 | 20 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 3

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/16/2016

| Station ID: Cocheco Site 1 | Start Time | End Time |
|---|---|---|
| Stream Name: Cocheco River | 7:20 | 7:39 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.194386N, -70.853897E | 43.194705N, -70.854641E |

% Cover Sea lettuce Typical for all Quadrats at site 1

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 1

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/13/2016

| | Start Time | End Time |
|---|---|---|
| Station ID: Cocheco Site 2 | Start Time | End Time |
| Stream Name: Cocheco River | 15:50 | 16:04 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.19151N, -70.848643E | not recorded |

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Sea lettuce Typical for all Quadrats at site 2

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

25" Downstream of Quadrat 3

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 2

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 25 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

25' Downstream of Quadrat 1

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

25" Downstream of Quadrat 4

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

25" Downstream of Quadrat 2

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

25" Downstream of Quadrat 5

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/13/2016

| Station ID: Cocheco Site 3 | Start Time | End Time |
|---|---|---|
| Stream Name: Cocheco River | 16:22 | 16:39 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.188870N, -70.841667E | 43.188817N, -70.841497E |

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Sea lettuce Typical for all Quadrats at site 3

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

15' Downstream of Quadrat 1

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

15' Downstream of Quadrat 2

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 25 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

15' Downstream of Quadrat 3

* 3,2 - 25% organic float mat

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

15' Downstream of Quadrat 4

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

15' Downstream of Quadrat 5

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 3

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/13/2016

| | | |
|---|---|---|
| Station ID: Cocheco Site 4 | Start Time | End Time |
| Stream Name: Cocheco River | 17:16 | 17:28 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.183968N, -70.834496E | 43.183847N, -70.834148E |

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Sea lettuce Typical for all Quadrats at site 4

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 20 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

** 1,1 - 20% rooted sea lettuce

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 4

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/14/2016

| | | |
|---|---|---|
| Station ID: Piscataqua Site 5 | Start Time | End Time |
| Stream Name: Piscataqua River | 18:22 | 18:41 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.174846N, -70.826226E | 43.174871N, -70.826300E |

% Cover Sea lettuce typical for all Quadrats at site 5

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 |
| 3 | 100 | 100 | 100 | 100 |
| 4 | 100 | 100 | 100 | 100 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 95 | 95 | 95 | 80 |
| 2 | 100 | 100 | 100 | 75 |
| 3 | 100 | 95 | 90 | 90 |
| 4 | 100 | 95 | 95 | 100 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 2 | 0 |
| 2 | 0 | 0 | 2 | 3 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 30 | 5 | 4 | 2 |
| 2 | 3 | 0 | 40 | 1 |
| 3 | 2 | 2 | 0 | 0 |
| 4 | 20 | 0 | 5 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 10 | 4 |
| 2 | 5 | 5 | 0 | 30 |
| 3 | 5 | 0 | 0 | 0 |
| 4 | 30 | 1 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 5

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/14/2016

| Station ID: Piscataqua Site 6 | Start Time | End Time |
|---|---|---|
| Stream Name: Piscataqua River | 17:35 | 17:57 |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.166216, -70.826957 | 43.166672N, -70.827170E |

% Cover Sea lettuce typical for all Quadrats at site 6

Quadrat 1 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 4 |
| 2 | 0 | 10 | 3 | 3 |
| 3 | 3 | 2 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |

Quadrat 4 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 5 | 10 | 30 | 60 |
| 2 | 10 | 1 | 5 | 10 |
| 3 | 1 | 0 | 5 | 2 |
| 4 | 30 | 20 | 10 | 5 |

Quadrat 2 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 75 | 80 | 40 | 5 |
| 2 | 25 | 40 | 20 | 5 |
| 3 | 3 | 1 | 2 | 5 |
| 4 | 3 | 10 | 30 | 20 |

Quadrat 5 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 5 | 10 | 20 | 15 |
| 2 | 95 | 95 | 100 | 60 |
| 3 | 10 | 2 | 3 | 10 |
| 4 | 10 | 1 | 0 | 2 |

Quadrat 3 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 3 | 0 | 0 | 4 |
| 2 | 0 | 1 | 2 | 6 |
| 3 | 5 | 0 | 0 | 3 |
| 4 | 30 | 30 | 1 | 25 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 20 | 20 | 5 | 5 |
| 2 | 0 | 2 | 3 | 4 |
| 3 | 10 | 30 | 5 | 4 |
| 4 | 4 | 1 | 3 | 10 |

% Cover Seaweed Typical for all Quadrats at site 6

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 10 | 0 | 0 | 5 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 3 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 2 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 10 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 4 | 3 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Date: 9/14/2016

| Station ID: Piscataqua Site 7 | Start Time | End Time |
|---|---|---|
| Stream Name: Piscataqua River | 16:36 | not recorded |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.162668N, -70.829799E | 43.161895N, -70.829997E |

% Cover Sea lettuce. Typical for all Quadrats at site 7

Quadrat 1 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 5 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 25 | 0 | 0 | 0 |
| 2 | 10 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 5 | 0 |

Quadrat 6 - % Cover Sea lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 7

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

| Date: 9/14/2016 | | |
|---|---|---|
| Station ID: Piscataqua - Site 8 | Start Time | End Time |
| Stream Name: Piscataqua River | 15:56 | no time recorded |
| Town: Rochester, NH | Start Coordinates: | End Coordinates: |
| Personnel: M. LaSelva, C. O'Brien | 43.156913N, -70.827350E | 43.156063N, -70.827699E |

% Cover Sea lettuce typical for all Quadrats at site 8

Quadrats spaced at 50' intervals

Quadrat 1 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 40 | 75 | 25 | 80 |
| 2 | 15 | 20 | 15 | 50 |
| 3 | 15 | 5 | 10 | 25 |
| 4 | 40 | 3 | 15 | 5 |

Quadrat 2 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 10 | 3 | 20 | 5 |
| 2 | 7 | 15 | 15 | 20 |
| 3 | 2 | 5 | 3 | 30 |
| 4 | 20 | 10 | 25 | 3 |

Quadrat 3 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 5 | 5 | 1 | 0 |
| 2 | 3 | 1 | 1 | 5 |
| 3 | 0 | 2 | 1 | 0 |
| 4 | 0 | 2 | 2 | 1 |

Quadrat 4 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 2 | 0 |
| 2 | 0 | 2 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Sea Lettuce

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 5 | 0 | 1 | 5 |
| 3 | 0 | 2 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

% Cover Seaweed Typical for all Quadrats at site 8

Quadrat 1 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 10 | 0 |
| 2 | 5 | 0 | 10 | 0 |
| 3 | 5 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 2 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 3 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 5 | 0 | 0 | 0 |
| 4 | 5 | 0 | 0 | 0 |

Quadrat 4 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 5 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

Quadrat 6 - % Cover Seaweed

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

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# Exhibit C: 2017 Field Investigations of the Cocheco River and Downstream Waters

(Brown and Caldwell, 2018)

# 2017 Field Investigations of the Cocheco River and Downstream Waters

Prepared for
Rath, Young and Pignatelli, P. C.
April 2018

*ATTORNEY WORK PRODUCT – PRIVILEGED AND CONFIDENTIAL*

# 2017 Field Investigations of the Cocheco River and Downstream Waters

Prepared for

Rath, Young and Pignatelli, P. C.

April 2018

*ATTORNEY WORK PRODUCT – PRIVILEGED AND CONFIDENTIAL*

Brown AND Caldwell

1 Tech Drive, Suite 310

Andover, MA 01810

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## List of Figures

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# List of Abbreviations

| | |
|---|---|
| ANTX-A | anatoxin-a |
| BC | Brown and Caldwell |
| cm | centimeter |
| DO | dissolved oxygen |
| EAI | Eastern Analytical, Inc. |
| EPA | Environmental Protection Agency |
| ft | feet |
| GBMC | Great Bay Municipal Coalition |
| MCs/NODs | microcystin/nodularins |
| MDEP | Maine Department of Environmental Protection |
| mg/L | milligram/liter |
| mm | millimeter |
| NHDES | New Hampshire Department of Environmental Services |
| OP | orthophosphate |
| PREP | Piscataqua River Estuary Partnership |
| TKN | total Kjeldahl nitrogen |
| TN | total nitrogen |
| TP | total phosphorus |
| µg/L | microgram/liter |
| WWTF | wastewater treatment facility |

# Executive Summary

This report presents the methods and results of qualitative and quantitative water quality and macroalgal community surveys in the non-tidal and tidal portions of the Cocheco River and the Upper Piscataqua River during 2017. This effort also includes a broader evaluation of the data collected over the last three years (2015-2017). The purpose of the evaluation is to support ongoing water resource management efforts by the City of Rochester, New Hampshire and the Great Bay Municipal Coalition (GBMC).

The specific elements of the monitoring program are:

- Water quality sampling in the non-tidal and tidal portions of the Cocheco River
- Benthic algal surveys of the non-tidal Cocheco River
- Qualitative photographic surveys of the non-tidal and tidal Cocheco River and the Upper Piscataqua River
- Macroalgal surveys in the tidal Cocheco and Upper Piscataqua Rivers and Portsmouth Harbor
- Phytoplankton identification and algal toxin analysis in the tidal Cocheco River

No water quality or biological (algal) impairments were observed during 2017 surveys. The major findings of the 2017 effort are:

- Water quality results in the non-tidal Cocheco River are generally consistent with previous years' results and indicate favorable water quality conditions.
- Extensive, dense beds of aquatic vegetation (e.g. milfoil) are observed in low velocity areas behind impoundments in the non-tidal Cocheco River upstream of influence from the Rochester WWTF and at nutrient concentrations lower than those observed downstream of the WWTF. Thus, impoundments and hydrologic conditions may be larger factors in determining the vegetation community than point source inputs.
- Floating plant coverage (duckweed) was low during 2017, generally consistent with 2016 findings.
- Algal abundance is low immediately downstream of the Rochester WWTF, and other locations upstream and downstream of the WWTF consistently exhibit moderate algal coverage. Abundance of attached algae varies over time in the non-tidal Cocheco River.
- Tidal Cocheco River water quality results in 2017 reflected seasonal differences between events (e.g. temperature, freshwater inflow).
- Attached and accumulated macroalgal cover was very low in the tidal Cocheco River during 2017, consistent with 2016 results.

## Section 1

# Introduction

This report presents the methods and results of the 2017 water quality related characterization of the non-tidal and tidal portions of the Cocheco River conducted by Brown and Caldwell (BC) on behalf of the City of Rochester, New Hampshire (the City) and GBMC. This effort was similar to water quality and algal monitoring efforts completed in 2015 and 2016 (Brown and Caldwell 2016 and Brown and Caldwell 2017). The continuation of these efforts in 2017added important data to the program that can be used to characterize the current water quality status of the Cocheco River and nearby tidal waters. In addition to the evaluation of 2017 data, a broader evaluation of the data collected over the last three (2015–2017) years is presented, providing additional understanding of any changes in water quality constituents that are relevant to the City's ongoing water resource management efforts.

Substantial efforts by organizations such as GBMC and Piscataqua River Estuary Partnership (PREP) are ongoing to characterize the dynamics of the Great Bay Estuary system. In addition, the New Hampshire Department of Environmental Services (NHDES) periodically collects and analyzes water quality data in the Great Bay Estuary system (including the Cocheco River) for assessment purposes. However, data collection efforts specific to the Cocheco and Piscataqua Rivers and regional macroalgal occurrences are limited, and the City and GBMC see value in conducting additional data collection to fill data gaps and better understand the water quality conditions of these receiving waters. These data contribute to the overall understanding of the Great Bay Estuary system and are also specifically valuable to the City to address water quality concerns and impairments raised by NHDES.

A primary objective of the City's Cocheco River monitoring program is to address specific concerns over water quality raised by the United States Environmental Protection Agency (EPA) and NHDES. The most recent 303(d) list of impaired waters assessment completed by NHDES (2017, released on November 30, 2017) includes multiple Cocheco River assessment units (Table 1-1 and Figure 1-1). Cocheco River assessment units upstream and downstream of the City and the Wastewater Treatment Facility (WWTF) discharge are currently listed impaired for pH and dissolved oxygen, with the tidal segment also listed for chlorophyll-a and total nitrogen (TN). Concerns over the water quality status of the Cocheco River warrant additional scrutiny to verify assessment listings and, where necessary, identify potential sources of observed conditions. Ongoing monitoring activities have been structured to collect necessary data to help inform upcoming water quality assessments by NHDES and to ensure proper regulatory and management decisions can be made with the best available data.

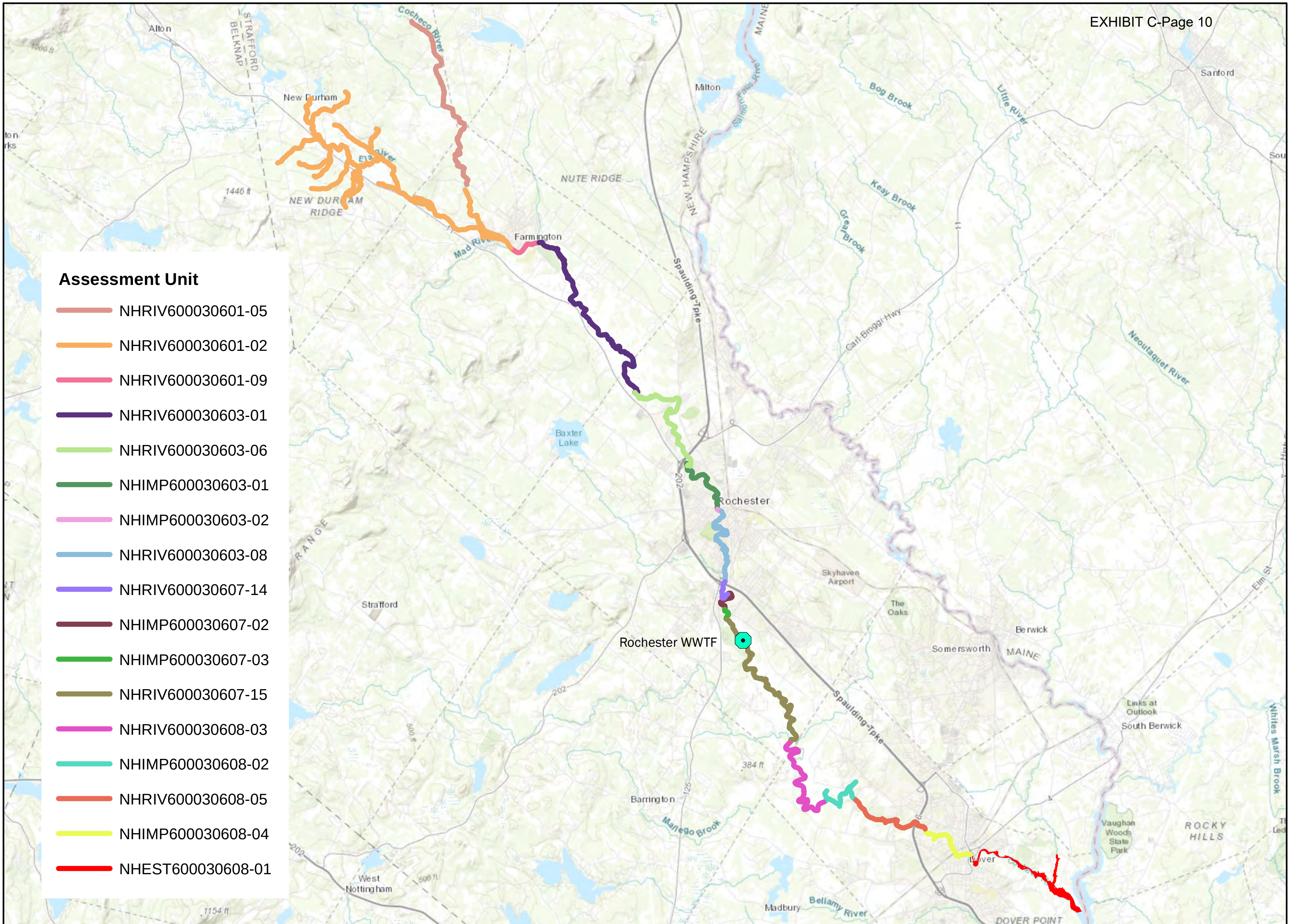
**Table 1-1. Cocheco River Assessment Unit Impairments, NHDES 2016 303(d) List, November 30, 2017.**

| Flow Direction | Assessment Unit | Waterbody Name | Designated Use Affected | Parameter* | Impairment Category |
|---|---|---|---|---|---|
| Upstream | NHRIV600030601-02 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHRIV600030601-05 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHRIV600030601-09 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHRIV600030603-01 | Cocheco River | Aquatic Life | Dissolved oxygen saturation | 5-P |
| | | | | Dissolved oxygen (mg/L) | 5-P |
| | | | | pH | 5-M |
| | NHRIV600030603-06 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHIMP600030603-01 | Cocheco River-City Dam 1 | Aquatic Life | Dissolved oxygen saturation | 5-M |
| | | | | Dissolved oxygen (mg/L) | 5-M |
| | NHIMP600030603-02 | Cocheco River-Hatfield Dam | Aquatic Life | pH | 5-M |
| | NHRIV600030603-08 | Cocheco River | Aquatic Life | Benthic Macroinvertebrate Bioassessment | 5-M |
| | | | | pH | 5-M |
| WWTF Location | NHRIV600030607-15 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHRIV600030608-03 | Cocheco River | Aquatic Life | Dissolved oxygen saturation | 5-M |
| | | | | pH | 5-M |
| | NHRIV600030608-05 | Cocheco River | Aquatic Life | pH | 5-M |
| | NHEST600030608-01 | Cocheco River, Tidal | Aquatic Life | Chlorophyll-a | 5-P |
| | | | | Nitrogen (Total) | 5-M |
| | | | | Dissolved oxygen (mg/L) | 5-P |
| | | | Primary Contact Recreation | Chlorophyll-a | 5-P |
| Downstream | | | | Nitrogen (Total) | 5-P |

**Does not include pH impairment listings that have been attributed to atmospheric deposition*

*** 5-M - parameter is pollutant that requires a TMDL. Impairment is marginal.*

*5-P - parameter is pollutant that requires a TMDL. Impairment is severe and causes poor water quality.*




Brown AND Caldwell

Date: 1/30/2018
Project No: 151145
Client: Rochester

Basemap: Esri

2 1 0 2 Miles

N

Figure 1-1. Cocheco River location overview and NHDES assessment units

## Section 2

# Survey Methods

The Cocheco River monitoring program includes monitoring in both the non-tidal and tidal portions of the river, covering a total of approximately 21 river miles (see Figure 1-1). The study area begins upstream of the City at the Little Falls Bridge Road crossing of the non-tidal Cocheco River and extends downstream to the tidal portion and its confluence with the Salmon Falls River, which together form the Piscataqua River. The non-tidal study area ends at the Central Avenue bridge in Dover, NH and transitions to the tidal study area. Some of the tidal monitoring components (e.g., macroalgae surveys) included sites in the Upper Piscataqua River and Portsmouth Harbor, in order to provide a system-wide perspective. Data collection methodologies employed were similar to methods from previous years (Brown and Caldwell 2016 and Brown and Caldwell 2017). A brief description of each methodology is provided in this section.

## 2.1 Non-Tidal Cocheco River

Data collection in the non-tidal Cocheco River consisted of water quality sampling, a qualitative river survey, and benthic algal surveys. Water quality sampling locations, benthic algal survey locations, and the qualitative survey area (from Station 1 to the Dover Dam) are shown on Figure 2-1. In 2017, two non-tidal surveys were completed: August 14–16 and October 24–26. These time frames were chosen to be consistent with previous years' monitoring and represent river conditions during what is anticipated to encompass the algal growing season.

### 2.1.1 Water Quality Sampling

Eight sampling locations were chosen to represent water quality in the non-tidal Cocheco River from upstream of the City to just upstream of the Central Avenue Dam in Dover, NH (Table 2-1 and Figure 2-1). Several locations were also sampled in 2016: Stations 1, 3, 4, 5, and 6. In addition, three new stations were added during 2017: Station 2, Watson Dam, and Dover Dam. Station 1 is located upstream of the City WWTF and the remaining locations are downstream.

**Table 2-1. Water Quality Sampling Locations, Non-Tidal Cocheco River, August and October 2017.**

| Station | Description | Latitude | Longitude | Survey1: August | | Survey 2: October | |
|---|---|---|---|---|---|---|---|
| | | | | Date | Time | Date | Time |
| Station 1 | downstream of Little Falls Bridge Road | 43.3390 | -70.9965 | 8/14/17* | 8:01 | 10/24/17* | 12:40 |
| Station 2 | downstream of Rochester WWTF outfall | 43.2518 | -70.9620 | 8/15/17 | 14:17 | 10/26/17 | 9:30 |
| Station 3 | near England Road | 43.2471 | -70.9562 | 8/15/17* | 12:05 | 10/24/17* | 11:02 |
| Station 4 | near Covered Bridge Road | 43.2218 | -70.9446 | 8/15/17 | 11:15 | 10/24/17 | 15:00 |
| Watson Dam | upstream side of Watson Dam | 43.2141 | -70.9228 | 8/15/17 | 9:08 | 10/24/17 | 16:25 |
| Station 5 | downstream of Watson Dam | 43.2134 | -70.9214 | 8/15/17* | 8:30 | 10/24/17* | 15:48 |
| Station 6 ALT | upstream of Spaulding Turnpike | 43.2050 | -70.9010 | -- | -- | 10/26/17 | 11:58 |
| Station 6 | downstream of Whittier Road | 43.2046 | -70.8932 | 8/15/17* | 15:10 | -- | -- |
| Dover Dam | upstream of Dover Dam | 43.1967 | -70.8762 | 8/15/17 | 15:31 | 10/24/17 | 18:16 |

* *algal survey was conducted*

During each sampling event, field measurements were collected for temperature, pH, specific conductivity, dissolved oxygen (DO), and turbidity at each location. In addition, grab samples were collected at each site for laboratory analysis of ammonia-nitrogen, orthophosphate (OP) total phosphorus (TP), total nitrogen (TN), total Kjeldahl nitrogen (TKN), nitrate, and nitrite by Eastern Analytical, Inc (EAI)

### 2.1.1 Qualitative River Survey

A qualitative visual and photographic assessment of the non-tidal Cocheco River was conducted to supplement information collected at the monitoring stations. The purpose was to identify any morphologic or habitat conditions in the river that would help to interpret results collected from the water quality and/or benthic algal sampling and provide a better understanding of the non-tidal portion of the river as a whole. Although the 2017 survey covered the entire study area, special attention was given to the upper portion from Station 1 (Little Falls Bridge Road) downstream to the City WWTF. This area was not traversed during the previous visual survey conducted in 2016.

The survey was conducted by canoe on August 14–16, 2017. Photographs were taken of habitat and river characteristics, with special attention given to transitional areas (i.e. where notable changes in habitat occurred). Ecological conditions, including submerged and emergent macrophyte communities, areas of macrophyte and/or algal accumulations, and incidental observations of wildlife were photographed and recorded in field notebooks. Other information such as changes in bank slopes, locations of obvious outfalls, and debris accumulation were also noted.

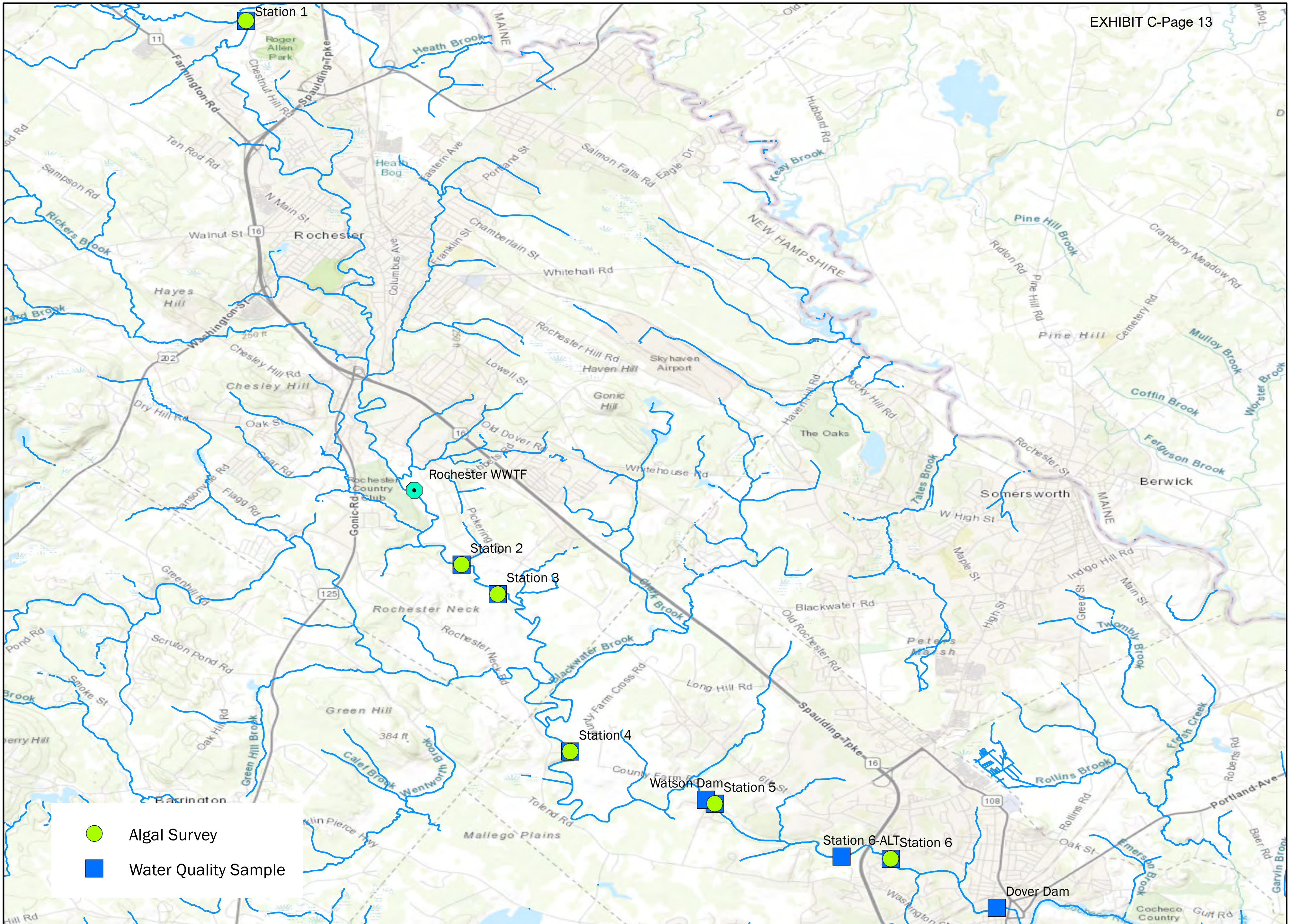
### 2.1.2 Benthic Algal Surveys

Surveys of algal growth in the non-tidal Cocheco River were conducted coincident with water quality sampling at four locations (see Figure 2-1 and Table 2-1). The surveys were conducted at the same locations as 2015 and 2016, following standard viewing bucket survey methods for New Hampshire and Maine (NHDES 2013 and MDEP 2014) to maintain consistency with the algal surveys completed in 2015 and 2016 (Brown and Caldwell 2016 and Brown and Caldwell 2017).

At each station, three transects were established perpendicular to the direction of streamflow, with transects spaced approximately 10 feet apart. A viewing bucket with a 16-point grid pattern was used to characterize streambed conditions at six viewing locations along each transect. At each location along a transect, the viewing bucket was immersed in the water and the algal community was characterized at each grid point (for a total of 96 observations per transect and 288 observations per location), using one of the following descriptors:

- *Sand/Clay/Mud* – Bare, unconsolidated substrate
- *Plant* – Aquatic plant/plant-like macroalga
- *Moss* – An aquatic moss
- *Crust* – A crust-forming algae
- *Mat 0* –No visible algae
- *Mat 1* – A thin layer of algae
- *Mat 2* – Periphyton mat 0.5–1 mm
- *Mat 3* – Periphyton mat 1–5 mm
- *Mat 4* – Periphyton mat 5 mm–2 cm
- *Mat 5* – Periphyton mat >2 cm
- *Macro 1* – Filamentous algae >5 cm
- *Macro 2* – Filamentous algae 5–15 cm
- *Macro 3* – Filamentous algae >15 cm

Photographs were also collected at each site. In addition, flow measurements were collected along the last transect of each site. Depth and velocity was recorded at regular intervals at each site to calculate discharge. These hydraulic measurements are not incorporated into the results or discussion of this report, but can be used in future reports to evaluate any relationships between flow and water quality and/or vegetation and algal communities.




| | | | |
|---|---|---|---|
| Brown AND Caldwell | Date: 1/30/2018<br>Project No: 151145<br>Client: Rochester | Basemap: Esri<br>1 0.5 0 1 Miles<br>N | Figure 2-1. Water quality and benthic algal survey locations, non-tidal Cocheco River, August and October 2017 |

## 2.2 Tidal Segments

Water quality sampling and qualitative and quantitative macroalgae surveys were conducted in the tidal Cocheco and Upper Piscataqua Rivers, as well as Portsmouth Harbor. Data collection activities were conducted in a similar time frame as the non-tidal effort: August 13 and 29–31 and October 25, 2017.

### 2.2.1 Water Quality Sampling

Surface water quality samples were collected at five locations in the tidal Cocheco River (Figure 2-2 and Table 2-2) on two days in 2017: August 13 and October 25. Sampling locations were selected to be consistent with previous monitoring efforts: CR-1, CR-3, CR-5 and CR-7 are locations established by NHDES and sample location BC-CR-9 was established by BC. During each sampling event, field measurements were collected for temperature, pH, specific conductivity, salinity, DO, and turbidity using a multi-parameter data recorder at each location. In addition, a grab sample was collected at each location for laboratory analysis of OP, TP, TN, TKN, nitrate, nitrite, and chlorophyll-a by EAI.

**Table 2-2. Water Quality Sampling Locations, Tidal Cocheco River, August and October 2017.**

| Station | Latitude | Longitude | Survey 1: August | | Survey 2: October | |
|---|---|---|---|---|---|---|
| | | | Date | Sample Time | Date | Sample Time |
| BC-CR-9 | 43.1945 | -70.8550 | 8/13/2017 | 10:45 | 10/25/2017 | 11:49 |
| CR-1 | 43.1878 | -70.8414 | 8/13/2017 | 11:08 | 10/25/2017 | 9:56 |
| CR-3 | 43.1871 | -70.8407 | 8/13/2017 | 11:25 | 10/25/2017 | 10:22 |
| CR-5 | 43.1861 | -70.8391 | 8/13/2017 | 11:44 | 10/25/2017 | 10:52 |
| CR-7 | 43.1839 | -70.8372 | 8/13/2017 | 11:57 | 10/25/2017 | 11:22 |

### 2.2.2 Phytoplankton and Cyanotoxin Identification

During each water quality monitoring event (see Table 2-2), grab samples were collected from each site for analysis of algal taxonomy and cyanotoxins. EAI analyzed each sample for total cell count and major phytoplankton taxonomic groups were identified and enumerated. Dominant genera for each taxon were also noted. Tests for microcystin/nodularins (MCs/NODs) and anatoxin-a (ANTX-A) were conducted by GreenWater Laboratories.

### 2.2.3 Macroalgae Surveys

**Qualitative: Photographic Survey**

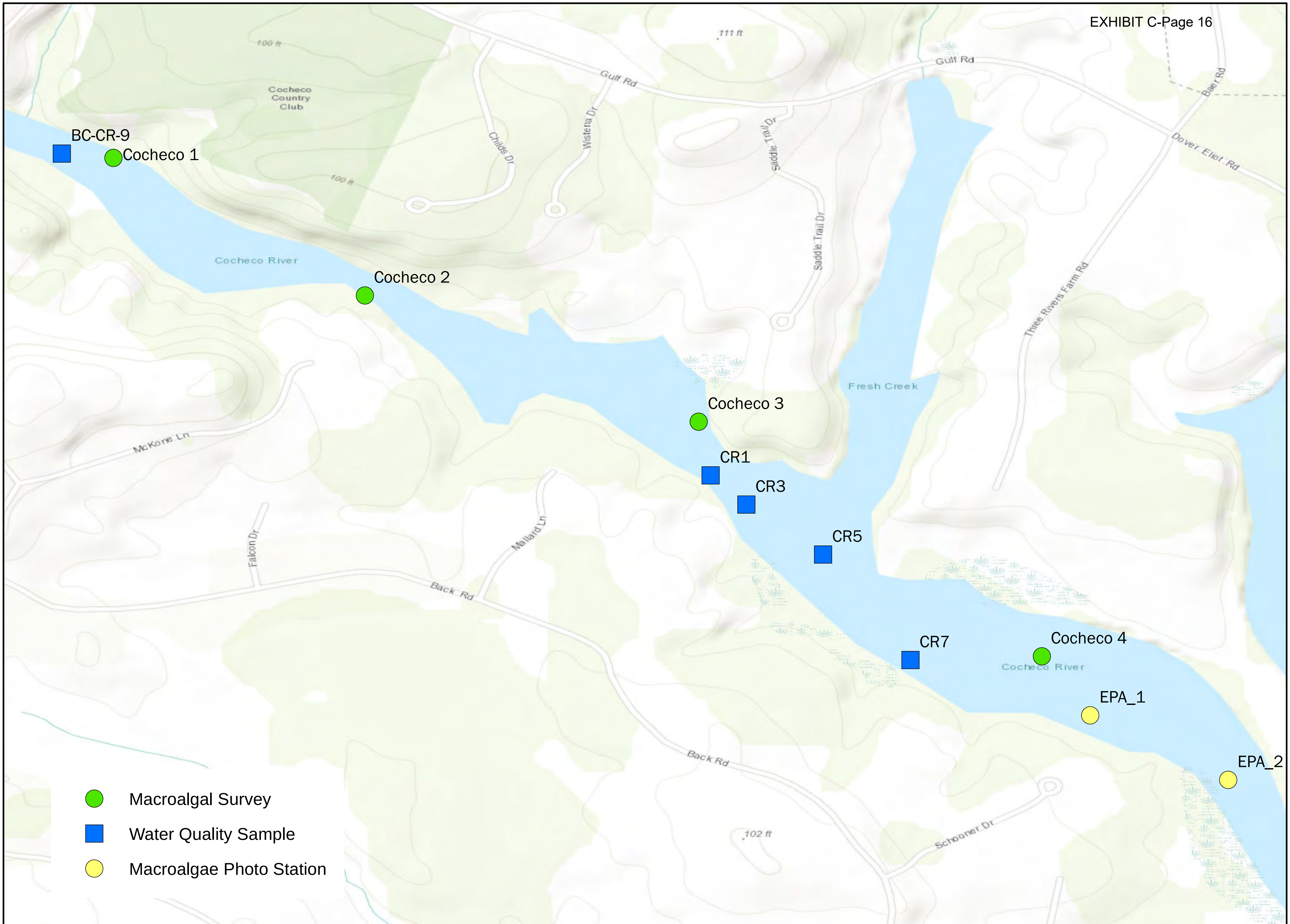
A photographic survey of the tidal Cocheco River and Upper Piscataqua River was conducted on August 13, 2017 to qualitatively characterize shoreline macroalgal conditions at low tide (Figures 2-2 and 2-3). Photographs were taken at, or as close as possible to, the photograph stations established in 2016, which were based on sites previously photographed by the EPA documenting a proliferation of sea lettuce (*Ulva* sp.) in 2014 (NHDES 2016). An additional photographic survey was planned for October 2017 was not completed due to adverse weather conditions and water levels during the intended survey period.

**Quantitative: Transect Surveys**

Macrophyte (macoralgae and plants) abundance was measured at 11 stations in the tidal Cocheco River, upper Piscataqua River, and Portsmouth Harbor (Table 2-3 and Figures 2-2 through 2-4) from August 29–30, 2017. An attempt was made to conduct transect surveys at the same locations surveyed in 2016 using the same methodology, but some locations and methods were slightly modified due to field conditions on the survey date (details provided in Section 3). Surveys were conducted at low tide to maximize visibility and accessibility of substrate along the edges of the river. At each station, a 100–250-foot transect was established along the shoreline between the mean low tide and mean high tide elevations. At six equally spaced locations along the transect, macrophyte presence/absence, type, and percent cover were recorded within a 3 ft x 3 ft quadrat subdivided into 16 grid squares. Photographs were taken at each transect and of each quadrat. In addition, measurements for temperature, specific conductivity, salinity, DO, pH, and turbidity were collected in the river near each transect.

**Table 2-3. Water Quality Sampling and Algal Survey Locations, Tidal Cocheco River, August 2017.**

| Station | Description | Latitude | Longitude | Date | Sample Time |
|---|---|---|---|---|---|
| Cocheco 1 | Cocheco River near Cocheco Country Club | 43.1944 | -70.8539 | 8/30/17 | 14:01 |
| Cocheco 2 | Cocheco River near McKone Lane | 43.1915 | -70.8486 | 8/30/17 | 14:36 |
| Cocheco 3 | Cocheco River upstream of Fresh Creek | 43.1889 | -70.8417 | 8/30/17 | 14:58 |
| Cocheco 4 | Cocheco River downstream of Fresh Creek | 43.1840 | -70.8345 | 8/30/17 | 15:33 |
| Piscataqua 5 | Piscataqua River near Cocheco River | 43.1748 | -70.8262 | 8/31/17 | 17:03 |
| Piscataqua 6 | Piscataqua River near Houde Road | 43.1662 | -70.8270 | 8/31/17 | 14:08 |
| Piscataqua 7 | Piscataqua River near Dover Neck Road | 43.1627 | -70.8298 | 8/31/17 | 15:40 |
| Piscataqua 8 | Piscataqua River upstream of Sturgeon Creek | 43.1569 | -70.8274 | 8/31/17 | 16:04 |
| Portsmouth 1 | Ordione Point State Park | 43.0520 | -70.7226 | 8/29/17 | 12:03 |
| Portsmouth 2 | North side of Pierce Island | 43.0758 | -70.7450 | 8/29/17 | 14:08 |
| Portsmouth 3 | South side of Pierce Island | 43.0733 | -70.7444 | 8/29/17 | 13:23 |




Brown AND Caldwell

Date: 1/30/2018
Project No: 151145
Client: Rochester

Basemap: Esri

0.15 0.075 0 0.15 Miles

N

Figure 2-2. Water quality and macroalgal survey locations, tidal Cocheco River, August and October 2017

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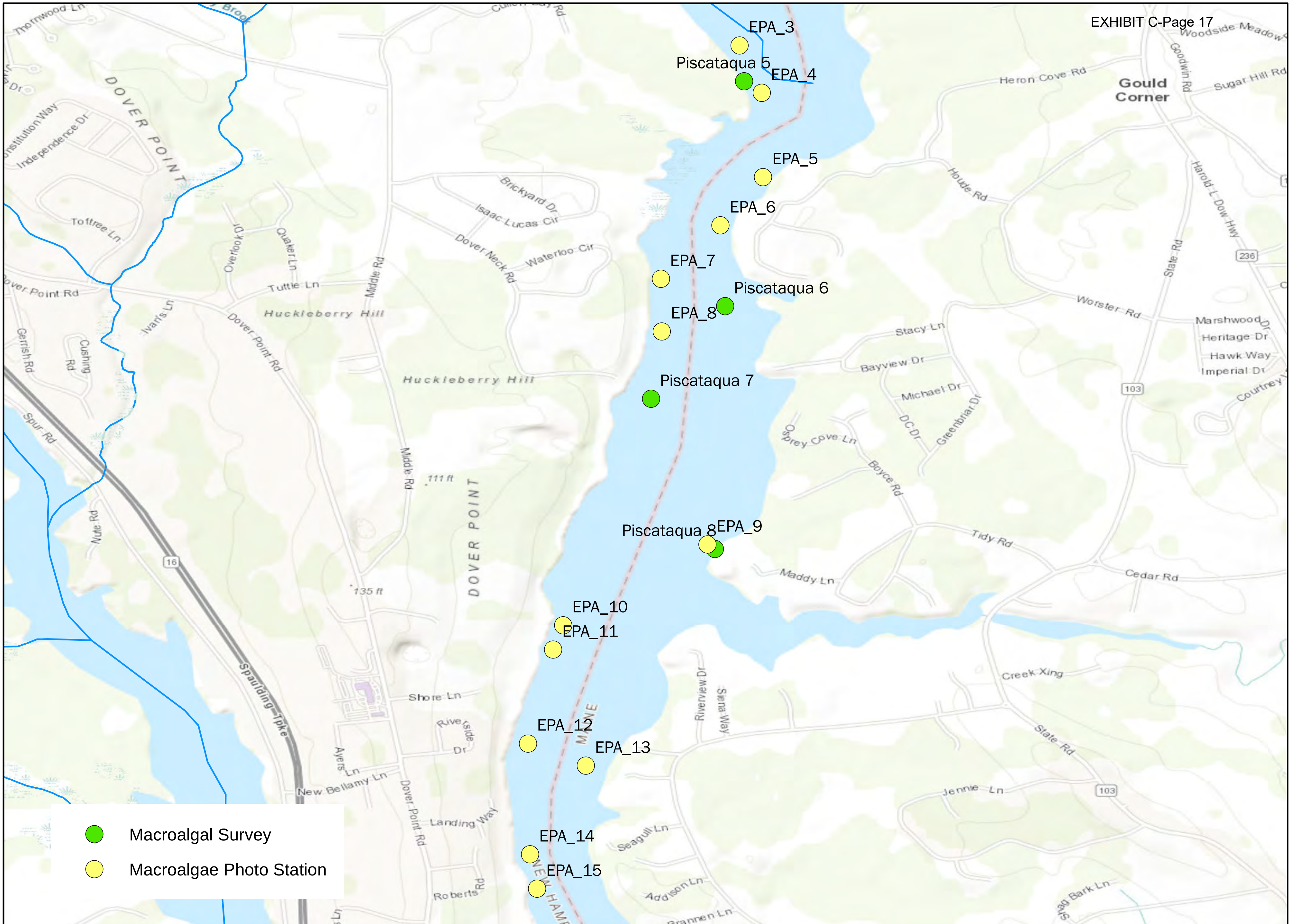


Brown AND Caldwell

Date: 1/30/2018
Project No: 151145
Client: Rochester

Basemap: Esri

0.25 0.125 0 0.25 Miles

N

Figure 2-3. Macroalgal survey locations, Upper Piscataqua River, August 2017


Date: 1/30/2018
Project No: 151145
Client: Rochester

Basemap: Esri

0.2 0.1 0 0.2 Miles

N

Figure 2-4. Macroalgal survey locations, Portsmouth Harbor, August 2017

## Section 3

# Results and Discussion

This section presents the results of the non-tidal and tidal monitoring efforts for 2017 with discussion of the findings. Each major section of river and monitoring type is presented separately. Where pertinent, the 2017 data are compared and evaluated against previous monitoring years' results (2015 and 2016).

## 3.1 Non-Tidal Cocheco River

### 3.1.1 Water Quality Sampling

Field measurements collected in the non-tidal Cocheco River were generally within normal, expected ranges with respect to location and seasonality (Table 3-1). Out of 16 measurements, only one exceedance of the applicable DO water quality standard was observed: at Station 1 during the October sampling event (4.43 mg/L). During the August event, Station 1 exhibited lower specific conductivity than all the other stations, the same patterns was not observed during the October sampling event.

Results of the laboratory analysis conducted on the 2017 water quality samples are provided in Table 3-2. As expected, ammonia and nitrite were undetected or at very low concentrations during the 2017 events. TN concentrations were variable, with the highest concentrations observed at Station 3 during both events. As flow moves downstream from Station 2 to the Dover Dam, there is an apparent shift in the dominant species of nitrogen: at Stations 2 and 3, nitrate was the dominant nitrogen species, but dominance shifts to TKN by the time flow reaches the Dover Dam. This was generally consistent between the August and October events and was also observed during the 2016 monitoring. TP concentrations were lowest at Station 1, but relatively consistent at all other stations during 2017. TP concentrations in the 2017 samples were consistent with values observed during August of 2016, but were lower than those observed during September of 2016 at most stations. Although the data collection for this program is insufficient to make a full assessment of compliance with water quality standards, the measurements collected do not suggest water quality impairments are present in the non-tidal Cocheco River.

### 3.1.2 Qualitative River Survey

Generally, the results of the 2017 qualitative river survey were comparable to the results of the 2016 survey. Similar species of submerged and emergent vegetation were present during both surveys and similar observations of bank slopes, riparian vegetation, and observance of scour holes and shoals were made. Representative photos of the survey area are shown in Figure 3-1.

The upper reach of the study area was characterized by shallow water, a sand and cobble substrate, clear water, and a substantial canopy cover. Several patches of aquatic grasses (e.g. *Vallisneria sp.*) were found in this stretch of the river, some exceeding two to three square meters in area. Progressing downstream, the Cocheco River began to exhibit deeper areas, slower velocity, and a more open canopy (see Figure 3-1, photo B).

**Table 3-1. Water Quality Sampling Results: Field Parameters, Non-Tidal Cocheco River, August and October 2017.**

| Parameter | Water Temperature (˚C) | | pH | | Dissolved Oxygen (mg/L) | | Dissolved Oxygen (% saturation) | | Specific Conductivity (µS/cm) | | ORP (mV) | | Turbidity (NTU) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Month | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct |
| Station 1 | 19.49 | 13.90 | 6.29 | 6.37 | 8.92 | 4.43 | 87.3 | 40.4 | 220 | 241 | 171.2 | 216.0 | 2.36 | 1.94 |
| Station 2 | 21.10 | 15.55 | 7.32 | 7.04 | 8.16 | 9.93 | 91.9 | 97.1 | 587 | 223 | 128.5 | 194.9 | 3.08 | 4.91 |
| Station 3 | 20.43 | 15.55 | 7.00 | 6.53 | 7.64 | 7.10 | 84.6 | 66.8 | 580 | 446 | 108.2 | 236.0 | 2.11 | 1.79 |
| Station 4 | 20.84 | 14.17 | 6.88 | 6.65 | 8.00 | 7.29 | 89.6 | 66.8 | 467 | 211 | 150.5 | 247.4 | 2.76 | 1.97 |
| Watson Dam | 22.20 | 14.42 | 6.96 | 6.69 | 10.90 | 6.79 | 117.5 | 62.8 | 465 | 227 | 150.1 | 263.8 | 3.01 | 2.59 |
| Station 5 | 21.71 | 13.26 | 6.98 | 6.95 | 7.91 | 9.03 | 89.9 | 81.4 | 456 | 228 | 152.5 | 236.1 | 1.86 | 2.71 |
| Station 6 ALT | 24.36 | 15.65 | 8.55 | 6.95 | 9.28 | 10.05 | 111.1 | 98.8 | 369 | 215 | 81.4 | 232.4 | 1.17 | 5.02 |
| Station 6 | 22.16 | -- | 7.04 | -- | * | -- | * | -- | 481 | -- | 187.7 | -- | 1.43 | -- |
| Dover Dam | 22.97 | 15.23 | 7.46 | 6.97 | 8.93 | 8.19 | 104.1 | 76.9 | 429 | 301 | 149.6 | 247.7 | NR | 3.66 |

*-- No sample collected*
**Value recorded in the field was outside the limit of the normal QA/QC range. Value could not be verified and is attributed to instrument error.*
*NR – Not Recorded*

**Table 3-2. Water Quality Sampling Results*: Laboratory Parameters, Non-Tidal Cocheco River, August and October 2017.**

| Parameter | Ammonia as N (mg/L) | | Nitrate as N (mg/L) | | Nitrite as N (mg/L) | | TKN (mg/L) | | Total Nitrogen (mg/L) | | Orthophosphate (mg/L) | | Total Phosphorus (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Month | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct |
| Station 1 | <0.05 | <0.05 | 0.13 | 0.17 | <0.05 | <0.05 | <0.5 | 0.5 | <0.5 | 0.67 | 0.003 | 0.003 | 0.009 | 0.009 |
| Station 2 | <0.05 | 0.05 | 2.9 | 0.18 | <0.05 | 0.05 | 0.8 | 0.5 | 3.7 | 0.5 | 0.007 | 0.01 | 0.03 | 0.04 |
| Station 3 | <0.05 | <0.05 | 3.1 | 2.3 | <0.05 | <0.05 | 0.8 | <0.5 | 3.9 | 2.3 | 0.007 | 0.027 | 0.04 | 0.058 |
| Station 4 | <0.05 | <0.05 | 0.75 | 0.31 | <0.05 | <0.05 | 0.7 | <0.5 | 1.45 | <0.5 | 0.005 | 0.004 | 0.03 | 0.019 |
| Watson Dam | <0.05 | <0.05 | 0.61 | 0.46 | <0.05 | <0.05 | 0.5 | 0.7 | 1.11 | 1.16 | 0.003 | 0.007 | 0.04 | 0.026 |
| Station 5 | 0.09 | <0.05 | 0.58 | 0.46 | <0.05 | <0.05 | 0.7 | 0.7 | 1.28 | 1.16 | 0.005 | 0.007 | 0.03 | 0.028 |
| Station 6 ALT | -- | 0.05 | -- | 0.2 | -- | 0.05 | -- | 0.6 | -- | 0.8 | -- | 0.01 | -- | 0.04 |
| Station 6 | <0.05 | -- | 0.47 | -- | <0.05 | -- | <0.5 | -- | <0.5 | -- | 0.005 | -- | 0.03 | -- |
| Dover Dam | <0.05 | <0.05 | 0.28 | 0.44 | <0.05 | <0.05 | 1.7 | 0.6 | 1.98 | 1.04 | 0.005 | 0.007 | 0.04 | 0.031 |

**Chlorophyll-a results corrected for phaeophytin-a are not available for this monitoring event. EAI is not certified for corrected chlorophyll-a analysis*
*-- No sample collected*


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Basemap: Esri

0 2 4 Miles

**Figure 3-1. Qualitative survey area and photographs, non-tidal Cocheco River, August 2017**

Downstream of Station 1, but upstream of the Rochester City Dam, the river opens into a large wetland feature with significant vegetative cover, reduced water clarity, and little to no observable velocity (see Figure 3-1, photos C and D). In this area, the water column has high densities of milfoil and floating mat algae. In addition, pondweed, bur-reed, lily, and pickerelweed were observed in dense accumulations throughout the area (see Figure 3-1, photo C). This feature is prominent and very likely affects the character of the non-tidal Cocheco River downstream. This area was the first notable observation of very large accumulations of milfoil and patches of duckweed. Progressing downstream, all backwater areas (i.e. area with little to no velocity, usually behind impoundments or other physical obstructions to flow) exhibited the same vegetation types and coverage.

This wetland feature is upstream of any influence from the Rochester WWTF. While no water quality samples were collected in the wetland during the 2017 events, nutrient concentrations upstream of the Rochester WWTF measured at Station 1 (see Figure 2-1) were low. If nutrient concentrations at Station 1 (see Table 3-2) are indicative of water quality in the wetland upstream of the City Dam, then this indicates factors other than nutrients (e.g. impoundments and hydrologic conditions) play an important role in the proliferation of invasive vegetation. Further characterization of this area, its water quality (e.g. nutrient concentrations), and its effect on downstream waters may be informative for future monitoring and management decisions.

As expected, the number and location of dams greatly influences the character of the river (see Figure 3-1, photos E and F). Large sections of deep, slow moving water were interspersed with shallower, higher velocity sections. Downstream of the City and the WWTF, large stands of *Vallisneria* sp. were observed in the shallower portions of the river (see Figure 3-1, Station 3). The canopy remained mostly open in the lower portions of the study area where the river is wider than the upper portions (see Figure 3-1, Station 4).

**Figure 3-2. Stone fly larvae and mussel at Station 1 (top), Station 3 (middle), and upstream of Station 6 (bottom) in August 2017**

Observations of macroinvertebrate communities were made at several locations along the river. Stone fly larvae (Plecoptera) and caddisfly larvae cases (Trichoptera) were commonly observed, along with mussels (Figure 3-2), indicating an abundant macroinvertebrate community may be present and possibly thriving. The macroinvertebrate types observed in the Cocheco River are typically used as general indictors of favorable water quality conditions. Incorporation of macroinvertebrate data could benefit the overall goals of this program. Many states, including New Hampshire for some waterbody types, include a measure of macroinvertebrate community health to determine if designated uses are being met. Incorporation of this data type can be useful for interpreting water quality conditions and drawing conclusions regarding the health of the river.

### 3.1.3 Benthic Algal Surveys

The nature of the viewing bucket methodology requires samples to be collected in shallow, wadable areas of a river or stream and should reflect areas where attached algae would be expected to grow, if conditions allow. Therefore, the benthic algal surveys in the non-tidal Cocheco River were conducted in shallow areas with adequate access. However, these areas are not representative of the non-tidal Cocheco River as a whole: much of the non-tidal portion of the river is characterized by deeper water that would not allow viewing bucket surveys and would likely not exhibit suitable conditions for algal growth.

Viewing bucket surveys were conducted at Stations 1, 3, and 5 during both 2017 events (August and October), and at Station 6 in August. Water depth (greater than 4 ft) at Station 4 coupled with difficult (unsafe) access prevented surveys at this location during 2017. Station 6 was surveyed in August to be consistent with 2015 and 2016 surveys. However, moving forward, this station will be relocated because the current location is immediately downstream of the Whittier Road bridge which is under major construction and affects the ability to collect a representative sample. The field team conducted reconnaissance of the Cocheco River upstream of the Whittier Road bridge in August and identified a more suitable location for future assessments (see Figure 3-1, Photo G). High flow and water levels in October prevented safe access to conduct an algal survey at the new location (Station 6 ALT), but under typical flow conditions Station 6 ALT will provide a representative sampling location with suitable habitat for viewing bucket surveys and other types of biological monitoring activities.

Differences in site and flow conditions between August and October were apparent and affected survey outcomes. Heavy rains prior to the October 2017 event resulted in greater flows and higher water levels making access and surveys more difficult than in August. Deeper water and significant seasonal leaf fall between August and October covered the riverbed at all stations which impaired the ability to observe the algal community and characterize the bottom substrate (Figure 3-3). More importantly, this leaf cover is likely to have affected algal growth by covering the bottom, shading out light and reducing water circulation near the bottom of the river where algae grow. This is a normal seasonal occurrence that is expected to reduce algal growth during the autumn months every year.

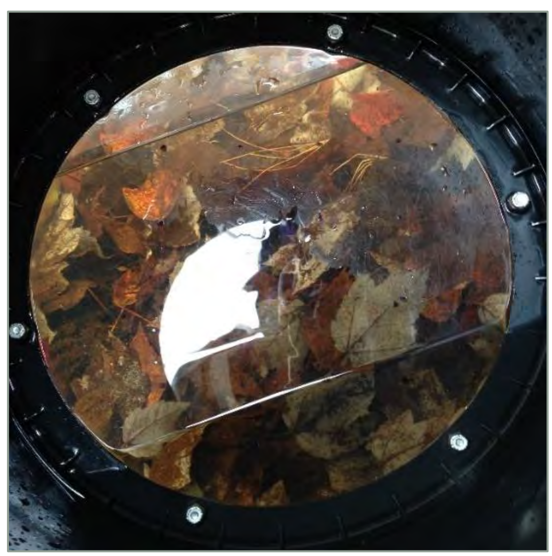

**Figure 3-3. Leaf covered riverbed, Station 1, October 2017**

A summary of results of the 2017 surveys are presented by station in Table 3-3. Overall, algal in the Cocheco River was low to moderate and consisted mostly of smaller growth forms that were not conspicuous when viewed from the surface of the water or edge or the river. The major observations at each station are as follows:

- Station 1 (upstream of the Rochester WWTF) was characterized by filamentous and mat algae, with substantial observations of aquatic vegetation. Filamentous algae coverage (28 percent) and mat algae (44 percent) coverage was greater during August than it was in October at Station 1. Significant leaf fall covering the substrate prior to the October event likely explains the lower algal coverage compared to the August event. Slight variations in transect placement between events may have resulted in the different levels of plant coverage observed (12 percent in August versus 51 percent in October) and may not be indicative of significant plant growth between the August and October events.
- During both 2017 events, most of the survey area at Station 3 (immediately downstream of the Rochester WWTF) was bare substrate devoid of algal growth (Figure 3-4). This provides evidence that water quality in this section of the river is not associated with adverse algal conditions.
- At Station 5, filamentous algae of greater than 15 cm was recorded in approximately one-third of the total observations during both events (Figure 3-5). This location is immediately downstream of an impoundment where the river is wide and slow moving with an open canopy. The physical and hydrological conditions at Station 5 may be more important drivers of the observed algal condition than nutrient levels.
- At Station 6, over 50 percent of the observations during the August event were recorded as filamentous algae of various lengths (from less than 5 cm to greater than 15 cm) This location is immediately downstream of the Whittier Road bridge, which was under construction at the time of the survey; this significant anthropogenic influence can impact algal growth.

**Table 3-3. Algal Survey Results, Non-Tidal Cocheco River, August and October 2017.**

| Station | Survey Month | Filamentous Algae 1 | 2 | 3 | Mat Algae 1 | 2 | 3 | 4 | 5 | Bare Substrate* (Mat 0 and Clay/Sand/ Mud) | Plant | Moss | Algal Crust |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | <5 cm | 5 - 15 cm | >15 cm | transparent | up to 1 mm | 1 - 5 mm | 5 mm - 2 cm | >2 cm | | | | |
| Station 1 | Aug | 10% | 6% | 12% | 9% | 32% | 3% | 0% | 0% | 16% | 12% | 0% | 0% |
| Station 1 | Oct | 2% | 2% | 4% | 12% | 1% | 0% | 0% | 0% | 25% | 51% | 1% | 0% |
| Station 3 | Aug | 9% | 0% | 0% | 8% | 0% | 0% | 0% | 0% | 71% | 12% | 0% | 0% |
| Station 3 | Oct | 2% | 1% | 0% | 14% | 1% | 0% | 0% | 0% | 67% | 9% | 5% | 1% |
| Station 5 | Aug | 2% | 3% | 30% | 23% | 35% | 0% | 0% | 0% | 7% | 0% | 0% | 0% |
| Station 5 | Oct | 5% | 6% | 30% | 21% | 13% | 7% | 6% | 0% | 7% | 7% | 0% | 0% |
| Station 6 | Aug | 31% | 16% | 7% | 16% | 25% | 2% | 1% | 0% | 3% | 0% | 0% | 0% |

** "Mat 0" and "Clay/Sand/Mud" categories were combined because both represent bare substrate, free from algal or plant cover.*

**Figure 3-4. Bare substrate dominant at Station 3, October 2017.**

**Figure 3-5. Filamentous algae observed at Station 5 during viewing bucket survey, October 2017**

The benthic algal survey protocol is designed to characterize the algal composition in rivers so that changes in site conditions can be tracked over time (NHDES 2013). To facilitate comparisons of site conditions across survey events, the descriptor categories recorded in the field (see Section 2.1.2) were consolidated into groups representing the relative absence or abundance of plant/algae growth (Table 3-4). These groups are not the same as the "score' groups presented in the 2016 field report, and were not used to calculate an overall score for each survey result.

**Table 3-4. Combined Algal Groups for Temporal Comparisons of Algal Survey Results**

| Combined Group | Descriptor* |
|---|---|
| Bare | Sand/Clay/Mud, Mat 0 |
| Plant/Moss | Plant, Moss |
| Algal 1 | Algal Crust, Mat 1 |
| Algal 2 | Mat 2 |
| Algal 3 | Macro 1, Mat 3 |
| Algal 4 | Macro 2, Mat 4 |
| Algal 5 | Macro 3, Mat 5 |

** See Section 2.1.2 for definitions of descriptor categories*

The results of the 2015, 2016, and 2017 surveys were then compared graphically to show changes in algal coverage at each site. We caution any direct comparison of these benthic algal survey results across stations. Differences in flow, water depth, substrate type, canopy cover, and other physical and morphological factors among stations prevent meaningful comparison without more information. However, comparison of changes in algal community at a station may allow for interpretation of changes in river conditions (including, but not limited to, nutrients) over time.

Figures 3-6 through 3-9 illustrate benthic algal survey results collected to date at each station. At all sites, density and type/size of algae fluctuates both within years and between years. This is apparent even at locations with typically low nutrient concentrations (i.e. Station 1, upstream of the Rochester WWTF) and stations with consistently low algal coverage (i.e. Station 3, downstream of the Rochester WWTF). Although no patterns in algal coverage are discernable at any station based on just three years of data, continued data collection will allow for identification of shifts in algal community over time. Given the number of environmental factors that influence algal growth (e.g. hydrology, light availability, water quality, temperature) temporal changes in the algal community are expected, but the relative importance of these variables in structuring the resulting algal community has not been determined for these sites. Algal surveys should be paired with robust water quality and environmental data collection to determine if any observed shifts could be attributed to changes in water quality, climatic, or streamflow conditions in the Cocheco River.

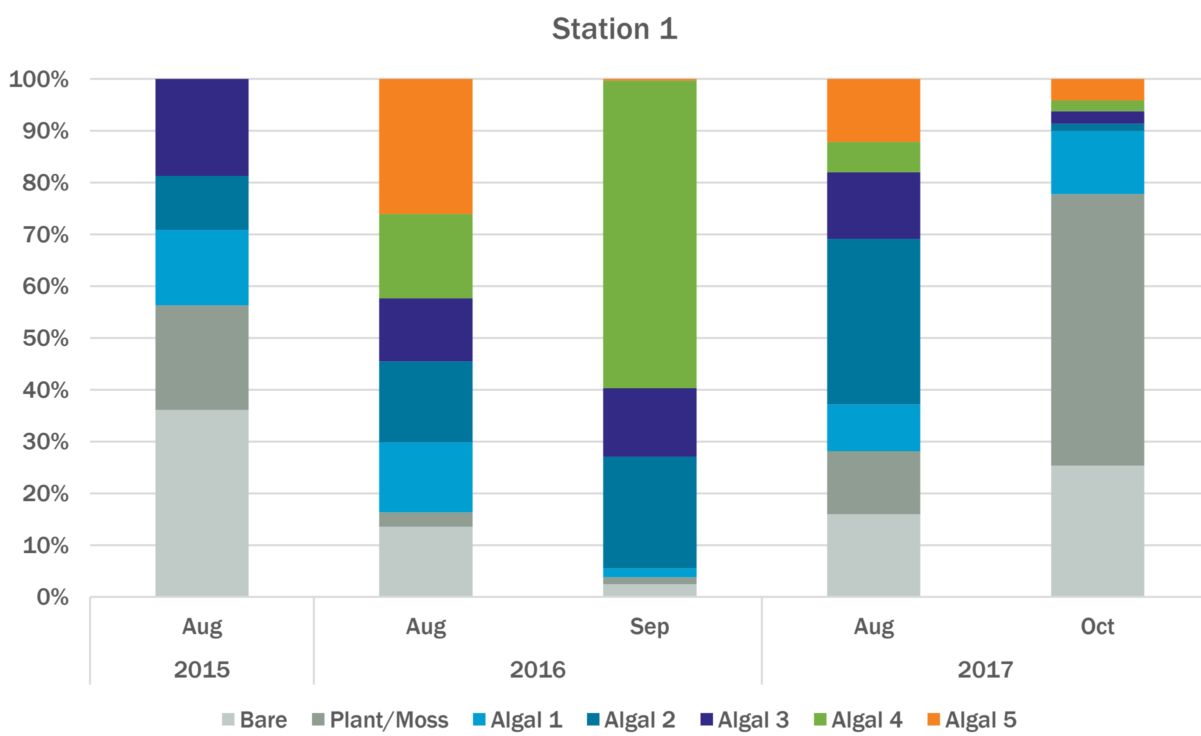


**Figure 3-6. Representative photo of Station 1 (top) and algal survey results compared over three years of monitoring (bottom), non-tidal Cocheco River, 2015–2017**

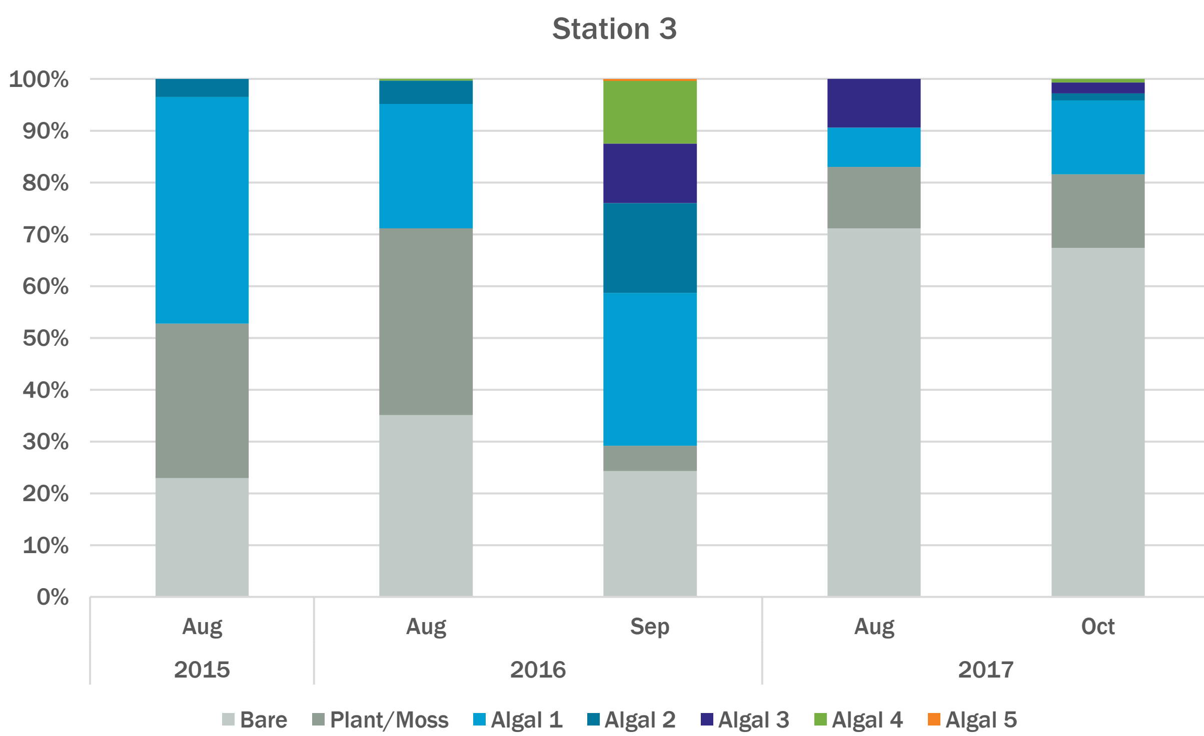


**Figure 3-7. Representative photo of Station 3 (top) and algal survey results compared over three years of monitoring (bottom), non-tidal Cocheco River, 2015–2017**

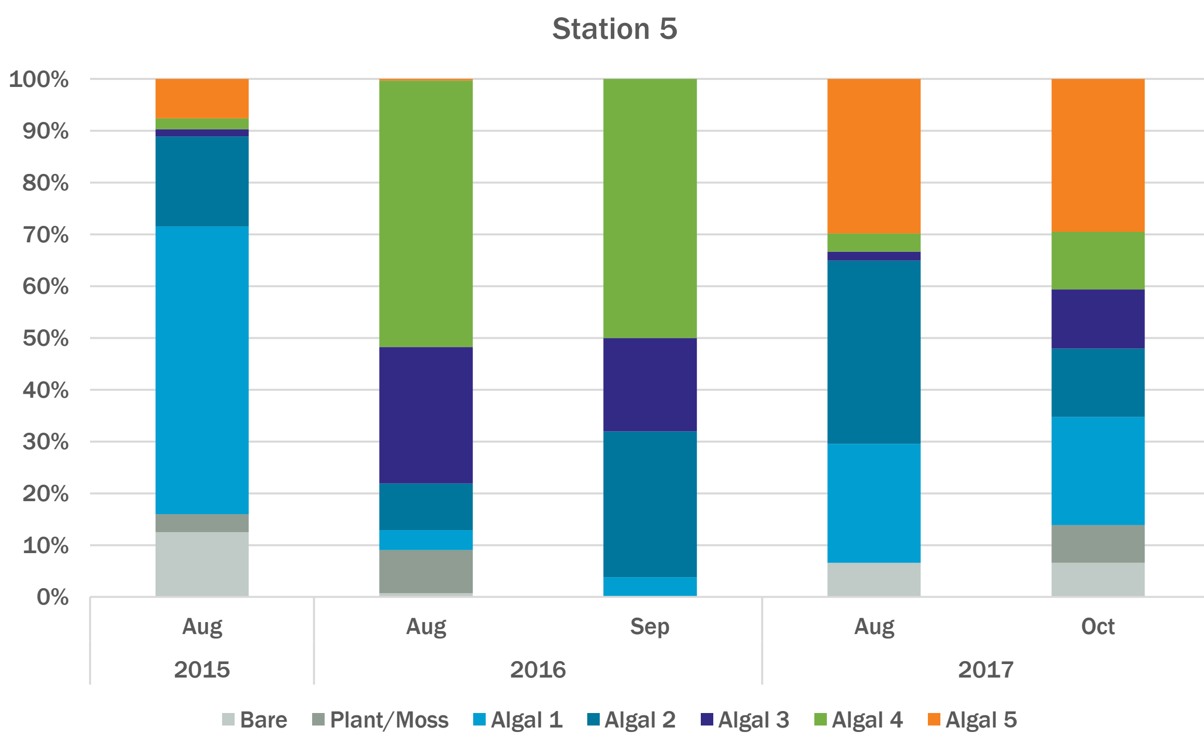


**Figure 3-8. Representative photo of Station 5 (top) and algal survey results compared over three years of monitoring (bottom), non-tidal Cocheco River, 2015–2017**

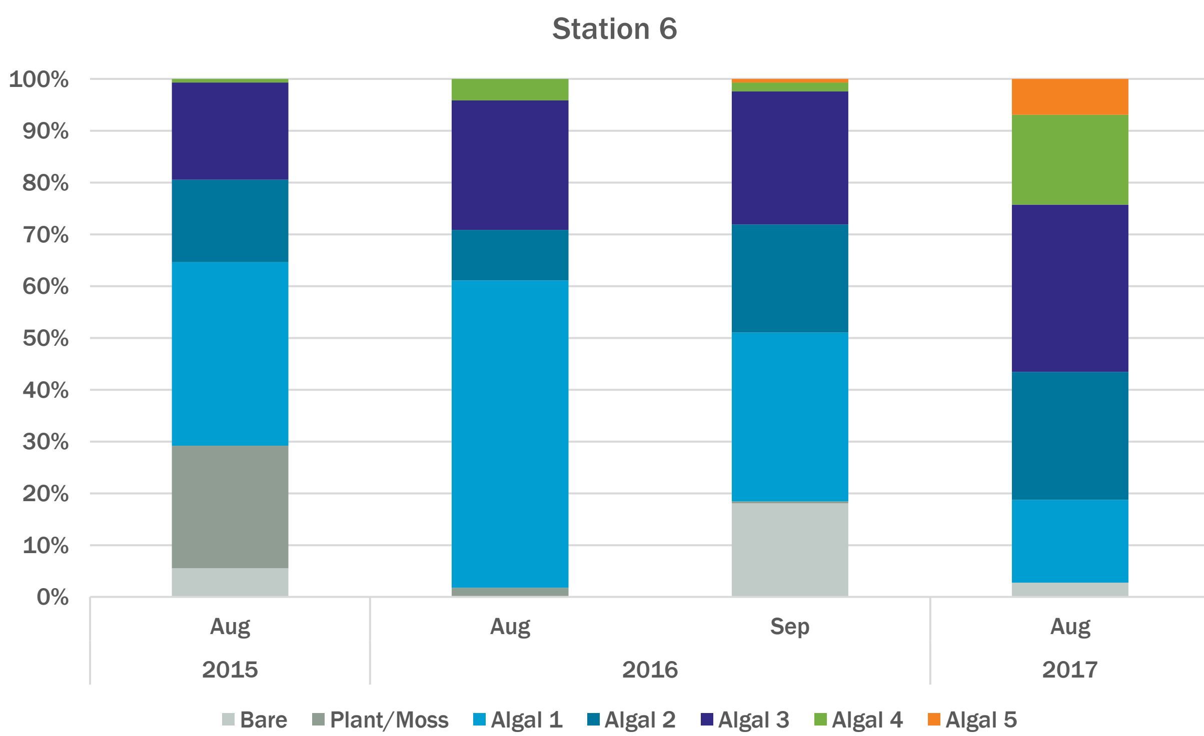


**Figure 3-9. Representative photo of Station 6 (top) and algal survey results compared over three years of monitoring (bottom), non-tidal Cocheco River, 2015–2017**

# 3.2 Tidal Cocheco River

## 3.2.1 Water Quality Sampling

Field water quality measurements collected during 2017 were within expected seasonal ranges for the tidal Cocheco River (Table 3-5). A single measurement at one station (BC-CR-9) was slightly below the pH minimum criterion of 6.5, but this was not observed at any other station. DO percent saturation was near or above 100 percent (August 2017), which is typically indicative of moderate photosynthetic activity. However, as described in the next section, phytoplankton and diatom cell counts at the time were not high and are not indicative of any harmful algal conditions or presence of cyanotoxins. Furthermore, TN and TP levels were very low or undetected at all stations during both survey events, but nitrate levels were generally higher in October than in August (Table 3-6). TSS was higher in August than in October at all sites.

Differences in laboratory analyte detection limits among survey events make comparisons between 2016 and 2017 data difficult for many parameters. Despite this, some generalizations can be made comparing the 2017 results to 2016. For example, TSS was generally higher in August 2017 than in 2016. In addition, OP and TP were generally lower in August 2017 than in 2016 samples. While intra-annual variability in water quality was observed and expected given the highly dynamic nature of this tidal system, an assessment of larger scale temporal patterns and correlations (i.e. over years) is not possible given the limited size of the dataset.

## 3.2.2 Phytoplankton and Cyanotoxin Identification

Green algae (Chlorophyceae) and diatoms (Bacillariophyceae) were the dominant algal groups in 2017 samples from the tidal Cocheco River (Table 3-7). Golden algae (Synurophyceae) and Euglenids (Euglenophyceae) were present in several samples, but usually in very small numbers. Only two samples contained cyanobacteria, both collected in October, and in both cases the cell counts were attributed the presence of only one or two cyanobacteria colonies/filaments. Except for these two samples, phytoplankton were more abundant overall in August 2017 than October 2017, which is expected due to seasonal differences in environmental conditions. In addition, there is a difference in species dominance between August and October: green algae were dominated by *Coleastrum* sp. in August and by *Scenedesmus* sp. and small, unicellular species in October, while diatoms were dominated by the genera *Thalassiosira* and *Coscinodiscus* in August and the genera *Cylindrotheca*, *Skeletonema*, and *Bacillaria* in October. Cyanotoxins (MCs/NODs) were detected at very low levels in samples from August at all five locations, despite the absence of cyanobacteria in the taxonomic samples (see Table 3-7). On the other hand, the two October samples that contained cyanobacteria (at low levels) did not have detectable levels of cyanotoxins. Anatoxin-a was not detected in any sample. While NHDES has not established any guidance or water quality criteria based on cyanotoxins, the observed cell counts and toxin concentrations in the tidal Cocheco River are well below all guidance levels and thresholds recommended by EPA (2016 and 2017).

The 2017 phytoplankton results are comparable to the results from samples collected in September of 2016 in terms of total densities, distribution of major taxonomic groups, and dominant species in each group. As in 2016, cyanobacteria and cyanotoxins were not abundant in 2017 samples. The algal community identified over the last two years appears to be typical of this segment of the Cocheco River, and is not indicative of harmful algal blooms or impairments of beneficial uses.

**Table 3-5. Water Quality Sampling Results: Field Parameters, Tidal Cocheco River, August and October 2017.**

| Parameter | Water Temperature (˚C) | | pH | | Dissolved Oxygen (mg/L) | | Dissolved Oxygen (% saturation) | | Salinity (ppt) | | Specific Conductivity (µS/cm) | | Turbidity (NTU) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Month | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct |
| BC-CR-9 | 25.35 | 15.93 | 6.40 | 7.60 | 7.52 | 7.88 | 98.7* | 79.7 | 12.60 | 3.33 | 20,870 | 6,437 | 0.74 | 12.1 |
| CR-1 | 24.90 | 16.21 | 7.20 | 7.19 | ** | 7.87 | NR | 78.8 | 14.30 | 11.50 | 23,633 | 19,190 | 11.2 | 6.10 |
| CR-3 | 26.36 | 15.83 | 7.71 | 7.37 | 7.63 | 7.78 | 104.4* | 78.8 | 17.31 | 11.05 | 27,950 | 18,333 | 7.54 | 7.34 |
| CR-5 | 25.27 | 16.10 | 7.99 | 7.38 | 7.87 | 7.66 | 105.2* | 77.9 | 16.77 | 10.59 | 27,375 | 17,936 | 8.39 | 9.87 |
| CR-7 | 25.26 | 16.28 | 8.09 | 7.42 | 8.58 | 7.90 | 114.4* | 80.5 | 16.17 | 11.46 | 26,458 | 17,290 | 8.15 | 7.97 |

**Not recorded in the field. Value calculated using concentration, temperature, and salinity measured in the field (https://water.usgs.gov/software/DOTABLES/)*

***Value recorded in the field was above the upper limit of the normal QA/QC range, value could not be verified.*

*NR – Not Recorded*

**Table 3-6. Water Quality Sampling Results*: Laboratory Parameters, Tidal Cocheco River, August and October 2017.**

| Parameter | Nitrate as N (mg/L) | | Nitrite as N (mg/L) | | TKN (mg/L) | | Total Nitrogen (mg/L) | | Orthophosphate (mg/L) | | Total Phosphorus (mg/L) | | TSS (mg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Month | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct |
| BC-CR-9 | 0.13 | 0.41 | <0.05 | <0.05 | <1 | <1 | <1 | <1 | 0.06 | <0.1 | 0.02 | <0.1 | 13 | 11 |
| CR-1 | 0.11 | 0.36 | <0.05 | <0.05 | <1 | <1 | <1 | <1 | 0.07 | <0.1 | 0.03 | <0.1 | 20 | 6 |
| CR-3 | 0.10 | 0.38 | <0.05 | <0.05 | <1 | <1 | <1 | <1 | <0.02 | <0.1 | 0.02 | <0.1 | 20 | 9 |
| CR-5 | 0.08 | 0.35 | <0.05 | <0.05 | <1 | <1 | <1 | <1 | 0.1 | <0.1 | 0.03 | <0.1 | 16 | 12 |
| CR-7 | 0.08 | 0.29 | <0.05 | <0.05 | <1 | <1 | <1 | <1 | <0.02 | <0.1 | 0.05 | <0.1 | 20 | 11 |

**Chlorophyll-a results corrected for phaeophytin-a are not available for this monitoring event. EAI is not certified for corrected chlorophyll-a analysis*

**Table 3-7. Water Quality Sampling Results: Algal Taxonomy, Tidal Cocheco River, August and October 2017.**

| Parameter | Total Cell Count (cells/mL) | | Cyanobacteria (cells/mL) | | Chlorophyceae (cells/mL) | | Bacillariophyceae (cells/mL) | | Synurophyceae (cells/mL) | | Euglenophyceae (cells/mL) | | MC/NODs (µg/L) | | Anatoxin-a (µg/L) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Survey Month | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct | Aug | Oct |
| BC-CR-9 | 1,044 | 184 | 0 | 0 | 716 | 10 | 300 | 68 | 0 | 8 | 0 | 6 | 0.17 E | <0.15 | <0.05 | <0.05 |
| CR-1 | 385 | 7,207 | 0 | 6,833 | 312 | 237 | 55 | 90 | 0 | 0* | 0 | 0* | 0.19 | <0.15 | <0.05 | <0.05 |
| CR-3 | 40 | 4,162 | 0 | 3,928 | 0 | 0* | 39 | 188 | 0 | 0* | 0 | 0* | 0.18 | <0.15 | <0.05 | <0.05 |
| CR-5 | 11,745 | 280 | 0 | 0 | 11,055 | 0* | 600 | 272 | 0 | 4 | 0 | 0* | 0.17 | <0.15 | <0.05 | <0.05 |
| CR-7 | 22,800 | 134 | 0 | 0 | 20,800 | 16 | 3,200 | 80 | 0 | 38 | 200 | 0 | 0.18 | <0.15 | <0.05 | <0.05 |

*E - Analytical result is estimated. Values achieved were outside calibration range.*

** - Noted as present in sample*

### 3.2.3 Macroalgae Surveys

**Qualitative: Photographic Survey**

Sea lettuce (*Ulva* sp.) and other green macroalgae were observed at (as well as in between) some of the photo locations on exposed mudflats along the shores of the Piscataqua River during the 2017 survey. However, the vast majority of the area along the riverbanks on the photographic and transect survey dates was devoid of green macroalgae (accumulated or attached). Representative photographs from the established photo stations are shown in Figure 3-10. These sites have been noted to have large accumulations of sea lettuce in previous years, but that was not the case during 2017. The monitoring effort to date is not sufficient to draw specific spatial or temporal conclusions regarding macrophyte persistence or abundance, nor is it sufficient to link macrophyte observations to any source or cause, such as natural or anthropogenic nutrient point or non-point source inputs.

**Quantitative: Transects**

Transect surveys were completed at eight of the eleven target sites during the 2017 survey (see Figures 2-2 and 2-3). Water levels were too high to survey at the previous location of site Cocheco 1, so the transect survey was conducted at a comparable site with suitable water levels on the opposite bank of the river across from Cocheco 1. At three sites, tidal conditions during the survey week inhibited the survey team's ability to make the necessary observations of the substrate to quantify macroalgae. In place of the transect survey, these three sites were photographed, site conditions and general observations were noted, and field water quality parameters were measured.

Water quality measurements collected in the field at each survey site are presented in Table 3-8. Results were within normal, expected ranges for the time of day and season. With the exception of the expected differences in salinity and specific conductivity, conditions were relatively comparable among stations. While DO levels measured during the survey were near the higher end of the normal range, there is no evidence that these observations are indicative of an ecological imbalance.

**Table 3-8. Macroalgal Survey: Field Parameters, Tidal Cocheco River and Piscataqua River, August 2017.**

| Site | Time | Water Temperature (˚C) | pH | Dissolved Oxygen (mg/L) | Dissolved Oxygen (% saturation) | Salinity (ppt) | Specific Conductivity (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| Cocheco 1 | 14:01 | 23.03 | 7.76 | 10.66 | 123.18 | 7.03 | 12161 | 5.44 |
| Cocheco 2 | 14:36 | 22.65 | 7.85 | 10.38 | 120.59 | 8.18 | 13963 | 18.2 |
| Cocheco 3* | 14:58 | 24.19 | 8.16 | 11.50 | 140.36 | 12.52 | 20355 | 8.94 |
| Cocheco 4 | 15:33 | 23.22 | 8.23 | 12.25 | 159.56 | 19.88 | 31489 | 7.71 |
| Piscataqua 5* | 17:03 | 21.12 | 8.24 | 10.20 | 127.11 | 22.64 | 35426 | 53.6 |
| Piscataqua 6 | 14:08 | 22.53 | 8.22 | 10.62 | 135.01 | 24.20 | 37659 | 12.4 |
| Piscataqua 7 | 15:40 | 23.12 | 8.24 | 10.89 | 139.62 | 25.46 | 39401 | 5.64 |
| Piscataqua 8* | 16:04 | 21.23 | 8.26 | 10.76 | 133.02 | 24.60 | 38259 | 11.6 |
| Portsmouth 1 | 12:03 | 18.74 | 8.16 | 10.74 | 129.74 | 31.91 | 48298 | 2.26 |
| Portsmouth 3 | 13:23 | 21.58 | 8.16 | 11.43 | 143.20 | 32.63 | 49119 | 7.51 |
| Portsmouth 2 | 14:08 | 18.01 | 8.07 | 9.40 | 111.92 | 31.81 | 48309 | 3.63 |

** Transect survey was not conducted*


Date: 1/30/2018
Project No: 151145
Client: Rochester

Basemap: Esri

0 0.25 0.5 Miles

**Figure 3-10. Qualitative macroalgal area and photographs, tidal Cocheco River and Piscataqua River, August 2017**

At all sites surveyed, attached and accumulated macroalgal cover was very low (Table 3-9, Figures 3-11 to 3-14). All occurrences of algae were single strands, small fragments, or small individual clumps (less than 4 $in^2$ in area) and most of the algae encountered were filamentous green or red algae, not *Ulva* sp. Nearly half of the individual quadrats surveyed did not have any macroalgae and no quadrat had more than 7 percent cover with macroalgae; in fact, three of the eight transects did not have any macroalgae at all.

**Table 3-9. Quantitative Macroalgal Survey Results, Tidal Cocheco River and Piscataqua River, August 2017.**

| Site | Estimated % Cover Along Transect | | | | Notes |
|---|---|---|---|---|---|
| | Attached *Ulva* | Other Attached Algae | Drift Algae | Plants | |
| Cocheco 1* | 0 | 0.8 | 0 | 0 | Other: filamentous green algae |
| Cocheco 2 | 0 | 0 | 0 | 0 | |
| Cocheco 3 | -- | -- | -- | -- | |
| Cocheco 4 | 0 | 0 | 0 | 0 | |
| Piscataqua 5 | -- | -- | -- | -- | |
| Piscataqua 6 | 0.5 | 0.03 | 1.1 | 0.5 | Other: red algae; Plants: *Ruppia maritima*; Drift: mixed red algae and small *Ulva* sp. fragments |
| Piscataqua 7 | 0 | 0 | 0.8 | 0 | Drift: mixed red algae and small *Ulva* sp. fragments |
| Piscataqua 8 | -- | -- | -- | -- | |
| Portsmouth 1 | 0 | 0 | 0 | 0 | |
| Portsmouth 2 | 0.02 | 0.3 | 0.3 | 0 | Other: filamentous green algae; Drift: mixed filamentous green algae and small *Ulva* sp. fragments |
| Portsmouth 3 | 0 | 0 | 3.0 | 0 | Drift: red algae |

**survey was conducted on opposite bank of river from 2016 survey location*
*-- site was not exposed, survey not conducted*

The 2017 macroalgal survey results are comparable to results from 2016. Overall macroalgal cover was low during both years. As expected given the substrate present at the survey sites, attached algae was rarely encountered during both years and most occurrences of algae were clumps of unattached, drift algae that moves with the tides and was deposited at the sites as the tide fell. Macroalgae (including *Ulva* sp.) are a common and important component of this estuarine ecosystem and incidental observations were made of low to moderate coverage of attached algae (*Ulva* sp. and fucoid algae) on rocky areas or hard substrate (fallen trees or branches) adjacent to some survey sites in the Piscataqua River and Portsmouth Harbor. However, large accumulations of *Ulva* sp. or any other drift algae were not observed on any nearby mudflats and there was no indication of impairment of designated uses of the system due to macroalgae.

Figure 3-11. Transect overview at quantitative macroalgal survey locations: Cocheco 1 (top) and Cocheco 2 (bottom)

Figure 3-12. Transect overview quantitative macroalgal survey locations: Cocheco 4 (top) and Piscataqua 6 (bottom)

Figure 3-13. Transect overview at quantitative macroalgal survey locations: Piscataqua 7 (top) and Portsmouth 1 (bottom)

Figure 3-14. Transect overview at quantitative macroalgal survey locations: Portsmouth 2 (top) and Portsmouth 3 (bottom)

Section 4

# Summary

In 2017, the Cocheco River monitoring program built on previous efforts from the 2016 monitoring. Quantitative and qualitative sampling activities in the non-tidal and tidal portions of the Cocheco River included water quality and macroalgal sampling along with qualitative surveys of habitat and river conditions to support quantitative results. The goal of this program is to collect data necessary to characterize water quality and biological conditions of the Cocheco River to inform future regulatory assessments as well as to ensure proper management decisions are made with the best available data. The major findings of this effort are presented as follows:

1. Water quality results in the non-tidal Cocheco River reflect favorable conditions and are generally consistent with previous years' results. The measurements collected to date do not suggest water quality impairments are present in the non-tidal Cocheco River.
2. Proliferations of aquatic vegetation (e.g. invasive milfoil) are observed in low velocity areas behind impoundments in the non-tidal Cocheco River, upstream of influence from the Rochester WWTF. Thus, hydrologic conditions may be a larger factor in determining the vegetation community than influence of point source inputs.
3. Floating plant coverage (duckweed) was low during 2017, generally consistent with 2016 findings. As stated above, no duckweed accumulations were observed upstream of the wetland feature, and only small patches were found in impoundments of dams, and up against other obstructions to flow.
4. Attached algal growth is low immediately downstream of the Rochester WWTF and other locations upstream and downstream of the WWTF consistently exhibit moderate algal growth. While no patterns in algal coverage are discernable at any station based on three years of data, continued data collection will allow for identification of patterns or shifts in algal community over time. These results should be paired with water quality and environmental data to determine if any observed shifts could be attributed to changes in nutrient regimes in the Cocheco River.
5. Tidal Cocheco River water quality results were variable during 2017 and reflected seasonal differences between events (e.g. temperature, freshwater inflow). Phytoplankton cell counts and cyanotoxins were low in all samples consistent with 2016 results. The algal community identified over the last two years appears to be typical of this segment of the Cocheco River, and is not indicative of harmful algal blooms or impairments of designated uses.
6. Attached and accumulated macroalgal cover was very low in the tidal Cocheco River during 2017 consistent with 2016 results. As expected, given the substrate present at the survey sites, attached algae was rarely encountered during both years and most occurrences of algae were clumps of unattached, drift algae that moves with the tides and was deposited at the sites as the tide fell. Large accumulations of *Ulva* sp. or any other drift algae were not observed on any nearby mudflats and there was no indication of impairment of designated uses of the system due to macroalgae.

## Section 5

# References

Brown and Caldwell, *Visual Algal Survey of the Cocheco River*, Prepared for the City of Rochester, New Hampshire, 2016, 19 pages.

Brown and Caldwell, *2016 Field Investigations of the Cocheco River and Regional Waters*, Prepared for the City of Rochester, New Hampshire, 2017, 94 pages.

Environmental Protection Agency. 2016. Fact Sheet: Draft Human Health Recreational Ambient Water Quality Criteria/Swimming Advisories for Microcystins and Cylindrospermopsin. EPA 822-D1-6001. Office of Water. December 2016.

Environmental Protection Agency. 2017. Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters. EPA 820-R-17-001. Office of Water. June 2017.

Maine Department of Environmental Protection (MDEP), *Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands*, 2014, DEPLW-0634B-2014, 19 pages.

New Hampshire Department of Environmental Services (NHDES), *Protocols for Benthic Algal Surveys*, 2013, 13 pages.

New Hampshire Department of Environmental Services (NHDES). *Draft 2014 Macroalgae in the Lower Tidal Cocheco River and Upper Piscataqua*, 2016 ftp://199.192.6.23/DES/wmb/WaterQuality/SWQA/2014/GBE_Data/

New Hampshire Department of Environmental Services (NHDES). 2016 Section 303(d) Surface Water Quality List. Prepared by Ken Edwardson, November 30, 2017.

# Exhibit D: Non-Tidal Cocheco River Data Matrix

(Brown and Caldwell, 2020)

# Technical Memorandum

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Prepared for: City of Rochester

Project No.: 154213.120

**Technical Memorandum**

Subject: Non-Tidal Cocheco River Data Matrix

Date: March 19, 2020

To: Sherilyn Burnett Young
Attorney-At-Law
Rath, Young and Pignatelli, P.C.

From: Clifton Bell, Brown and Caldwell

Copy to: David Green, City of Rochester

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# Executive Summary

Water quality data and biological metrics (1990s – 2018) were compiled for the non-tidal Cocheco River and organized into a matrix to support graphical and statistical analysis. An evaluation of the most recent 10 years of data reveals that the river has not experienced nutrient-related water quality impairments even under low flow summer conditions. Dissolved oxygen and chlorophyll-a have remained within acceptable ranges, and due to natural acidity, the river is more prone to low pH than eutrophication-driven high pH. Most benthic macroinvertebrate scores were above assessment thresholds, and occasional lower values were similar upstream and downstream of the outfall, indicating a lack of impact by nutrients. Visual periphyton scores were moderate. No response variable had a marked correlation with total phosphorus concentration. The nutrient assimilative capacity of the Cocheco River appears to be high due to high concentrations of naturally-occurring dissolved organic matter and tree canopy, which impart light limitations and allow attenuation of nutrients (settling, biological uptake) over relatively long stream distances.

Based on this evaluation, the prevailing phosphorus concentrations are protective of beneficial uses in the non-tidal Cocheco River. A straightforward permitting approach would be to conclude no reasonable potential for total phosphorus and continue to pursue voluntary monitoring and phosphorus controls at the Rochester WWTF.  Periodic monitoring or studies could be performed to confirm that response variables remain at favorable levels.

# Section 1: Cocheco Data Matrix Description

This section provides a brief description of the Excel workbook entitled “Cocheco Data Matrix 22 Nov 2019.xlsx” (the Workbook) that accompanies this technical memo. The Workbook contains the streamflow data, water quality data, biological metrics of the non-tidal Cocheco River that were collected from the mid-1990s to 2018. The data were matched by date, station, and assessment unit, which facilitates the exploration of relations between streamflow, total phosphorus concentrations, and nutrient-related response variables (e.g., dissolved oxygen, chlorophyll-a) in the river. This analysis in turn can support decisions on what phosphorus concentrations are protective of beneficial uses in the Cocheco River.

Table 1 describes the individual worksheets of the Workbook. The source of each observation is noted in column AO of the worksheet entitled “WQ & Bio Data”. As noted in Table 1, the majority of the water quality data were derived from NHDES data files for the 2018 305b/303d assessment, which include observations from 1990 to early 2018. The City of Rochester provided river monitoring data collected by City staff in 2015 and 2016 (elec. comm., K. Henderson, City of Rochester, 8 Aug 2019). The City’s 2016 monitoring dates and locations were largely identical to those of a separate NHDES study that was already represented in the NHDES data files, and had similar results. The 2016 City data were thereby excluded from the workbook to avoid duplicate data. Some additional water quality data were obtained from monitoring performed by BC on behalf of the City in 2016, as documented by Brown and Caldwell (2017).

Benthic macroinvertebrate scores were provided by NHDES (elec. comm., A. Chapman, NHDES, 4 Nov 2019). Visual periphyton scores were obtained from NHDES for a special 2016 monitoring study of the Cocheco River. The visual periphyton scores in the Workbook represent the mean of the scores at individual transect locations. Visual periphyton scores were also available from monitoring performed by BC on behalf of the City in 2015 (Brown and Caldwell, 2016) and 2016 (Brown and Caldwell, 2017). Daily streamflow values were obtained from the USGS National Water Information System for USGS gage 1072800, the Cocheco River near Rochester.

| Table 1. Description of Individual Worksheets | | |
|---|---|---|
| **Worksheet** | **Description** | **Information Source(s)** |
| DES Codes | Explanation of various codes used in the data matrix. | NHDES data files for the 2018 305b/303d assessment. |
| AUIDs | List of assessment units for which data are available on the non-tidal Cocheco River | NHDES shapefile entitled "auids_lines_2012". |
| Stations | List of monitoring stations for which data are available on the non-tidal Cocheco River | NHDES shapefile entitled "Environmental_Monitoring_Sites_Nonsecure", supplemented with information on additional stations monitoring by the City of Rochester in 2016. |
| WQ & Bio Data | Compilation of water quality data and biological metrics on the non-tidal Cocheco River, 1990 - 2018 | The majority of the water quality data were obtained from NHDES data files for the 2018 305b/303d assessment. These were supplemented with 2015 and 2016 monitoring data from City of Rochester and BC. See text for additional details on data sources. |
| Flow Lookup | Daily streamflow values (1995-2019) for USGS gage 1072800, Cocheco R. nr Rochester | USGS National Water Information System |
| Water Quality Data Matrix | Table of water quality data and biological metrics matched by station and date, and including streamflow. | Post-1995 data queried from the "WQ & Bio Data" worksheet, matched by station and date, and with streamflow values assigned from "Flow Lookup". Values marked as "N" in the "Valid" column of "WQ & Bio Data" were not used. |
| Statistics | Statistical summary of variables | Derived from "Water Quality Data Matrix", unfiltered data only. |

# Section 2: Evaluation of Cocheco River Nutrient Response Variables

The Cocheco data matrix was used to evaluate eutrophication-related response variables of the River below the Rochester WWTF outfall. The non-tidal Cocheco River assessment units downstream of the Rochester WWTF are not listed as impaired for eutrophication-related response variables on the 2018 303(d) list. The present evaluation is not intended to replicate the formal assessment process, but to determine if the data indicate the reasonable potential for phosphorus-related issues under critical seasonal and streamflow conditions, and to determine if data support the selection of specific in-stream phosphorus targets for permitting. This was accomplished by evaluating the status of eutrophication-related response variables under summer low flow conditions, and by examining the relation of response variables with phosphorus concentration.

### 2.1.1 Water Quality Data

To obtain a water quality dataset for analysis, the following filters were applied to the "Data Matrix" workbook within "Cocheco Data Matrix 22 Nov 2019.xlsx":

- Year 2006 and more recent data
- Downstream of the Rochester WWTF outfall
- Summer months (Jun – Sep)
- Streamflow less than or equal to the Jun-Sep median flow (30.5 cfs)

The month and streamflow filters were applied to focus on relatively low-flow summer conditions, when the potential for eutrophication-related impairments is higher than normal. Data collected since 2006 were used because the filtered data included water quality observations below the Rochester WWTF for ten different years over the 2006-2016 period (no data were available for 2009). The ten-year dataset was considered reasonably large for statistical and graphical evaluation, but still representative of recent historical conditions. Table 2 summarizes the statistics for major assessment units and eutrophication-related response variables Tenth and ninetieth percentiles were only computed if at least 10 observations were available in a particular data subset.

**Table 2. Summary Statistics of Water Quality under Low-Flow Summer Conditions, Non-Tidal Cocheco River, 2006-2016**

| AUID | Statistic | TP (ug/L) | DO (mg/L) | DO 24-hr Minimum (mg/L) | pH | pH 24-hr Maximum | Chl-a (ug/L) |
|---|---|---|---|---|---|---|---|
| All (Downstream of Rochester WWTF only) | Count | 60 | 145 | 95 | 139 | 91 | 12 |
| | Minimum | 18 | 4.9 | 5.4 | 5.98 | 6.60 | 0.5 |
| | 10th Perc. | 32 | 7.0 | 5.8 | 6.56 | 6.70 | 0.8 |
| | Median | 107 | 8.7 | 6.7 | 6.88 | 7.00 | 2.6 |
| | 90th Perc. | 452 | 9.8 | 8.1 | 7.22 | 7.30 | 7.2 |
| | Maximum | 2,200 | 11.0 | 8.3 | 8.42 | 8.28 | 11.5 |
| NHRIV600030607-15 (Downstream of Rochester WWTF only) | Count | 14 | 83 | 74 | 78 | 70 | 5 |
| | Minimum | 45 | 5.9 | 5.4 | 6.47 | 6.60 | 0.7 |
| | 10th Perc. | 49 | 7.5 | 5.8 | 6.60 | 6.70 | |
| | Median | 326 | 9.0 | 7.0 | 6.83 | 6.99 | 2.3 |
| | 90th Perc. | 1,270 | 10.3 | 8.2 | 7.10 | 7.30 | |
| | Maximum | 2,200 | 11.0 | 8.3 | 7.25 | 7.37 | 2.9 |
| NHRIV600030608-03 | Count | 7 | 11 | 7 | 11 | 7 | 0 |
| | Minimum | 44 | 6.4 | 5.7 | 5.98 | 6.90 | |
| | 10th Perc. | | 6.6 | | 6.38 | | |
| | Median | 250 | 7.2 | 6.1 | 6.85 | 6.93 | |
| | 90th Perc. | | 8.4 | | 6.88 | | |
| | Maximum | 760 | 8.5 | 6.9 | 6.91 | 6.97 | |
| NHIMP600030608-02 (To Watson Dam) | Count | 6 | 20 | 14 | 20 | 14 | 2 |
| | Minimum | 22 | 7.3 | 5.4 | 6.24 | 6.98 | 7.2 |
| | 10th Perc. | | 7.4 | 5.7 | 6.56 | 7.02 | |
| | Median | 140 | 8.6 | 6.1 | 6.95 | 7.18 | 9.4 |
| | 90th Perc. | | 9.9 | 6.7 | 7.22 | 7.37 | |
| | Maximum | 290 | 11.0 | 7.7 | 7.88 | 8.28 | 11.5 |
| NHRIV600030608-05 | Count | 8 | 5 | 0 | 5 | 0 | 0 |
| | Minimum | 18 | 7.9 | | 6.51 | | |
| | 10th Perc. | | | | | | |
| | Median | 58 | 8.9 | | 6.55 | | |
| | 90th Perc. | | | | | | |
| | Maximum | 300 | 9.8 | | 6.88 | | |
| NHIMP600030608-04 | Count | 25 | 26 | 0 | 25 | 0 | 5 |

**Table 2. Summary Statistics of Water Quality under Low-Flow Summer Conditions, Non-Tidal Cocheco River, 2006-2016**

| AUID | Statistic | TP (ug/L) | DO (mg/L) | DO 24-hr Minimum (mg/L) | pH | pH 24-hr Maximum | Chl-a (ug/L) |
|---|---|---|---|---|---|---|---|
| (To Central Ave. Dam) | Minimum | 23 | 4.9 | | 6.46 | | 0.5 |
| | 25th Perc. | 60 | 7.0 | | 6.77 | | |
| | Median | 82 | 7.7 | | 7.15 | | 3.2 |
| | 90th Perc. | 178 | 9.0 | | 7.53 | | |
| | Maximum | 281 | 9.2 | | 8.42 | | 6.9 |

Following are observations on specific response variables:

*Dissolved oxygen*: All river segments and impoundments below the Rochester WWTF were well-oxygenated under summer low flow conditions. Only a single grab sample (out of 145 under the selected conditions) has a DO concentration less than the water quality criterion of 5 mg/L, and that value was only slightly lower (4.9 mg/L). Continuous data loggers were installed in three assessment units (NHRIV600030607-15, NHIMP600030608-02, and NHRIV600030608-03) over the data period, and none showed 24-hour minimum DO concentrations to fall below 5 mg/L. A scatterplot of DO vs. total phosphorus (Figure 1) indicated little relationship between the two variables.

*pH*: Values of pH were moderate on the Cocheco River below the Rochester WWTF under summer low flow conditions. $90^{th}$ percentile pH values were 7.5 or lower for all segments. Fewer than 3 percent of observations exceeded the water quality criterion of 8.0 in all segments. In general, these segments were more likely to experience pH values less than 6.5 than greater than 8.0, due to natural acidity.

*Chlorophyll-a*: The 12 chlorophyll-a measurements taken under low-flow summer conditions had a median value of 3 ug/L and a maximum value of 12 ug/L. None exceeded the value used for assessment in non-tidal river segments, which is 15 ug/L. A scatterplot of DO vs. chlorophyll-a (Figure 2) indicated little relationship between the two variables.

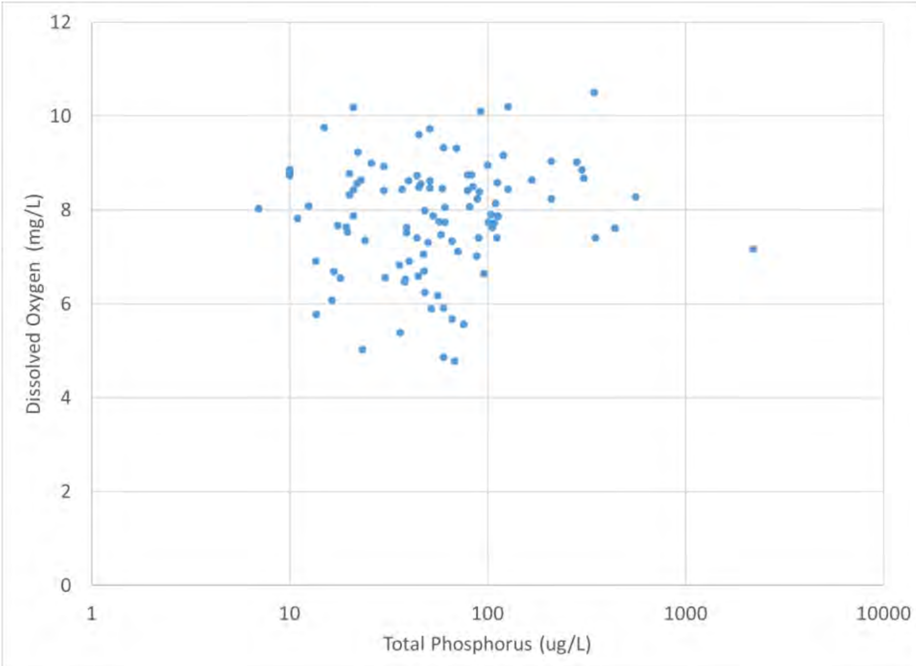


**Figure 1 – Dissolved oxygen vs total phosphorus in the non-tidal Cocheco Rover downstream of the Rochester WWTF outfall, 2007 – 2016.**

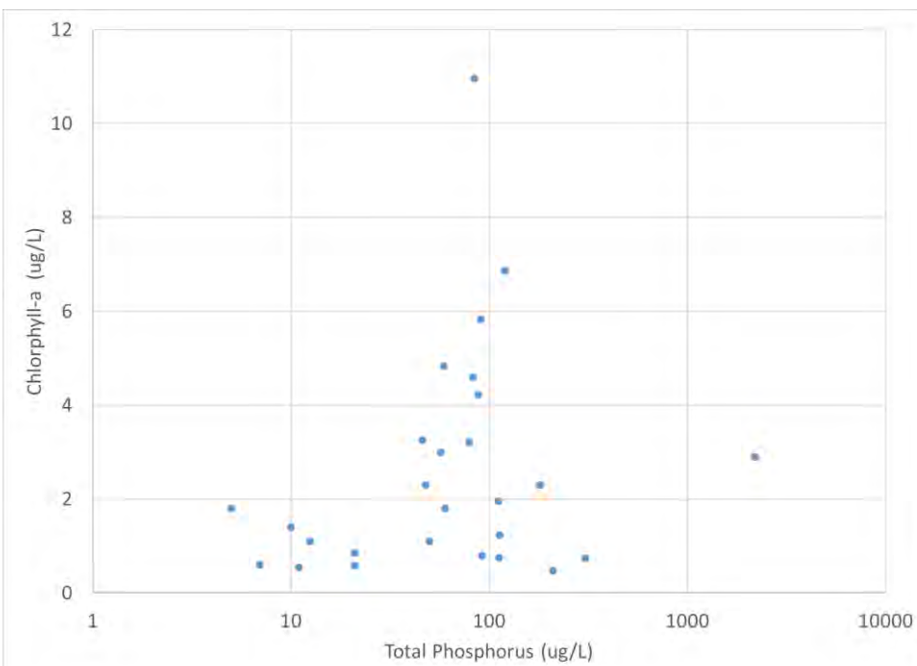


**Figure 2 - Dissolved oxygen vs chlorophyll-a in the non-tidal Cocheco Rover down-stream of the Rochester WWTF outfall, 2007 – 2016.**

### 2.1.2 Benthic Macroinvertebrates

Table 3 presents all the benthic macroinvertebrate index of biotic integrity (B-IBI) scores calculated by DES for the Cocheco River since 2004, which includes nine B-IBI scores upstream of the Rochester WWTF and seven scores downstream of the outfall. A slightly longer data period was utilized for B-IBI scores than for water quality data because there are fewer B-IBI scores available, and because the full dataset provides insights into the long-term B-IBI status of the Cocheco River.

For assessment purposes, the relevant B-IBI thresholds is approximately 53 for NH coastal plain sites (elec. comm., A. Chapman, NHDES, 4 Nov 2019). The majority of the B-IBI scores (9 of 12) available for the Cocheco River since 2004 exceeded this threshold, indicated attainment of aquatic life uses. This included about 70% (5 of 7) of the scores from upstream of the Rochester WWTF outfall and 80% (4 of 5) of the scores from downstream of the Rochester outfall. No segments of the Cocheco River are currently listed as impaired based on B-IBI scores, and the scores were not obviously related to either position upstream/downstream of the Rochester WWTF or with total phosphorus concentrations. Considering all observations, the median score upstream of the Rochester WWTF was 61.0, and the median score downstream of the Rochester WWTF was 62.6. This was the case even though phosphorus concentration increased significantly downstream of the outfall. For example, under low flow summer conditions (defined using data filters given in section 2.1.2) showed that the median total phosphorus increased from 12 to 283 ug/L between stations CCH-16 (upstream of the outfall) to CCH-15 (downstream of the outfall).

**Table 3. B-IBI Scores from the Cocheco River, 2004 - 2016**

| Station | Assessment Unit | Date | Position Relative to Farmington WWTF | Position Relative to Rochester WWTF | B-IBI |
|---|---|---|---|---|---|
| 27-CCH | NHRIV600030601-02 | 30-Aug-2005 | Upstream | Upstream | 68.4 |
| 22U-CCH | NHRIV600030603-01 | 30-Aug-2005 | Downstream | | 57.3 |
| 23-CCH | | 13-Oct-2011 | | | 77.7 |
| 21X-CCH | NHRIV600030603-06 | 14-Oct-2004 | | | 70.2 |
| | | 19-Oct-2009 | | | 50.7 |
| 19R-CCH | NHRIV600030603-08 | 30-Aug-2005 | | | 53.6 |
| 16-CCH | NHRIV600030607-15 | 23-Sep-2016 | | | 48.9 |
| 15-CCH | | 28-Sep-2011 | | Downstream | 65.1 |
| | | 30-Aug-2012 | | | 59.3 |
| | | 1-Oct-2013 | | | 64.0 |
| | | 23-Sep-2016 | | | 46.0 |
| 10AJ-CCH | NHRIV600030608-05 | 8-Sep-2005 | | | 63.0 |

The two lowest B-IBI scores were measured in September 2016 during a special NHDES evaluation of the Cocheco near the Rochester WWTF outfall. The scores upstream of the outfall (at CCH-16) and downstream of the outfall (at CCH-15) were similar and both were below the B-IBI threshold. This caused NHDES to place assessment unit NHRIV600030607-15 in category 3-PNS as potentially not supporting the narrative aquatic life use criterion on the 2018 303(d) list. The cause of the lower scores in 2016 is not known, but was probably related to very low streamflows. Streamflow on the Cocheco River near Rochester was only 5.6 cfs on the day of the B-IBI measurements, which is significantly lower than both the Jun-Sep median streamflow

(30.5 cfs) and August median streamflow (20.1 cfs), and almost as low as the 7Q10 value (3.2 cfs). Regardless, the lower B-IBI scores were unlikely to have been caused by nutrients. The B-IBI scores were similar upstream and downstream of the Rochester WWTF, even though the August-September 2016 median phosphorus concentration increased from 13 ug/L to 676 ug/L between these two locations. This conclusion is also supported by similar 2016 visual periphyton scores between the two locations (see section 2.1.3), and by the longer-term record that does not show a linkage between phosphorus and B-IBI scores on the Cocheco River.

### 2.1.3 Macrophytes and Periphyton

NHDES cites the segment NHIMP600030603-01 of the Cocheco River (to Central Avenue Dam in Dover) as having high densities of variable milfoil. This rooted aquatic plant is not native to New Hampshire but has become established in many water bodies throughout the state (NHDES, 2019a). A literature review (Brown and Caldwell, 2017) revealed that milfoil obtain nutrients from the sediment and can practice luxury nutrient consumption. As a result, milfoil is usually limited by space/light rather than by nutrient concentrations, and can proliferate even in oligotrophic water bodies. There is essentially no record of controlling milfoil by external nutrient load reductions. Potential control strategies cited by NHDES (2019b) include hand-pulling, diver-assisted suction harvesting, benthic barrier placement, and herbicide treatment.

In some years, the Cocheco River has also been observed to experience short (250-400 ft) accumulations of duckweed in stagnant dam backwaters. Duckweed is common in stagnant waters of New Hampshire (NHDES, 2007). A literature review (Brown and Caldwell, 2017) provided mixed conclusions on the potential to control duckweed growth with nutrient reduction. Some studies indicated that—given favorable light, temperature, and hydrologic conditions—duckweed can grow at relatively high rates even at low nutrient concentrations. Under this condition, duckweed would not be expected to be sensitive to changes in phosphorus loading to the system, and would primarily be a result of the dam-induced hydraulic condition. Regardless, the areas of occasional duckweed accumulation are limited to very small (2-3%) portions of the Cocheco River between Rochester and Dover.

The Cocheco River data matrix assembled for the present effort includes visual periphyton scores from viewing bucket surveys by BC in 2015 and 2016 and by NHDES in 2016. The 2015 surveys by BC used the Maine protocol for viewing bucket surveys (MDEP, 2014), whereas the 2016 surveys utilized the methodology wing bucket survey method outlined in the NHDES Protocols for Benthic Algal Surveys (NHDES, 2013). The Maine and New Hampshire viewing bucket protocols are very similar. New Hampshire does not use a visual periphyton score for assessment purposes, but does have a method for scoring viewing bucking transects based on the prevalence of different types of periphyton. To provide a simple means of comparing periphytic conditions by site, BC calculated the average transect score for each site and sampling day. Table 4 presents the periphyton scores for 2015 and 2016. All scores were in the range of ~1—2 on a scale that runs from 0 to 4, indicating moderate productivity. As with B-IBI scores, there was no apparent relation between visual periphyton scores and upstream/downstream position relative to the Rochester WWTF or to total phosphorus concentration.

**Table 4. Visual Periphyton Scores from the Cocheco River, 2015-2016**

| Station | Assessment Unit | Date | Position Relative to Rochester WWTF | Visual Periphyton Score (scale of 0 to 4) |
|---|---|---|---|---|
| 22-CCH | NHRIV600030603-06 | 26-Aug-2015 | Upstream | 0.9 |
| 22-CCH | | 3-Aug-2016 | | 2 |
| 22-CCH | | 21-Sep-2016 | | 2.1 |
| 16-CCH | NHRIV600030607-15 | 28-Jul-2016 | | 1.8 |
| 15-CCH | | 28-Aug-2015 | Downstream | 1.1 |
| 15-CCH | | 28-Jul-2016 | | 1.8 |
| 15-CCH | | 3-Aug-2016 | | 1.1 |
| 15-CCH | | 21-Sep-2016 | | 1.2 |
| BC2 | | 27-Aug-2015 | | 1.2 |
| 12-CCH | NHRIV600030608-03 | 29-Aug-2015 | | 1.0 |
| 12-CCH | | 3-Aug-2016 | | 2 |
| 12-CCH | | 21-Sep-2016 | | 2.3 |
| 10-CCH | NHRIV600030608-05 | 31-Aug-2015 | | 1.2 |
| 10-CCH | | 3-Aug-2016 | | 1.2 |
| 10-CCH | | 21-Sep-2016 | | 1.2 |
| BC5 | | 30-Aug-2015 | | 1.1 |
| BC5 | | 3-Aug-2016 | | 2.1 |
| BC5 | | 21-Sep-2016 | | 2.1 |

# Section 3: Implications for Phosphorus Permitting

The weight of the evidence presented in Section 2 indicates that the non-tidal Cocheco River does not experience nutrient-related impairments downstream of the Rochester WWTF outfall, which is consistent with the fact that the River is not 303(d)-listed as impaired for nutrient-related response variables. Moreover, the evaluations demonstrated that the Cocheco River did not experience nutrient-related impairments under the prevailing phosphorus concentrations/loadings, even when restricting the analysis to low-flow summer conditions. Dissolved oxygen and chlorophyll-a concentrations remained within acceptable ranges, and the primary issue with pH was low values driven by natural acidity, rather than high values driven by eutrophication. Most benthic macroinvertebrate scores were above assessment thresholds, and the lower values were similar upstream and downstream of the outfall, indicating a lack of impact by nutrients. Visual periphyton scores were moderate and showed no relation with phosphorus.

Based on these conclusions, the non-tidal Cocheco River appears to have a high assimilative capacity for phosphorus. The river has naturally-high carbonaceous dissolved organic matter (CDOM), and also has high tree canopy in many locations including downstream of the Rochester WWTF (Figure 3). These factors are likely to impose a light limitation on primary productivity, and allow phosphorus inputs to be attenuated over relatively long stream distances. A straightforward permitting approach would be to conclude no reasonable potential for total phosphorus, and continue to pursue voluntary monitoring and phosphorus controls at the Rochester WWTF. Periodic monitoring or studies could be performed to confirm that response variables remain at favorable levels.

**Figure 3–Cocheco River near England Road, downstream of the Rochester WWTF. This photo illustrates the tree canopy and high CDOM concentration which can impose light limitations on primary productivity.**

# References

Brown and Caldwell. 2016. Visual Algal Survey of the Cocheco River. Technical memorandum prepared for the City of Rochester. 19 p.

Brown and Caldwell. 2017. 2016 Field Investigations of Cocheco River and Regional Waters. Report prepared for the City of Rochester. 114 p.

Maine Department of Environmental Protection, Protocols for Sampling Algae in Wadeable Rivers, Streams, and Freshwater Wetlands, 2014, DEPLW-0634B-2014, 19 p.

NHDES. 2007. Aquatic Plants and Algae of New Hampshire's Lakes and Ponds. 102 p.

NHDES. 2013. New Hampshire Department of Environmental Services (NHDES) Protocols for Benthic Algal Surveys. 13 p.

NHDES. 2019a. Infested Waterbodies in New Hampshire (as of 4/19). Excel spreadsheet accessed 22 Nov 2019 at https://www.des.nh.gov/organization/divisions/water/wmb/exoticspecies/exotic_plant_map.htm.

NHDES. 2019b. Variable milfoil–*Myriophyllum heterophyllum (Michx)*. Environmental Fact Sheet WD-BB-23. 2 p.

# Exhibit E: Phosphorus Background Concentration

## Table E.1

## Total Phosphorus Concentrations at Station CCH-16 Under Critical Conditions for P Permitting

| **Station** | **Date** | **Streamflow @ Rochester (cfs)** | **Streamflow ≦ August Median (20.1 cfs)** | **TP (ug/L)** |
|---|---|---|---|---|
| 16-CCH | 16-Sep-2016 | 2.44 | Yes | 7 |
| 16-CCH | 14-Oct-2016 | 4.24 | Yes | 8 |
| 16-CCH | 1-Sep-2015 | 15.2 | Yes | 10 |
| 16-CCH | 21-Aug-2013 | 14.7 | Yes | 11 |
| 16-CCH | 23-Aug-2016 | 10.1 | Yes | 12.5 |
| 16-CCH | 28-Jun-2016 | 9.84 | Yes | 19.3 |
| 16-CCH | 5-Oct-2000 | 11 | Yes | 22 |
| 16-CCH | 21-Sep-2016 | 12.8 | Yes | 27 |
| 16-CCH | 19-Jul-2016 | 11.6 | Yes | 50 |
| | | | **Median** | **12.5** |

# Exhibit F: Chronic Ammonia WQBEL

## Table F.1
## Inputs and Results of WQBEL Calculation – Chronic Ammonia

| Parameter | Value |
|---|---|
| pH-acute | 6.56 |
| pH-chronic | 6.56 |
| Temp.-acute | 25 |
| Temp.-chronic | 25 |
| Background ammonia as N (mg/L) | 0 |
| Combined Flow | 5.05 |
| CV | 2.50 |
| CCC, mussels present | 1.38 |
| $WLA_a$ (mg/L) | 21.14 |
| $WLA_c$ (mg/L), 30-day avg | 1.99 |
| $WLA_a$ (lb/d) | 890 |
| $WLA_c$ (lb/d), 30-day avg | 84 |
| Z95 | 1.645 |
| Z99 | 2.326 |
| $\sigma^2$ | 1.9810 |
| $\sigma$ | 1.4075 |
| $\sigma^2_{30}$ | 0.1892 |
| $\sigma_{30}$ | 0.4350 |
| $LTA_a$ | 5.62 |
| $LTA_c$ | 1.07 |
| n | 8 |
| $\sigma^2_{n\text{-sample}}$ | 0.5773 |
| $\sigma_{n\text{-sample}}$ | 0.7598 |
| AML | 2.79 |

# ATTACHMENT 2

## Total Phosphorus Treatment Cost Estimates

## (Brown & Caldwell)

Attachment 2

# Memorandum

One Tech Drive, Suite 310
Andover, MA 01810-2435

T: 978.794.0336

Prepared for: City of Rochester, NH

Project Title: NPDES Permitting Support

Project No.: 150914

**Technical Memorandum**

Subject: Total Phosphorus Treatment Cost Updates

Date: January 30, 2020

Updated: May 9, 2022

To: Peter Nourse, PE

Michael Bezanson, PE

David Green

From: Mark Allenwood, PE

The City of Rochester, New Hampshire owns and operates a 5.03 million gallon per day (MGD) wastewater treatment facility (WWTF) which discharges treated effluent to the Cocheco River. The Cocheco River is within the Great Bay watershed and forms the Piscataqua River where the Cocheco and Salmon Falls Rivers meet.

The WWTF operates under a National Pollutant Discharge Elimination System (NPDES) Permit which expired in 2002, but is administratively continued until a new NPDES permit is issued. The expired permit includes the following pollutant limitations:

| Parameter | NPDES Permit Limit |
|---|---|
| Carbonaceous biochemical oxygen demand | 6 mg/L summer, 13 mg/L winter |
| Total suspended solids | 6 mg/L summer, 13 mg/L winter |
| Total ammonia as $NH_3$ (ave monthly) | 3.61 mg/L summer, 7.65 mg/L winter |
| pH | 6.5 to 8.0 SU |
| Dissolved oxygen | 7.0 mg/L |
| E-coli | 126/100 mL (geo mean), 406/100 mL (max day) |

EPA Region 1 issued a Draft NPDES Permit renewal in 2022, which includes the following limitations:

| Parameter | NPDES Permit Limit |
|---|---|
| Carbonaceous biochemical oxygen demand | 6 mg/L summer, 13 mg/L winter |
| Total suspended solids | 6 mg/L summer, 13 mg/L winter |
| Total ammonia as $NH_3$ (ave monthly) | 2.0 mg/L summer, 6.3 mg/L winter |
| pH | 6.5 to 8.0 SU |
| Total Phosphorus | 0.12 mg/L (reported in pounds per day) |
| Dissolved oxygen | 7.0 mg/L |
| E-coli | 126/100 mL (geo mean), 406/100 mL (max day) |

In general, TP limits greater than 0.50 mg/L can be met with chemical addition at various locations within the treatment process to coagulate the phosphorus and have it settle out in the secondary clarifiers. For TP limits less than 0.50 mg/L, a dedicated tertiary process is typically required to meet lower limits. In 2012 the City retained Brown and Caldwell (BC) to evaluate the WWTF and evaluate options to meet total phosphorus (TP) levels of 0.10 to 0.20 mg/L. The issuance of the Draft NPDES Permit includes a 0.12 mg/L TP limit, which will require a phosphorus reduction process.

In 2009 Cambridge Water Technology, the then owner of the CoMag® process, requested permission to test the process on the algae laden liquid in the storage lagoons at the City's WWTF. The City agreed and, following the testing on the lgaoons, the CoMag process was tested on secondary effluent to confirm that it would meet TP limits of 0.10 mg/L or less. That testing proved positive, and based on BC's experience with the process, has recommended that CoMag be fully pilot tested to confirm the initial findings.

The CoMag process would be completely enclosed in a building that would house the reaction tanks, tertiary clarifiers, chemical storage and all associated equipment and controls. The process would include the following:

- Five (5) concrete reaction tanks operating in series, each approximately 11 feet wide by 11 feet long and 11 feet deep;

- Two (2) concrete rectangular tertiary clarifiers, each approximately 45 feet long and 15 feet wide;
- Two (2) 1.5 h.p. clarifier sludge collection systems;
- Two (2) 5 h.p. shear mills (one standby);
- Two (2) 5 h.p. magnetic drum separators (one standby);
- Three (3) 20 h.p. sludge pumps (one standby);

Following standard engineering practice, the design of the CoMag process would be based on 80 percent of the TP limit to provide a 20 percent buffer between the permit limit and actual operations. The design buffer is required to account for operational variables such as influent and recycle flows, influent TP load and chemical reactivity. For a TP limit of 0.12 mg/L, the system would be designed to meet an effluent TP level of 0.096 mg/L. Unlike the denitrification process, the CoMag process is not impacted by wastewater temperatures. Therefore, the system would either be operated year round to meet a annual average, or operated during only from April to October to meet the seasonal TP limit.

The CoMag process is a physical-chemical process that requires chemical addition to reduce the pH of the wastewater to bring dissolved phosphorus out of solution, a coagulant to destabilize the phosphorus particle charge and a flocculant to bind the phosphorus into a settleable solid. The chemical addition would take place in the five mix tanks and the settling would take place in the tertiary clarifiers.

The CoMag tanks would be constructed of cast in place concrete. A foundation support system will be required due to clay soils in the area, and it is assumed the process would be constructed on an H-Pile system driven to bedrock, similar to the sludge dewatering facility.

The support equipment would be housed in a small masonry block structure located on or adjacent to the CoMag tanks.

A schematic layout of the CoMag system is shown in Figure 1.

The opinion of cost for the CoMag system to meet a TP limit of 0.12 mg/L is approximately $18,300,000 in 2022 dollars. Estimated annual operations and maintenance costs are $300,000 per year for a TP limit of 0.12 mg/L. These costs include electrical costs to operate the support equipment and chemical costs and are based on year-round operation. A summary of costs is provided in Table 1.

Figure 1 – MBBR Schematic Layout

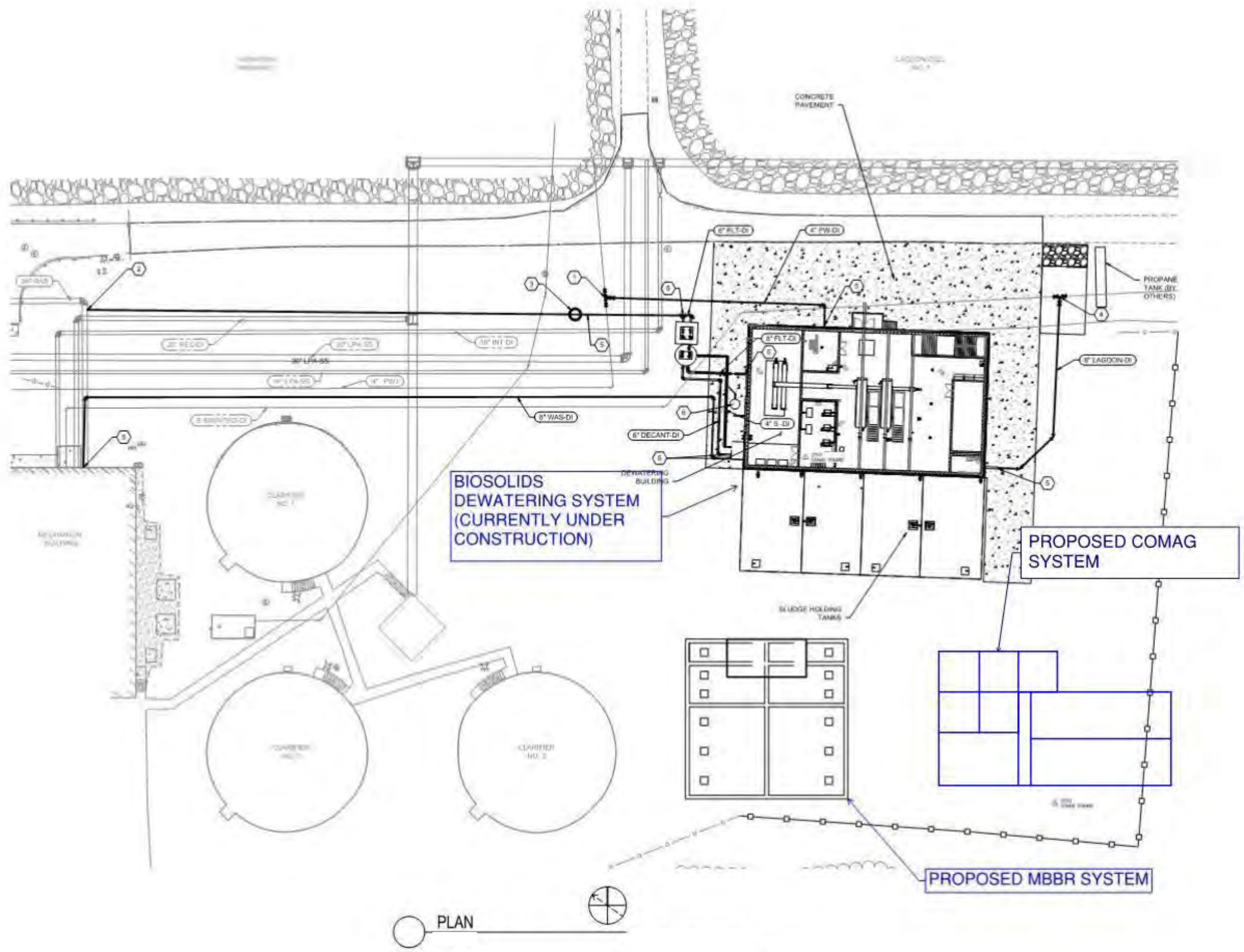

Table 1 – Summary of Costs for Annual Average TP 0.12 mg/L

| Item | Quantity | Unit | Unit Cost | Extended Cost |
|---|---|---|---|---|
| | | | | |
| Excavation | 1,950 | CY | $ 30 | $ 58,500 |
| Backfill | 360 | CY | $ 40 | $ 14,400 |
| Concrete Base Slabs | 220 | CY | $ 1,000 | $ 220,000 |
| Concrete Tank Walls | 190 | CY | $ 1,200 | $ 228,000 |
| Concrete Top Slab | 220 | CY | $ 1,800 | $ 396,000 |
| Equipment Building | 1000 | SF | $ 250 | $ 250,000 |
| Equipment (installed) | 1 | LS | $ 3,200,000 | $ 3,200,000 |
| Piping | 1 | LS | $ 1,310,070 | $ 1,310,070 |
| Electrical | 1 | LS | $ 1,310,070 | $ 1,310,070 |
| Instrumentation | 1 | LS | $ 873,380 | $ 873,380 |
| Site Work | 1 | LS | $ 436,690 | $ 436,690 |
| H-Pile Supports | 1 | LS | $ 400,000 | $ 400,000 |
| | | | Subtotal | $ 8,697,110 |
| Contingency (25%) | | | | $ 2,174,278 |
| Engineeering (20%) | | | | $ 1,739,422 |
| | | | Total 2012 Dollars | $ 12,610,810 |
| CCI Sept 2012 to May 2022 Increase | | | | 45% |
| | | | Grand Total, 2022 Dollars | $ 18,285,673.78 |
| . | | | **Use** | **$ 18,300,000** |

| Estimated Annual Operating Costs | $300,000 |
|---|---|

Notes:

*The CCI 2012 to 2022 increase value is based on the Engineering New Record Construction Cost Index change from September 2012 when the cost estimate was originally developed to May 2022. These values are as follows for the Boston index:*

*September 2012: CCI = 12,024.06*
*May 2022 CCI = 17,471.16*

# ATTACHMENT 3

## City of Rochester, NH

## EPA Financial Capability Assessment (June 16, 2022)

Attachment 3

# City of Rochester
# New Hampshire

## EPA Financial Capability Assessment

## June 16, 2022

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# TABLE OF CONTENTS

## EPA FINANCIAL CAPABILITY ASSESSMENT JUNE 16, 2022-CITY OF ROCHESTER NH



## APPENDIX EXHIBITS

COST PER HOUSEHOLD
Worksheet 1

| CURRENT WWT COSTS | Amounts | | Notes |
|---|---|---|---|
| Annual Operations & Maintenance Expenses (Excluding Depreciation) | $2,960,865 | | FY22 Forecast-See User Rate Forecast Model |
| Annual Debt Service | $3,614,272 | | FY22 Forecast-See User Rate Forecast Model |
| **Interest -$953,271** | | | |
| **Principal-$1,381,609** | | | |
| **Sub Total** (Line 100+Line 101) | **$6,575,137** | | |
| | | | |
| **PROJECTED WWT AND CSO COSTS** (Current Dollars) | | | |
| Estimated Annual Operations & Maintenance Expenses (Excluding Depreciation) | $1,671,590 | 103 | Data Cost and user rates projection |
| Annual Debt Service (Principal & Interest) | $6,130,000 | 104 | Projected New Debt Service P&I |
| **Sub Total** (Line 103+Line 104) | **$7,801,590** | **105** | |
| | | | |
| Total Current and Projected WWT and CSO Costs (Line 102 + Line 105) | $14,376,727 | 106 | |
| Residential Share of Total WWT and CSO Costs | $8,626,036 | 107 | 60%-Source 2021 Billable flow per residential households Based on the FY21 Billing Summary Data per 2021 EPA Financial Capability Assessment Guidance |
| | | | |
| Total Number of Households in Service Area | 8,000 | 108 | City of Rochester GIS Analyisis estimate of households |
| Cost Per Household (Line 107 / Line 108) | $1,078 | 109 | |

Link to City of Rochesters Audit Financial Results
Financial Statements (all years) | Rochester NH

RESIDENTIAL INDICATOR
Worksheet 2

| Median Household Income | Amounts | Line | Source |
| --- | --- | --- | --- |
| Census MHI | $66,831 | 201 | The 2020 Census American Community Survey<br>2020 ACS 5-year estimates |
| MHI Adjustment Factor | 1.050 | 202 | Source 2021 All Urban CPI 4.7%,<br>1 Year factor page 58 of EPA Financial Guidance |
| Adjusted MHI (Line 201 x Line 202) | $70,172.55 | 203 | |
| Annual WWT & CSO Control Costs<br>Per Household (Line 109) | $1,078.25 | 204 | |
| Residential Indicator | 1.54% | 205 | |

Annual WWT & CSO Controls
Per Household as a Percent of Adjusted
Median Househould Income
CPH as % of MHI (Line (204/203)x100

BOND RATING
Worksheet 3

| BOND RATING | | Line | Notes/Sources |
|---|---|---|---|
| **Most Recent General Obligation** | | | Standard & Poors March 24, 2020 Rating |
| **Bond Rating** | | | |
| Date | 3/24/2020 | | |
| Rating Agency | S&P Global | | |
| Rating | **AA** | 301 | |
| Per Household (Line 109) | | | |
| **Most Recent Revenue** | **N/A** | | Rochester's S&P Rating includes Water-Sewer |
| **(Water/Sewer or Sewer) Bond** | | | as part of the General Obligagtions |
| Date | | | |
| Rating Agency | | | |
| Bond Issue (Yes/No) | | | |
| Rating | | 302 | |
| Summary Bond Rating | | 303 | |

NET DEBT
Worksheet 4

| NET DEBT | Amounts/Values | Line | Notes/Sources |
|---|---|---|---|
| Direct Net Debt | $46,146,627 | 401 | 2022 Certified Net Debt Statement |
| (G.O. Bonds Excluding Double Barreled Bonds) | | | School District included in above-Rochester's SAU 54 is a dependent School District |
| Debt of Overlapping Entities (Proportionate Share of Multijurisdictional debt) | $1,844,872 | 402 | FY21 Strafford County Debt $9,097,000 Rochester's Share 20.28%. Source FY21 Continuing Disclosure Report |
| | $49,305,666 | 402 | This amount includes all debt related to Enterprise and Tax Incremental Financing Funds. Rochester considers overlapping due to the General Obligation Bond status. In |
| **Overall Net Debt** | **$97,297,165** | 403 | |
| **(Lines 401 +402)** | | | |
| Market Value of Property | $3,663,214,547 | 404 | 2021 NH DRA MS 1 Assessors Summary of Inventory Valuation-Updated for full market valuations. |
| Overall Net Debt as a Percent of Full Market Property Value (Line 403 divided by Line 404 x 100) | 2.66% | 405 | |

UNEMPLOYMENT RATE

Worksheet 5

| Unemployment Rate | Percentage | Line | Notes |
|---|---|---|---|
| Unemployment Rate Permittee | 2.10% | 501 | State of NH Enployment Security<br>Economic Labor Market Information Bureau<br>NH Unemployment Rates by Citys & Towns March-<br>https://www.nhes.nh.gov/elmi/statistics/laus-data.htm |
| Unemployment Rate County ( Use if Permitte Rate Unavailable) | | 502 | |
| **Benchmark**<br>Average National Unemployment Rate | 3.60% | 503 | US Bureau of Labor Statisics- April-2022 Seasonal Adjusted<br>https://data.bls.gov/pdq/SurveyOutputServlet |
| Results | 1.50% | | Rochester 1.5% below the Benchmark |

MEDIAN HOUSEHOLD INCOME-MHI
Worksheet 6

| Median Household Income (MHI) | Amounts/Values | Line | Notes |
|---|---|---|---|
| Median Household Income Permittee Line 203 Source | $66,831 | 601 | US Census American Community Survey 2020<br>2020 ACS 5-year estimates |
| **Benchmark** | | | |
| Census Year National MHI | $67,521 | 602 | US Census 2020<br>Income and Poverty in the United States: 2020 (census.gov) |
| MHI Adjustment Factor | 1.050 | 603 | |
| Adjusted MHI | $70,172 | 604 | |

PROPERTY TAX REVENUES PERCENT OF FULL MARKET PROPERTY
Worksheet 7

| **Property Tax Revenues Percent of Full Market Property** | **Amount/Values** | **Line** | **Source** |
|---|---|---|---|
| Full Market Value of Real Property (Line 404) | $3,663,214,547 | 701 | 2021 NH DRA MS 1 Assessors Summary of Inventory Valuation-Updated for full market |
| Property Tax Revenues | $69,131,939 | 702 | 2021 NH DRA Tax Rate Report |
| Property Tax Revenues as Percent of Full Market Property (702/701)x100 | 1.89% | 703 | |

PROPERTY TAX REVENUE COLLECTION RATE
Worksheet 8

| Property Tax Revenue Collection Rate | Amount/Values | Line | Notes |
|---|---|---|---|
| Property Tax Collected | $68,096,512 | 801 | Tax Collector Summary Report 4-30-22 |
| Property Taxes Levied | $69,388,398 | 802 | Tax Collector Summary Report 4-30-22 |
| Property Tax Collection Rate (Line 801/Line 802)x 100 | 98.14% | 803 | |

SUMMARY OF PERMITTEE FINANCIAL CAPABILITY INDICATORS
Worksheet 9

| Indicator | Column A Actual Value | Column B Score | Line Item |
|---|---|---|---|
| Bond Rating (line 303) | AA | 3 | 901 |
| Overal Net Deb as a Percent of Full Market Property Value (line 405) | 2.66% | 2 | 902 |
| Unemployment Rate (line 501) | 2.10% | 3 | 903 |
| Median Household Income (line 601) | $70,172 | 3 | 904 |
| Property Tax Revenues as a Percent of Full Market Property Value (line 703) | 1.89% | 3 | 905 |
| Property Tax Revenue Collection Rate (line 803) | 98.14% | 3 | 906 |
| Permittee Indicators Score (Sum of Column B / Number of Entries | | **2.83** | **907** |

FINANCIAL CAPABILTY MATRIX SCORE
Worksheet 10

| Financial Capability Matrix Score | Value | Line |
|---|---|---|
| Residential Indicator (Line 205) | 1.54% | 1001 |
| Permittee Financial Capabilty Score (Line 907) | 2.83 | 1002 |
| Financial Capability Matrix Score | **LOW** | 1003 |

LOWEST QUINTILE RESIDENTIAL INDICATOR
Alternative 1: LQRI

| **Lowest Quintile Residential Indicator** | **Amounts** | **Line** | **Source** |
|---|---|---|---|
| Ratio of Lowest Quintile HH Size to Median HH Size | 70.20% | | Per 2021 EPA Financial Guidance Document Page 11 |
| Cost for Median Household | $1,078.25 | 109 | |
| Cost for Lowest Quintile Household | $756.93 | | |
| Upper Limit of Lowest Income Quintile for Service Area | $27,532.00 | | US Census Household Income Quintile Upper Limits<br>B19080: HOUSEHOLD INCOME QUINTILE... - Census Bureau Table |
| Cost as a Percentage of Low Income Households | 2.75% | | |
| LQRI Impact Rating | **HIGH** | | |

| Lowest Quintile Residential Indicator Benchmarks | |
|---|---|
| Low Impact | Less than 1% |
| Mid-Range Impact | 1.0% to 2.0% |
| High Impact | Above 2.0% |

POVERTY INDICATOR
Alternative 1: Poverty

| Indicator | Strong (3) | Mid Range (2) | Weak (1) | Census Code (3) | Rating | Rochester Data |
|---|---|---|---|---|---|---|
| PI #1<br>Percentage of Population with Income Below 200% of Federal Poverty Level | More than 25% below National Value | +- 25% of National Value | More than 25% above National Value | S1701 | 2 | 27.15% |
| PI #2<br>Percentage of Population with Income Below Federal Poverty Level | More than 25% below National Value | +- 25% of National Value | More than 25% above National Value | S1701 | 2 | 8.90% |
| PI #3<br>Upper Limit of Lowest Income Quintile | More than 25% below National LQI | +- 25% of National LQI | More than 25% above National LQI | B19080 | 2 | $27,532 |
| PI#4<br>Lowest Quintile Income as a Percentage of Aggregate Income | More than 25% below National Value | +- 25% of National Value | More than 25% above National Value | B19082 | 2 | 27% |
| PI#5<br>Percentage of Population Receiving Food Stamps/SNAP Benefits | More than 25% below National Value | +- 25% of National Value | More than 25% above National Value | S2201 | 2 | 11.40% |
| | | | | **Sum** | **10** | |

**Poverty Indicator Score (Sum divided by 5** **2**

Poverty Indicator Bench Marks
Low Impact (Above 2.5)
Mid-Range Impact (2.5-1.5)
High Impact (Below 1.5)

LOWEST QUINTILE RESIDENTIAL INDICATOR VALUE SCORE

| **Lowest Quintile Residential Indicator** | **Value** |
|---|---|
| Lowest Quintile Residential Indicator | 2.75% |
| Poverty Indicator | 2.00 |
| **Lowest Quintile Residential Indicator Score** | **HIGH** |

EXPANDED FINANCIAL CAPABILITY ASSESSMENT SCORE

| **Expanded Financial Capability Assessment** | **Value** |
|---|---|
| LQ & PI Burden | HIGH |
| FCA Burden | LOW |
| **Expanded Financial Capability Assessment** | **MEDIUM** |

Exhibit A

## FINANCIAL CAPABILITY MATRIX
## Table 3

| **Permittee Financial Capability Indicators Score** (Socioeconomic, Debt and Financial Indicators) | **Residential Indicator** (Cost Per Household as a % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0 %) | Mid-Range (Between 1.0 and 2.0%) | High (Above 2.0 %) |
| Weak (Below 1.5) | Medium Burden | High Burden | High Burden |
| Mid-Range (Between 1.5 and 2.5) | Low Burden | Medium Burden | High Burden |
| Strong (Above 2.5) | Low Burden | Low Burden | Medium Burden |

Expanded FCA Matrix gives equal consideration to the RI, FCI, LQRI, and PI, first by combining RI and FCI to determine an FCA Burden, then by combining LQRI and PI to determine a Lowest Quintile Burden, and finally by combining the FCA Burden and Lowest Quintile Burden to determine the overall burden level for the community's service area.

**Financial Capability Matrix**

The Financial Capability Matrix determines the FCA Burden by combining RI and FCI. The matrix is included below as Exhibit 3.

**Exhibit 3: Financial Capability Matrix**

| Financial Capability Indicator | Residential Indicator | | |
|---|---|---|---|
| | Low Impact (Below 1.0%) | Mid-Range (1.0% to 2.0%) | High Impact (Above 2.0%) |
| Strong (Above 2.5) | Low Burden | Low Burden | Medium Burden |
| Mid-Range (1.5 to 2.5) | Low Burden | Medium Burden | High Burden |
| Weak (Below 1.5) | Medium Burden | High Burden | High Burden |

**Lowest Quintile Burden Matrix**

The Lowest Quintile Burden Matrix determines the Lowest Quintile Burden by combining LQRI and PI. The Lowest Quintile Burden Matrix is included below as Exhibit 4.

**Exhibit 4: Lowest Quintile Burden Matrix**

| Poverty Indicator | Lowest Quintile Residential Indicator | | |
|---|---|---|---|
| | Low Impact (Below 1.0%) | Mid-Range (1.0% to 2.0%) | High Impact (Above 2.0%) |
| Low Impact (Above 2.5) | Low Burden | Low Burden | Medium Burden |
| Mid-Range (1.5 to 2.5) | Low Burden | Medium Burden | High Burden |
| High Impact (Below 1.5) | Medium Burden | High Burden | High Burden |

### Expanded FCA Matrix and Associated Schedule Recommendations

The Expanded FCA Matrix determines the overall burden level when combining all four critical metrics (RI, FCI, LQRI, and PI). The Expanded FCA Matrix is included below as Exhibit 5.

**Exhibit 5: Expanded Financial Capability Assessment Matrix**

| FCA Burden (RI and FCI) | LQ Burden (LQRI and PI) | | |
|---|---|---|---|
| | Low Burden | Medium Burden | High Burden |
| Low Burden | Low Burden | Low Burden | Medium Burden |
| Medium Burden | Low Burden | Medium Burden | High Burden |
| High Burden | Medium Burden | High Burden | High Burden |

The results of the Expanded FCA Matrix correspond to the recommended implementation schedule benchmarks in Exhibit 6, below. EPA has developed these schedule benchmarks to account for the consideration of two new critical metrics, the LQRI and the PI. The schedule benchmarks are based on EPA's experience negotiating over 100 CWA consent decrees with communities of various sizes, including negotiations with communities that voluntarily submitted additional financial and demographic information for consideration, consistent with the 2014 FCA Framework, regarding lowest quintile income and poverty within their service area. It is important to note that EPA evaluates financial capability on a continuum. Although the Expanded FCA Matrix categorizes a community's overall burden level as "high, medium, or low," this does not necessarily mean that schedules would be rigidly set according to the break points between the categories. This is discussed in Section III.g. (Schedule Development), below.

**Exhibit 6: 2021 FCA Recommended Implementation Schedule Benchmarks for Alternative 1**

| Expanded FCA Matrix Results | Recommended Implementation Schedule Benchmarks |
|---|---|
| Low Burden | Normal Engineering/Construction Schedule |
| Medium Burden | Up to 15 years |
| High Burden | Up to 25 years (absent consideration of additional information) |

FY22-FY27 SEWER USER RATE FORECAST-INCLUDES EPA TP UPGRADE-Exhibit B

| | FY22 PROJECTION SEWER-INCLUDES EPA TP UPGRADE | FY21 | FY22-Forecast | FY23-Forecast | FY24-Forecast | FY25-Forecast | FY26-Forecast | FY27-Forecast |
|---|---|---|---|---|---|---|---|---|
| A | USER FEE UNITS | 588,095 | 591,035 | 593,991 | 596,961 | 599,946 | 602,945 | 605,960 |
| | HIGH VOLME UNITS | 132,196 | 132,857 | 133,521 | 133,000 | 133,000 | 133,000 | 133,000 |
| | OPERATING REVENUES | | | | | | | |
| | User Fees | $5,039,128 | $5,323,875 | $5,885,867 | $6,792,254 | $8,525,385 | $10,700,785 | $12,894,071 |
| | Other Service Charges-Misc | $720,729 | $425,000 | $425,000 | $425,000 | $425,000 | $425,000 | $425,000 |
| B | TOTAL OPERATING REVENUES | $5,759,857 | $5,748,875 | $6,310,867 | $7,217,254 | $8,950,385 | $11,125,785 | $13,319,071 |
| | | | | | | | | |
| | ALL OPERATIONAL EXPENSES | $2,888,653 | $2,960,869 | $3,049,695 | $3,141,186 | $3,235,422 | $3,332,485 | $4,615,797 |
| | | | | | | | | |
| | SEWER CURRENT 20 YR & FORECAST DEBT SERVICE-FY22 | $3,268,483 | $3,614,272 | *$3,305,079* | *$3,201,002* | *$3,058,000* | *$2,677,788* | *$2,561,446* |
| | NEW BOND ISSUED DEBT FY23-CWA-CSO $10MM | | | $1,000,000 | $900,000 | $875,000 | $850,000 | $825,000 |
| | NEW BOND ISSUED DEBT FY24-CWA-CSO $8MM | | | | $800,000 | $780,000 | $760,000 | $740,000 |
| | NEW BOND ISSUED DEBT FY25-CWA-CSO $10.5MM | | | | | $1,050,000 | $1,023,750 | $997,500 |
| | NEW BOND ISSUED DEBT FY25 UPGRADE TP $10MM | | | | | $800,000 | $785,000 | $770,000 |
| | NEW BOND ISSUED DEBT FY26 -CWA-CSO $8MM | | | | | | $800,000 | $780,000 |
| | NEW BOND ISSUED DEBT FY26 UPGRADE TP $11MM | | | | | | $880,000 | $863,500 |
| | NEW BOND ISSUED DEBT FY27 -CWA-CSO $8MM | | | | | | | $800,000 |
| C | TOTAL DEBT SERVICE | $3,268,483 | $3,614,272 | $4,305,079 | $4,901,002 | $6,563,000 | $7,776,538 | $8,337,446 |
| | | | | | | | | |
| D | ALL EXPENSE TOTALS | $6,157,136 | $6,575,141 | $7,354,774 | $8,042,188 | $9,798,422 | $11,109,023 | $12,953,243 |
| | | | | | | | | |
| | PROJECTED USER RATES | $7.43 | $7.43 | $8.17 | $9.40 | $11.75 | $14.69 | $17.62 |
| | HIGH VOLUME RATE | $6.68 | $6.68 | $7.36 | $8.46 | $10.57 | $13.22 | $15.86 |
| E | RATE INCREASE PERCENTAGE | 0.00% | 0.00% | 10.00% | 15.00% | 25.00% | 25.00% | 20.00% |
| | | | | | | | | |
| F | PROJECTED O&M SURPLUS (DEFICIT) | ($397,279) | ($826,267) | ($1,043,908) | ($824,934) | ($848,037) | $16,763 | $365,828 |
| | | | | | | | | |
| G | CASH FUNDED CIP PROJECTS & OTHER TRANSFERS | $400,000 | $256,836 | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 |
| H | ADJUSTED SURPULS (DEFICIT) | ($797,279) | ($1,083,103) | ($1,293,908) | ($1,074,934) | ($1,098,037) | ($233,237) | $115,828 |
| | | | | | | | | |
| I | ESTIMATED CASH FUND BALANCE | $5,949,039 | $4,803,742 | $3,509,834 | $2,434,900 | $1,336,864 | $1,103,626 | $1,219,455 |
| | | | | | | | | |
| J | BOND ISSUES | | $10,000,000 | $8,000,000 | $10,500,000 | $18,000,000 | $8,000,000 | $19,000,000 |

# Exhibit C

**FY 2021 Water-Sewer Billed Activity**

| Code | Category | Accounts | Percent | Total | Percentages | | |
|---|---|---|---|---|---|---|---|
| | | Active | Accounts | Units Billed | | | |
| **Water** | | | | | | | |
| 100 | Residential | 7,232 | 90.66% | 534,939 | 67.56% | | |
| 105 | Elderly | 161 | 2.02% | 5,289 | 0.67% | | |
| 110 | Commercial | 486 | 6.09% | 207,171 | 26.17% | | |
| 115 | Governmental | 19 | 0.24% | 2,989 | 0.38% | | |
| 120 | School | 15 | 0.19% | 6,115 | 0.77% | | |
| 125 | Industrial | 25 | 0.31% | 12,735 | 1.61% | | |
| 140 | Non Profit | 31 | 0.39% | 1,878 | 0.24% | | |
| 145 | Elderly 2 unit | 2 | 0.03% | 169 | 0.02% | | |
| 150 | Non Billed | 6 | 0.08% | 20,497 | 2.59% | | |
| | **Sub Total** | **7,977** | | **791,782** | **100.00%** | | |
| | | | | | | | |
| **Sewer** | | | | | **Percent Flows** | | |
| 200 | Residential | 5,415 | 91.33% | 427,034 | **59.29%** | Standard Residential | |
| 200 | Residenti Reclass | | | 0 | | | |
| | | | | | | | |
| 201 | Pool Credit | - | 0.00% | | | | |
| 205 | Elderly | 127 | 2.14% | 3,992 | **0.55%** | Eldery Residential | |
| | | | | | | | |
| 210 | Commercial | 313 | 5.28% | 144,559 | **20.07%** | | |
| **213** | **High Volume** | **1** | 0.02% | **132,196** | **18.35%** | | |
| 215 | Governmental | 15 | 0.25% | 1,897 | **0.26%** | | |
| 220 | School | 14 | 0.24% | 2,233 | **0.31%** | | |
| 225 | Industrial | 18 | 0.30% | 6,744 | **0.94%** | | |
| 240 | Non Profit | 25 | 0.42% | 1,491 | **0.21%** | | |
| 245 | Elderly 2 unit | 1 | 0.02% | 148 | **0.02%** | Eldery Residential | |
| | **Sub Total** | **5,929** | | **720,294** | **100.00%** | | |
| | | | | | | | |
| | **All Total** | | | **1,512,310** | | | |

Exhibit D

# INCOME IN THE PAST 12 MONTHS (IN 2020 INFLATION-ADJUSTED DOLLARS)

United States Census Bureau

**Note: This is a modified view of the original table produced by the U.S. Census Bureau. This download or printed version may have missing information from the original table.**

| | Rochester city, Strafford County, New Hampshire | | | | |
|---|---|---|---|---|---|
| | Households | | Families | | Married-cou |
| Label | Estimate | Margin of Er | Est | Margin of Er | Estim |
| Total | 13,151 | ±430 | 8,257 | ±386 | 6,267 |
| Less than $10,000 | 5.0% | ±1.8 | 2.8% | ±1.4 | 0.4% |
| $10,000 to $14,999 | 4.7% | ±1.6 | 1.6% | ±1.2 | 0.6% |
| $15,000 to $24,999 | 7.2% | ±1.4 | 4.0% | ±1.5 | 2.6% |
| $25,000 to $34,999 | 9.8% | ±2.6 | 5.9% | ±2.0 | 4.1% |
| $35,000 to $49,999 | 11.3% | ±2.4 | 13.... | ±3.4 | 11.8% |
| $50,000 to $74,999 | 21.1% | ±2.7 | 22.... | ±4.0 | 19.9% |
| $75,000 to $99,999 | 15.3% | ±2.2 | 18.... | ±3.5 | 20.8% |
| $100,000 to $149,999 | 16.2% | ±2.7 | 19.... | ±3.6 | 24.2% |
| $150,000 to $199,999 | 6.3% | ±1.7 | 8.1% | ±2.3 | 10.2% |
| $200,000 or more | 3.1% | ±1.1 | 4.2% | ±1.7 | 5.3% |
| Median income (dollars) | 66,831 | ±3,647 | 75,... | ±5,723 | 88,071 |
| Mean income (dollars) | 80,784 | ±5,166 | 94,... | ±7,225 | N |
| PERCENT ALLOCATED | | | | | |
| Household income in the past 12 months | 30.1% | (X) | (X) | (X) | (X) |
| Family income in the past 12 months | (X) | (X) | 31.... | (X) | (X) |
| Nonfamily income in the past 12 months | (X) | (X) | (X) | (X) | (X) |

# Table Notes

## INCOME IN THE PAST 12 MONTHS (IN 2020 INFLATION-ADJUSTED DOLLARS)

**Survey/Program:** American Community Survey
**Year:** 2020
**Estimates:** 5-Year
**Table ID:** S1901

Although the American Community Survey (ACS) produces population, demographic and housing unit estimates, for 2020, the 2020 Census provides the official counts of the population and housing units for the nation, states, counties, cities, and towns. For 2016 to 2019, the Population Estimates Program provides estimates of the population for the nation, states, counties, cities, and towns and intercensal housing unit estimates for the nation, states, and counties.

Source: U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates

When information is missing or inconsistent, the Census Bureau logically assigns an acceptable value using the response to a related question or questions. If a logical assignment is not possible, data are filled using a statistical process called allocation, which uses a similar individual or household to provide a donor value. The "Allocated" section is the number of respondents who received an allocated value for a particular subject.

Between 2018 and 2019 the American Community Survey retirement income question changed. These changes resulted in an increase in both the number of households reporting retirement income and higher aggregate retirement income at the national level. For more information see Changes to the Retirement Income Question .

The categories for relationship to householder were revised in 2019. For more information see Revisions to the Relationship to Household item.

Data are based on a sample and are subject to sampling variability. The degree of uncertainty for an estimate arising from sampling variability is represented through the use of a margin of error. The value shown here is the 90 percent margin of error. The margin of error can be interpreted roughly as providing a 90 percent probability that the interval defined by the estimate minus the margin of error and the estimate plus the margin of error (the lower and upper confidence bounds) contains the true value. In addition to sampling variability, the ACS estimates are subject to nonsampling error (for a discussion of nonsampling variability, see ACS Technical Documentation). The effect of nonsampling error is not represented in these tables.

The 2016-2020 American Community Survey (ACS) data generally reflect the September 2018 Office of Management and Budget (OMB) delineations of metropolitan and micropolitan statistical areas. In certain instances, the names, codes, and boundaries of the principal cities shown in ACS tables may differ from the OMB delineation lists due to differences in the effective dates of the geographic entities.

Estimates of urban and rural populations, housing units, and characteristics reflect boundaries of urban areas defined based on Census 2010 data. As a result, data for urban and rural areas from the ACS do not necessarily reflect the results of ongoing urbanization.

Explanation of Symbols:

-

The estimate could not be computed because there were an insufficient number of sample observations. For a ratio of medians estimate, one or both of the median estimates falls in the lowest interval or highest interval of an open-ended distribution.

N

The estimate or margin of error cannot be displayed because there were an insufficient number of sample cases in the selected geographic area.

(X)
The estimate or margin of error is not applicable or not available.
median-
The median falls in the lowest interval of an open-ended distribution (for example "2,500-")
median+
The median falls in the highest interval of an open-ended distribution (for example "250,000+").
**
The margin of error could not be computed because there were an insufficient number of sample observations.
***
The margin of error could not be computed because the median falls in the lowest interval or highest interval of an open-ended distribution.
*****
A margin of error is not appropriate because the corresponding estimate is controlled to an independent population or housing estimate. Effectively, the corresponding estimate has no sampling error and the margin of error may be treated as zero.

Supporting documentation on code lists, subject definitions, data accuracy, and statistical testing can be found on the American Community Survey website in the Technical Documentation section.

Sample size and data quality measures (including coverage rates, allocation rates, and response rates) can be found on the American Community Survey website in the Methodology section.

U.S. BUREAU OF LABOR STATISTICS Exhibit E



# Economic News Release



## Employment Situation Summary

Transmission of material in this news release is embargoed until USDL-22-0787
8:30 a.m. (ET) Friday, May 6, 2022

Technical information:
Household data: (202) 691-6378 * cpsinfo@bls.gov * www.bls.gov/cps
Establishment data: (202) 691-6555 * cesinfo@bls.gov * www.bls.gov/ces

Media contact: (202) 691-5902 * PressOffice@bls.gov

### THE EMPLOYMENT SITUATION -- APRIL 2022

Total nonfarm payroll employment increased by 428,000 in April, and the unemployment rate was unchanged at 3.6 percent, the U.S. Bureau of Labor Statistics reported today. Job growth was widespread, led by gains in leisure and hospitality, in manufacturing, and in transportation and warehousing.

This news release presents statistics from two monthly surveys. The household survey measures labor force status, including unemployment, by demographic characteristics. The establishment survey measures nonfarm employment, hours, and earnings by industry. For more information about the concepts and statistical methodology used in these two surveys, see the Technical Note.

Household Survey Data

The unemployment rate remained at 3.6 percent in April, and the number of unemployed persons was essentially unchanged at 5.9 million. These measures are little different from their values in February 2020 (3.5 percent and 5.7 million, respectively), prior to the coronavirus (COVID-19) pandemic. (See table A-1.)

Among the major worker groups, the unemployment rates for adult men (3.5 percent), adult women (3.2 percent), teenagers (10.2 percent), Whites (3.2 percent), Blacks (5.9 percent), Asians (3.1 percent), and Hispanics (4.1 percent) showed little or no change over the month. (See tables A-1, A-2, and A-3.)

Among the unemployed, the number of permanent job losers remained at 1.4 million in April, and the number of persons on temporary layoff was little changed at 853,000. These measures are little different from their values in February 2020. (See table A-11.)

In April, the number of long-term unemployed (those jobless for 27 weeks or more) was little changed at 1.5 million. This measure is 362,000 higher than in February 2020. The long-term unemployed accounted for 25.2 percent of all unemployed persons in April. (See table A-12.)

Both the labor force participation rate, at 62.2 percent, and the employment-population ratio, at 60.0 percent, were little changed over the month. These measures are each 1.2 percentage points below their February 2020 values. (See table A-1.)

The number of persons employed part time for economic reasons was little changed at 4.0 million in April and is down by 357,000 from its February 2020 level. These individuals, who would have preferred full-time employment, were working part time because their hours had been reduced or they were unable to find full-time jobs. (See table A-8.)

The number of persons not in the labor force who currently want a job was little changed at 5.9 million in April. This measure is above its February 2020 level of 5.0 million. These individuals were not counted as unemployed because they were not actively looking for work during the 4 weeks preceding the survey or were unavailable to take a job. (See table A-1.)

Among those not in the labor force who wanted a job, the number of persons marginally attached to the labor force increased by 262,000 in April to 1.6 million. These individuals wanted and were available for work and had looked for a job sometime in the prior 12 months but had not looked for work in the 4 weeks preceding the survey. Discouraged workers, a subset of the marginally attached who believed that no jobs were available for them, numbered 456,000 in April, little different from the prior month. (See Summary table A.)

Household Survey Supplemental Data

In April, 7.7 percent of employed persons teleworked because of the coronavirus pandemic, down from 10.0 percent in the prior month. These data refer to employed persons who teleworked or worked at home for pay at some point in the 4 weeks preceding the survey specifically because of the pandemic.

In April, 1.7 million persons reported that they had been unable to work because their employer closed or lost business due to the pandemic--that is, they did not work at all or worked fewer hours at some point in the 4 weeks preceding the survey due to the pandemic. This measure is down from 2.5 million in the previous month. Among those who reported in April that they were unable to work because of pandemic-related closures or lost business,

Exhibit E

19.0 percent received at least some pay from their employer for the hours not worked, little different from the prior month.

Among those not in the labor force in April, 586,000 persons were prevented from looking for work due to the pandemic, down from 874,000 in the prior month. (To be counted as unemployed, by definition, individuals must be either actively looking for work or on temporary layoff.)

These supplemental data come from questions added to the household survey beginning in May 2020 to help gauge the effects of the pandemic on the labor market. The data are not seasonally adjusted. Tables with estimates from the supplemental questions for all months are available online at www.bls.gov/cps/effects-of-the-coronavirus-covid-19-pandemic.htm.

Establishment Survey Data

Total nonfarm payroll employment rose by 428,000 in April. Job gains were widespread, with the largest gains occurring in leisure and hospitality, in manufacturing, and in transportation and warehousing. However, nonfarm employment is down by 1.2 million, or 0.8 percent, from its pre-pandemic level in February 2020. (See table B-1.)

Employment in leisure and hospitality increased by 78,000 in April. Job growth continued in food services and drinking places (+44,000) and accommodation (+22,000). Employment in leisure and hospitality is down by 1.4 million, or 8.5 percent, since February 2020.

Manufacturing added 55,000 jobs in April. Employment in durable goods rose by 31,000, with gains in transportation equipment (+14,000) and machinery (+7,000). Nondurable goods added 24,000 jobs, with job growth in food manufacturing (+8,000) and plastics and rubber products (+6,000). Since February 2020, manufacturing employment is down by 56,000, or 0.4 percent.

Employment in transportation and warehousing rose by 52,000 in April. Within the industry, job gains occurred in warehousing and storage (+17,000), couriers and messengers (+15,000), truck transportation (+13,000), and air transportation (+4,000). Employment in transportation and warehousing is 674,000 above its February 2020 level, led by strong growth in warehousing and storage (+467,000) and in couriers and messengers (+259,000).

In April, employment in professional and business services continued to trend up (+41,000). Since February 2020, employment in the industry is up by 738,000.

Financial activities added 35,000 jobs in April, led by a gain in insurance carriers and related activities (+20,000). Employment also rose in nondepository credit intermediation (+6,000) and in securities, commodity contracts, and investments (+5,000). Employment in financial activities is 71,000 higher than in February 2020.

Health care employment rose by 34,000 in April, reflecting a gain in ambulatory health care services (+28,000). Employment in health care is down by 250,000, or 1.5 percent, since February 2020.

Employment in retail trade increased by 29,000 in April. Job gains in food and beverage stores (+24,000) and general merchandise stores (+12,000) were partially offset by losses in building material and garden supply stores (-16,000) and health and personal care stores (-9,000). Retail trade employment is 284,000 above its level in February 2020.

In April, wholesale trade employment rose by 22,000. Employment in the industry is down by 57,000, or 1.0 percent, since February 2020.

Mining added 9,000 jobs in April, with a gain in oil and gas extraction (+5,000). Mining employment is 73,000 higher than a recent low in February 2021.

Employment showed little change over the month in other major industries, including construction, information, other services, and government.

Average hourly earnings for all employees on private nonfarm payrolls rose by 10 cents, or 0.3 percent, to $31.85 in April. Over the past 12 months, average hourly earnings have increased by 5.5 percent. In April, average hourly earnings of private sector production and nonsupervisory employees rose by 10 cents, or 0.4 percent, to $27.12. (See tables B-3 and B-8.)

The average workweek for all employees on private nonfarm payrolls was unchanged at 34.6 hours in April. In manufacturing, the average workweek for all employees fell by 0.2 hour to 40.5 hours, and overtime held at 3.4 hours. The average workweek for production and nonsupervisory employees on private nonfarm payrolls was unchanged at 34.1 hours. (See tables B-2 and B-7.)

The change in total nonfarm payroll employment for February was revised down by 36,000, from +750,000 to +714,000, and the change for March was revised down by 3,000, from +431,000 to +428,000. With these revisions, employment in February and March combined is 39,000 lower than previously reported. (Monthly revisions result from additional reports received from businesses and government agencies since the last published estimates and from the recalculation of seasonal factors.)

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The Employment Situation for May is scheduled to be released on Friday, June 3, 2022, at 8:30 a.m. (ET).

- Employment Situation Summary Table A. Household data, seasonally adjusted
- Employment Situation Summary Table B. Establishment data, seasonally adjusted

Exhibit F

**U.S. BUREAU OF LABOR STATISTICS**

# Databases, Tables & Calculators by Subject

**Change Output Options:** From: 2011 To: 2021 GO

☐ include graphs ☑ include annual averages More Formatting Options

Data extracted on: January 13, 2022 (2:56:58 PM)

**CPI for All Urban Consumers (CPI-U)**

**Series Id:** CUUR0000SA0
Not Seasonally Adjusted
**Series Title:** All items in U.S. city average, all urban consumers, not seasonally adjusted
**Area:** U.S. city average
**Item:** All items
**Base Period:** 1982-84=100

**Download:** xlsx

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual | HALF1 | HALF2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 220.223 | 221.309 | 223.467 | 224.906 | 225.964 | 225.722 | 225.922 | 226.545 | 226.889 | 226.421 | 226.230 | 225.672 | 224.939 | 223.598 | 226.280 |
| 2012 | 226.665 | 227.663 | 229.392 | 230.085 | 229.815 | 229.478 | 229.104 | 230.379 | 231.407 | 231.317 | 230.221 | 229.601 | 229.594 | 228.850 | 230.338 |
| 2013 | 230.280 | 232.166 | 232.773 | 232.531 | 232.945 | 233.504 | 233.596 | 233.877 | 234.149 | 233.546 | 233.069 | 233.049 | 232.957 | 232.366 | 233.548 |
| 2014 | 233.916 | 234.781 | 236.293 | 237.072 | 237.900 | 238.343 | 238.250 | 237.852 | 238.031 | 237.433 | 236.151 | 234.812 | 236.736 | 236.384 | 237.088 |
| 2015 | 233.707 | 234.722 | 236.119 | 236.599 | 237.805 | 238.638 | 238.654 | 238.316 | 237.945 | 237.838 | 237.336 | 236.525 | 237.017 | 236.265 | 237.769 |
| 2016 | 236.916 | 237.111 | 238.132 | 239.261 | 240.229 | 241.018 | 240.628 | 240.849 | 241.428 | 241.729 | 241.353 | 241.432 | 240.007 | 238.778 | 241.237 |
| 2017 | 242.839 | 243.603 | 243.801 | 244.524 | 244.733 | 244.955 | 244.786 | 245.519 | 246.819 | 246.663 | 246.669 | 246.524 | 245.120 | 244.076 | 246.163 |
| 2018 | 247.867 | 248.991 | 249.554 | 250.546 | 251.588 | 251.989 | 252.006 | 252.146 | 252.439 | 252.885 | 252.038 | 251.233 | 251.107 | 250.089 | 252.125 |
| 2019 | 251.712 | 252.776 | 254.202 | 255.548 | 256.092 | 256.143 | 256.571 | 256.558 | 256.759 | 257.346 | 257.208 | 256.974 | 255.657 | 254.412 | 256.903 |
| 2020 | 257.971 | 258.678 | 258.115 | 256.389 | 256.394 | 257.797 | 259.101 | 259.918 | 260.280 | 260.388 | 260.229 | 260.474 | 258.811 | 257.557 | 260.065 |
| 2021 | 261.582 | 263.014 | 264.877 | 267.054 | 269.195 | 271.696 | 273.003 | 273.567 | 274.310 | 276.589 | 277.948 | 278.802 | 270.970 | 266.236 | 275.703 |

**12-Month Percent Change**
**Series Id:** CUUR0000SA0
Not Seasonally Adjusted
**Series Title:** All items in U.S. city average, all urban consumers, not seasonally adjusted
**Area:** U.S. city average
**Item:** All items
**Base Period:** 1982-84=100

**Download:** xlsx

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual | HALF1 | HALF2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 1.6 | 2.1 | 2.7 | 3.2 | 3.6 | 3.6 | 3.6 | 3.8 | 3.9 | 3.5 | 3.4 | 3.0 | 3.2 | 2.8 | 3.5 |
| 2012 | 2.9 | 2.9 | 2.7 | 2.3 | 1.7 | 1.7 | 1.4 | 1.7 | 2.0 | 2.2 | 1.8 | 1.7 | 2.1 | 2.3 | 1.8 |
| 2013 | 1.6 | 2.0 | 1.5 | 1.1 | 1.4 | 1.8 | 2.0 | 1.5 | 1.2 | 1.0 | 1.2 | 1.5 | 1.5 | 1.5 | 1.4 |
| 2014 | 1.6 | 1.1 | 1.5 | 2.0 | 2.1 | 2.1 | 2.0 | 1.7 | 1.7 | 1.7 | 1.3 | 0.8 | 1.6 | 1.7 | 1.5 |
| 2015 | -0.1 | 0.0 | -0.1 | -0.2 | 0.0 | 0.1 | 0.2 | 0.2 | 0.0 | 0.2 | 0.5 | 0.7 | 0.1 | -0.1 | 0.3 |
| 2016 | 1.4 | 1.0 | 0.9 | 1.1 | 1.0 | 1.0 | 0.8 | 1.1 | 1.5 | 1.6 | 1.7 | 2.1 | 1.3 | 1.1 | 1.5 |
| 2017 | 2.5 | 2.7 | 2.4 | 2.2 | 1.9 | 1.6 | 1.7 | 1.9 | 2.2 | 2.0 | 2.2 | 2.1 | 2.1 | 2.2 | 2.0 |
| 2018 | 2.1 | 2.2 | 2.4 | 2.5 | 2.8 | 2.9 | 2.9 | 2.7 | 2.3 | 2.5 | 2.2 | 1.9 | 2.4 | 2.5 | 2.4 |
| 2019 | 1.6 | 1.5 | 1.9 | 2.0 | 1.8 | 1.6 | 1.8 | 1.7 | 1.7 | 1.8 | 2.1 | 2.3 | 1.8 | 1.7 | 1.9 |
| 2020 | 2.5 | 2.3 | 1.5 | 0.3 | 0.1 | 0.6 | 1.0 | 1.3 | 1.4 | 1.2 | 1.2 | 1.4 | 1.2 | 1.2 | 1.2 |
| 2021 | 1.4 | 1.7 | 2.6 | 4.2 | 5.0 | 5.4 | 5.4 | 5.3 | 5.4 | 6.2 | 6.8 | 7.0 | 4.7 | 3.4 | 6.0 |

Exhibit G

S&P Global
Ratings

RatingsDirect®

**Summary:**

# Rochester, New Hampshire; General Obligation

**Primary Credit Analyst:**
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## Table Of Contents

## Summary:

# Rochester, New Hampshire; General Obligation

| Credit Profile | | |
|---|---|---|
| US$19.665 mil GO ser 2020 A dtd 04/09/2020 due 04/01/2040 | | |
| *Long Term Rating* | AA/Stable | New |
| US$3.07 mil GO rfdg bnds ser 2020B due 01/15/2030 | | |
| *Long Term Rating* | AA/Stable | New |
| Rochester GO | | |
| *Long Term Rating* | AA/Stable | Affirmed |

## Rating Action

S&P Global Ratings assigned its 'AA' rating to Rochester, N.H.'s series 2020A general obligation (GO) bonds and series 2020B GO refunding bonds and affirmed its 'AA' rating on the city's existing GO debt. The outlook is stable.

Rochester's full-faith-and-credit-GO pledge secures the bonds. Officials intend to use series 2020A bond proceeds, totaling about $19.7 million, toward various capital improvement projects and series 2020B bond proceeds, totaling about $3 million, to refund the city's series 2010 GO bond for present value savings.

### Credit overview

The rating reflects our view of the city's strong economy with a growing and diversified tax base. The outlook reflects what we views as Rochester's very strong flexibility and liquidity supported by historically strong budgetary performance, and strong management conditions. Further rating stability is provided by the city's very strong reserve position and manageable retirement costs, although current plan assumptions could lead to increases in costs. Therefore, we do not expect to change the rating over the next two years.

We believe the city's stable, property-tax based revenue source is unlikely to result in materially delayed collections or revenue volatility in the current environment. While the scope of economic and financial challenges posed by COVID-19 remain to be seen, particularly in light of the possibility being suspended for an extended period, given the historical stability and resiliency of the city's tax base, in addition to its strong management team and very strong reserves, we believe it is currently well positioned to navigate the possible effects of the pandemic. However, if the duration of an economic disruption turns out to be more prolonged, the city's economy could be affected. While we continue to monitor events related to COVID-19, we do not currently expect it to affect the city's ability to maintain budgetary balance and pay debt service costs. For more information, see our article "COVID-19's Potential Effects In U.S. Public Finance Vary By Sector" (published March 5, 2020 on RatingsDirect).

The city's general creditworthiness is also supported by its:

- Strong economy, with access to a broad and diverse metropolitan statistical area (MSA);
- Strong management, with good financial policies and practices under our Financial Management Assessment (FMA)

methodology;

- Strong budgetary performance, with operating surpluses in the general fund and at the total governmental fund level in fiscal 2019;
- Very strong budgetary flexibility, with an available fund balance in fiscal 2019 of 25% of operating expenditures;
- Very strong liquidity, with total government available cash at 37.5% of total governmental fund expenditures and 5.7x governmental debt service, and access to external liquidity we consider strong;
- Adequate debt and contingent liability position, with debt service carrying charges at 6.6% of expenditures and net direct debt that is 70.9% of total governmental fund revenue, as well as rapid amortization, with 72.7% of debt scheduled to be retired in 10 years, but a large pension and other postemployment benefit (OPEB) obligation; and
- Very strong institutional framework score.

## Stable Two-Year Outlook

### Upside scenario

Should economic indicators improve to levels comparable with those of higher rated peers while increasing available reserves through strong budgetary performance and managing its increasing retirement costs, we could raise the rating.

### Downside scenario

Although unlikely, should the city experience continuous negative financial results, leading to decreases in available reserves, we could lower the rating.

## Credit Opinion

### Strong economy

We consider Rochester's economy strong. The city, with an estimated population of 30,577, encompasses more than 46 square miles of rolling hills and rivers, is in Strafford County in southeastern New Hampshire, 40 miles east of Manchester, 50 miles from Portland, Me., and 70 miles northeast of Boston. It is in the Boston-Cambridge-Newton MSA, which we consider to be broad and diverse. The city has a projected per capita effective buying income of 92.0% of the national level and per capita market value of $89,208. Overall, market value grew by 1.0% over the past year to $2.7 billion in 2020. The county unemployment rate was 2.3% in 2018.

Rochester is the second-largest city in the seacoast region. Major employers include Frisbie Memorial Hospital, the local school department, Market Basket, and Albany Engineered Composites. The city's assessed value grew by about 15% in 2019 as a result of a revaluation, which officials indicate has not resulted in any large appeals or delinquencies in tax payments.

The city maintains a mix of industrial and commercial development with various business parks for business of all types and sizes. This includes Granite State Business Park, a 450-acre multiuse industrial high-technology park which houses more than 1,300 skilled employees at several major companies, including Safran Aerospace Composites, Albany International Inc., and NCS Global. Officials report the park continues to grow. Management also indicates development continues along its Granite Ridge Development District as the project has entered Phase II, which will consist of new retail and entertainment venues such as a multiscreen cinema and others.

The city's downtown area has also seen expansion with new restaurant, retail, and other businesses opening up within the last few years. Rochester continues encourage further development and private investments in its downtown area with improvements to infrastructure, diversifying the housing market in the area, and providing more amenities and recreational opportunities to attract more businesses and residential developers. In particular, officials report there has been a significant utilization of the city's 79-E program, which provides tax incentives to developers for 10 years, for certain redevelopment projects in its downtown area. This includes renovations to existing buildings in the downtown area that will be turned into market-rate residential and commercial units as well as retail space.

### Strong management

We view the city's management as strong, with good financial policies and practices under our FMA methodology, indicating financial practices exist in most areas, but that governance officials might not formalize or monitor all of them on a regular basis.

Highlights include management's conservative assumptions and three- to five-year historical trend analysis when budgeting for revenue and expenditures. Management reports budget-to-actual results to the city council monthly. In addition, the city has a formal investment policy; it reports holdings to the city council at least annually. Rochester also has a formal five-year capital improvement plan (CIP), with identified funding sources for projects that management updates annually.

The city, however, does not have a formal debt management policy. In addition, it does not conduct any long-term financial planning. The council approved a reserve and liquidity policy that calls for the maintenance of a minimum of 8% of expenditures and a maximum of 17% of expenditures in unassigned fund balance reserves. Should reserves decline below 8% of expenditures, the city manager will develop a plan to replenish shortages for the council's approval. Should reserve balance exceed 17%, the city will consider such fund balance surpluses for one-time expenditures that will not require additional expenses.

The city also has cyber-security protections in place, conducts citywide cyber-security education and tests, and maintains various back-ups of its networks and systems. It also maintains cyber-security insurance.

### Strong budgetary performance

Rochester's budgetary performance is strong, in our opinion. The city had operating surpluses of 6.0% of expenditures in the general fund and 3.5% across all governmental funds in fiscal 2019. Our assessment accounts for the fact that we expect budgetary results could deteriorate somewhat from 2019 results in the near term.

We adjusted fiscal 2019 audited operating results for recurring transfers and one time capital expenditures paid for with bond proceeds. According to management, the city's positive performance was primarily due to higher-than-expected revenue and expenditures coming in on budget. In particular, the city had favorable variances in motor vehicle permits, host community fees, and investment income. In addition, it experienced savings of about $1.5 million in school department costs, which also contributed to the general fund surplus. Management also indicates there were no major one- time revenues that affected the general fund results in fiscal 2019. Prior to this, the city ended fiscal 2018 with a general fund surplus of approximately $778,000.

The fiscal 2020 budget totals $106.2 million, representing a 2% increase over the prior year and includes a $1.3 million fund balance appropriation which it has done historically. While budget-to-actuals are trending favorably, the city indicates it has appropriated an additional $8.2 million from fund balance during the year toward the school department for unanticipated special education costs and other one-time expenses. However at the same time, officials indicate the school department has received additional one-time state aid for the school-related costs and the city has received an additional $686,000 in municipal aid from the state, which it did not budget for. In addition, local receipts such as motor vehicle excise taxes, host community fees, and investment income are projected to arrive at more than $2.6 million over budget by fiscal year-end. Therefore, management currently anticipates ending the year with at least balanced , not including the city's use of reserves for planned one-time purposes. As a result, due to the city's conservative budgeting practices and history of maintaining balanced operations, we expect its budgetary performance to remain strong. In addition, we don't expect any material budgetary pressure as a result of school closures due to recent events related to COVD-19, as the state will continue to provide aid and resources to school departments.

Property taxes generate 52% of general fund revenue with intergovernmental revenue accounting for 32%. Collections have averaged 99% over the past three years.

### Very strong budgetary flexibility

Rochester's budgetary flexibility is very strong, in our view, with an available fund balance in fiscal 2019 of 25% of operating expenditures, or $23.2 million.

The city has improved reserves over the past three years through consistent positive financial performance. It also appropriated about $1.3 million in fund balance toward the budget in fiscal 2020, which it has done historically. In addition, it appropriated about $8.2 million in additional fund balance during the year toward unexpected school department costs and other planned one-time expenses. However, although officials indicate reserves could decrease by around $5 million as a result of the city's planned use of reserves for one-time items, they do not anticipate any additional significant drawdowns in fund balance aside from that by fiscal year-end as revenues are currently exceeding the budget and expenditures remain on target.

In fiscal 2008, residents approved an amendment to the city charter to limit annual budget increases the council could override with a two-thirds majority vote. We understand the city elected to override the tax cap by about $1.7 million for school-related costs in fiscal 2019 but has not done so since then. The city also has a formal reserve policy of maintaining unassigned fund balance between 8%-17% of expenditures, which it adheres to.

### Very strong liquidity

In our opinion, Rochester's liquidity is very strong, with total government available cash at 37.5% of total governmental fund expenditures and 5.7x governmental debt service in 2019. In our view, the city has strong access to external liquidity if necessary.

Rochester's issuance of GO bonds and bond anticipation notes during the past 20 years demonstrates its strong external liquidity. The city does not currently have any contingent liquidity risks from financial instruments with payment provisions that change on the occurrence of certain events. The city's series 2016 GO bonds are privately placed with TD Bank N.A., and have a current outstanding balance of $7.7 million as of fiscal 2019. Its series 2007 GO bonds are also privately placed with Bank of America N.A., and have a current outstanding balance of $800,000 as of fiscal 2019. However, based on a review of the documents, there are no adverse covenants or rating triggers and we consider the likelihood of principal acceleration remote. For these reasons, available cash remains, in our view, very strong and stable; therefore, we expect the liquidity profile will not change over the next two fiscal years.

### Adequate debt and contingent liability profile

In our view, Rochester's debt and contingent liability profile is adequate. Total governmental fund debt service is 6.6% of total governmental fund expenditures, and net direct debt is 70.9% of total governmental fund revenue. Approximately 72.7% of the direct debt is scheduled to be repaid within 10 years, which is, in our view, a positive credit factor.

Following the current issue, Rochester will have approximately $107.8 million of total direct debt outstanding. Over the next two years, officials expect to issue about $48 million as part of its CIP with the majority intended to fund water and sewer-related projects which is expected to be fully self-supported through user fees. We also do not expect new financing to have a material effect on the city's debt profile.

Pension and OPEB highlights include:

- We do not view pension and OPEB liabilities as an immediate source of credit pressure for Rochester despite lower funding levels and our expectation that costs will increase.
- Because the pension plan's actuarially determined contribution is built from what we view as weak assumptions and methodologies, we believe it increases the risk of unexpected contribution escalations. However, we anticipate higher contributions will likely remain affordable given the city's conservative budgeting practices and very strong reserves
- Although OPEB liabilities are funded on a pay-as-you-go basis, which, given claims volatility, as well as medical cost and demographic trends, is likely to lead to escalating costs, costs remain low and the city has legal flexibility to alter OPEB benefits, which we view as a potential means to mitigate escalating costs.

As of June 30, 2019, Rochester participates in:

- New Hampshire Retirement System, which is 64.7% funded with a proportionate share of the city's net pension liability at $80.3 million, assuming a 7.25% discount rate as of fiscal 2019;
- New Hampshire Retirement System (NHRS) Medical Subsidy plan, a cost-sharing, multiple-employer OPEB plan for retirees, which is 7.53% funded with a proportionate share of the city's net pension liability at $7.5 million as of fiscal 2019; and
- A defined-benefit city health care plan that provides implicit subsidies to retirees, with an OPEB liability of about $10.6 million.

Rochester's combined required pension and actual OPEB contributions totaled 2.9% of total governmental fund expenditures in 2019. Of that amount, 2.2% represented required contributions to pension obligations, and 0.6% represented OPEB payments. The city made its full annual required pension contribution in 2019.

Although pension contributions in fiscal 2019 did not meet minimum funding progress, it did exceed static funding by more than 100%. There is an actuarial plan to reach full funding within a closed 20 years. However, we believe the plan's amortization methods, including its level 3% of payroll amortization, defer costs and will result in slow funding progress, which could lead to growth in the unfunded liability. In addition, with a 7.25% discount rate, the plan could also be susceptible to market-volatility risk. However, we believe pension and OPEB costs should remain manageable for the city given its conservative budgeting practices which have led to stable finances, strong management conditions, and a very strong reserve position.

### Very strong institutional framework

The institutional framework score for New Hampshire municipalities is very strong.

## Related Research

- S&P Public Finance Local GO Criteria: How We Adjust Data For Analytic Consistency, Sept. 12, 2013
- Alternative Financing: Disclosure Is Critical To Credit Analysis In Public Finance, Feb. 18, 2014
- Criteria Guidance: Assessing U.S. Public Finance Pension And Other Postemployment Obligations For GO Debt, Local Government GO Ratings, And State Ratings, Oct. 7, 2019

| Ratings Detail (As Of March 24, 2020) | | |
|---|---|---|
| Rochester GO | | |
| *Long Term Rating* | AA/Stable | Affirmed |
| Rochester GO rfdg bnds | | |
| *Long Term Rating* | AA/Stable | Affirmed |

Exhibit G

Exhibit H

**City of Rochester, New Hampshire**
**Continuing Disclosure Report – FY2021**

**Financial Summary**

*(As of 6/30/21)*

| | |
|---|---|
| Net Assessed Valuation (Real and Personal) | $2,814,722,128 |
| Plus: Blind, Elderly and Special Exemptions | $33,644,542 |
| Total Assessed Valuation | $2,848,366,670* |
| Tax Anticipation Notes Currently Outstanding | $0 |
| Bond Anticipation Notes Currently Outstanding | $0 |
| Total Tax and Bond Anticipation Notes Outstanding | $0 |

* Tax year 2021 (4/1/2021-3/31/2022)

Bonded Debt (Principal Outstanding as of June 30, 2021):

| | |
|---|---|
| Public Improvements | $25,685,479.09 |
| Schools[(1)] | 16,074,338.34 |
| Water[(2) (4)] | 17,147,246.03 |
| Sewer[(2)] | 19,268,112.98 |
| Arena | 1,501,249.75 |
| TIF Project[(3)] | 5,239,578.38 |

| | |
|---|---|
| Total Current Bonded Debt | $84,916,004.57 |
| Total Net Debt (less RSA 162-K & RSA 205:4-c Tax Increment Finance Bonds, State School Building Aid grants and self-supporting debt) | $43,169,300.18 |

*(1) State School Building Aid grants totaling $91,767 are to be received to offset school debt over a period of years subject to the annual appropriation of the state legislature.*
*(2) Debt fully supported by user fees. Includes State revolving fund loans.*
*(3) Debt incurred under RSA 162k & RSA 205:4-c will be supported by a special tax increment but remains a general obligation of the City.*
*(4) Includes principal to be forgiven by the State of NH on DWSRF loans currently in payback mode.*

**Overlapping Debt** ***(as of 6/30/21)***

| Entity | Amount of Debt Outstanding | Authorized but Unissued Debt | % of Debt Charged to City | Amount of Debt Charged to City |
|---|---|---|---|---|
| Strafford County | $9,097,000.00 | $0 | 20.28% | $1,844,871.60 |

Exhibit H

# CITY OF ROCHESTER, NEW HAMPSHIRE

## Balance Sheet
## General Fund
## For Fiscal Years Ending June 30, 2017 - 2021

| | 2017 | 2018 | 2019 | 2020 | Draft 2021 |
|---|---|---|---|---|---|
| **ASSETS:** | | | | | |
| Cash & Short-Term Investments | $ 40,992,553 | $ 30,781,550 | $ 36,731,804 | $ 66,123,090 | $ 51,792,628 |
| Investments | 7,074,411 | 7,268,132 | 5,198,343 | 3,093,621 | 3,170,835 |
| Receivables | | | | | |
| Property Taxes | 3,722,779 | 2,820,528 | 2,653,872 | 2,649,403 | 2,961,396 |
| User Fees | 490,068 | 1,302,687 | 1,286,466 | 316,865 | 266,635 |
| Intergovernmental and other | | | | | 5,633 |
| Due From Other Funds | 1,039,097 | 3,080,041 | 5,230,006 | 1,391,618 | 28,332,115 |
| Other Assets | 24,446 | 35,228 | 48,642 | 61,960 | 50,297 |
| **TOTAL ASSETS** | **$ 53,343,354** | **$ 45,288,166** | **$ 51,149,133** | **$ 73,636,557** | **$ 86,579,539** |
| **DEFERRED OUTFLOWS OF RESOURCES:** | | | | | |
| **TOTAL DEFERRED OUTFLOWS OF RESOURCES** | $ - | $ - | $ - | $ - | $ - |
| **TOTAL ASSETS & DEFERRED OUTFLOWS OF RESOURCES** | **$ 53,343,354** | **$ 45,288,166** | **$ 51,149,133** | **$ 73,636,557** | **$ 86,579,539** |
| **LIABILITIES:** | | | | | |
| Accounts Payable | $ 1,951,931 | $ 2,234,586 | $ 2,103,744 | $ 1,921,697 | $ 1,966,532 |
| Accrued Liabilities | 2,726,677 | 2,826,605 | 2,949,868 | 2,991,692 | 4,481,017 |
| Tax Refunds Payable | - | - | - | 18,521 | 675,000 |
| Due to Other Funds | 9,555,069 | - | - | 12,595,828 | 26,585,600 |
| Other Liabilities | 82,021 | 64,509 | 42,764 | 81,562 | 1,190,346 |
| **TOTAL LIABILITIES** | **$ 14,315,698** | **$ 5,125,700** | **$ 5,096,376** | **$ 17,609,300** | **$ 34,898,495** |
| **DEFERRED INFLOWS OF RESOURCES:** | | | | | |
| **TOTAL DEFERRED INFLOWS OF RESOURCES** | **$ 21,512,467** | **$ 21,248,725** | **$ 21,567,065** | **$ 32,627,211** | **$ 23,342,132** |
| **FUND BALANCES:** | | | | | |
| Nonspendable | $ 24,446 | $ 35,228 | $ 48,642 | $ 687,451 | $ 50,297 |
| Restricted | 115,311 | 198,187.00 | 371,054 | 311,169 | 311,169 |
| Committed | 796,326 | 199,576 | 856,474 | 1,870,704 | 870,704 |
| Assigned | 20,000 | 20,000 | 20,000 | 48,053 | 3,067,153 |
| Unassigned | 16,559,106 | 18,460,750 | 23,189,522 | 20,482,669 | 24,039,589 |
| **TOTAL FUND BALANCES** | **$ 17,515,189** | **$ 18,913,741** | **$ 24,485,692** | **$ 23,400,046** | **$ 28,338,912** |
| **TOTAL LIABILITIES, DEFERRED INFLOWS OF RESOURCES & FUND BALANCES** | **$ 53,343,354** | **$ 45,288,166** | **$ 51,149,133** | **$ 73,636,557** | **$ 86,579,539** |

Exhibit H

# CITY OF ROCHESTER, NEW HAMPSHIRE

## Statement of Revenues, Expenditures and Changes in Fund Balances
## General Fund
## For Fiscal Years Ending June 30, 2017 - 2021

| | 2017 | 2018 | 2019 | 2020 | Draft 2021 |
|---|---|---|---|---|---|
| **REVENUES:** | | | | | |
| Property Taxes | $ 45,641,426 | $ 47,474,372 | $ 51,344,667 | $ 53,203,837 | $ 55,099,382 |
| Penalties, Interest, and Other Taxes | 1,400,698 | 2,226,742 | 1,488,593 | 1,080,001 | 950,034 |
| Licenses and Permits | 3,651,362 | 5,763,004 | 6,585,414 | 6,480,626 | 6,872,641 |
| Intergovernmental | 29,601,466 | 29,205,982 | 31,535,203 | 33,639,588 | 37,796,755 |
| Charges for Services | 5,575,200 | 5,551,626 | 6,051,123 | 6,108,067 | 7,086,956 |
| Investment Income | 133,912 | 332,624 | 683,200 | 530,996 | 135,912 |
| Miscellaneous | 2,154,094 | 2,174,597 | 898,182 | 562,989 | 664,575 |
| Contributions | 812,403 | 697,508 | - | - | - |
| **TOTAL REVENUES** | **$ 88,970,561** | **$ 93,426,455** | **$ 98,586,382** | **$ 101,606,104** | **$ 108,606,255** |
| **EXPENDITURES:** | | | | | |
| Current Operations: | | | | | |
| General Government | $ 5,322,282 | $ 5,402,799 | $ 5,641,888 | $ 5,956,472 | $ 6,171,045 |
| Public Safety | 12,125,497 | 12,610,017 | 12,415,881 | 13,259,537 | 14,225,879 |
| Highways and Streets | 2,839,299 | 2,696,244 | 2,961,149 | 2,959,512 | 2,925,263 |
| Health and Welfare | 387,592 | 406,765 | 451,263 | 424,237 | 356,729 |
| Culture and Recreation | 1,856,956 | 1,916,088 | 1,997,696 | 2,030,040 | 1,983,088 |
| Community Development | - | - | - | 370,285 | 2,285,267 |
| Education | 56,985,599 | 58,858,752 | 59,401,982 | 60,316,842 | 60,810,592 |
| Community Services | | | | | 5,462 |
| Conservation | 901 | - | - | 4,600 | - |
| Debt Service | 5,649,812 | 6,328,475 | 6,179,609 | 6,448,605 | 6,827,599 |
| **TOTAL EXPENDITURES** | **$ 85,167,938** | **$ 88,219,140** | **$ 89,049,468** | **$ 91,770,130** | **$ 95,590,924** |
| **Excess of Revenues Before Other Financing Sources (Uses)** | $ 3,802,623 | $ 5,207,315 | $ 9,536,914 | $ 9,835,974 | $ 13,015,331 |
| **OTHER FINANCING SOURCES (USES):** | | | | | |
| Operating Transfers In | $ 618,748 | $ 1,145,847 | $ 235,477 | $ 200,646 | $ 1,354,408 |
| Operating Transfers Out | (3,720,826) | (5,574,830) | (4,200,440) | (11,122,266) | (9,430,873) |
| Proceeds of capital lease obligations | 247,119 | 620,220 | - | - | - |
| Proceeds of refunding bonds | - | - | - | - | - |
| Payment to bond refunding escrow agent | - | - | - | - | - |
| **TOTAL OTHER FINANCING SOURCES (USES)** | $ (2,854,959) | $ (3,808,763) | $ (3,964,963) | $ (10,921,620) | $ (8,076,465) |
| **NET CHANGE IN FUND BALANCE** | 947,664 | 1,398,552 | 5,571,951 | (1,085,646) | 4,938,866 |
| **FUND BALANCE - BEGINNING OF YEAR** | **$ 16,567,525** | **$ 17,515,189** | **$ 18,913,741** | **$ 24,485,692** | **$ 23,400,046** |
| **FUND BALANCE - END OF YEAR** | **$ 17,515,189** | **$ 18,913,741** | **$ 24,485,692** | **$ 23,400,046** | **$ 28,338,912** |

Exhibit H

**Projected Payments by Purpose**

| Fiscal Year | Public Improvements | School | Arena Fund | Water Fund | Sewer Fund | TIF Project | Total |
|---|---|---|---|---|---|---|---|
| 2022 | $ 3,075,356 | $ 1,537,415 | $ 144,631 | $ 1,745,988 | $ 1,898,504 | $ 591,275 | $ 8,993,169 |
| 2023 | 2,970,368 | 1,509,861 | 144,802 | 1,674,258 | 1,697,028 | 600,103 | 8,596,420 |
| 2024 | 2,809,225 | 1,349,106 | 113,283 | 1,644,570 | 1,677,454 | 608,930 | 8,202,568 |
| 2025 | 2,722,894 | 1,347,734 | 113,283 | 1,646,358 | 1,616,996 | 622,172 | 8,069,437 |
| 2026 | 1,849,015 | 1,180,070 | 110,783 | 1,298,116 | 1,316,631 | 630,999 | 6,385,614 |
| 2027 | 1,687,937 | 1,165,820 | 104,732 | 1,289,623 | 1,268,933 | 643,827 | 6,160,872 |
| 2028 | 1,559,734 | 1,114,467 | 101,505 | 1,271,389 | 1,225,244 | 283,068 | 5,555,407 |
| 2029 | 1,167,542 | 1,034,464 | 98,032 | 1,078,230 | 1,043,107 | 291,896 | 4,713,271 |
| 2030 | 1,102,542 | 831,514 | 90,552 | 983,314 | 963,975 | 305,137 | 4,277,034 |
| 2031 | 943,776 | 801,514 | 74,552 | 845,736 | 919,702 | 313,965 | 3,899,245 |
| 2032 | 944,128 | 811,231 | 74,552 | 728,210 | 925,793 | 327,206 | 3,811,120 |
| 2033 | 876,151 | 768,731 | 59,552 | 575,710 | 793,526 | 5,000 | 3,078,670 |
| 2034 | 867,454 | 769,231 | 59,492 | 562,929 | 774,201 | 5,000 | 3,038,307 |
| 2035 | 872,340 | 733,671 | 63,612 | 562,983 | 775,701 | 5,000 | 3,013,307 |
| 2036 | 666,226 | 724,788 | 35,552 | 438,701 | 670,292 | 5,000 | 2,540,559 |
| 2037 | 661,226 | 154,788 | 35,552 | 343,142 | 675,292 | 5,000 | 1,875,000 |
| 2038 | 319,782 | 74,966 | 30,891 | 158,995 | 380,366 | 5,000 | 970,000 |
| 2039 | 329,782 | 74,966 | 25,891 | 158,995 | 380,366 | - | 970,000 |
| 2040 | 260,000 | 50,000 | 20,000 | 140,000 | 265,000 | - | 735,000 |
| | $ 25,685,478 | $ 16,034,337 | $ 1,501,249 | $ 17,147,247 | $ 19,268,111 | $ 5,248,578 | $ 84,885,000 |

Exhibit H

**Capital Improvement Program**

The City of Rochester utilizes a six-year Capital Improvement Plan ("CIP") which is updated annually. This program defines a capital item as any project or improvements having useful life in excess of ten (10) years and value exceeding $10,000. The CIP is presented by individual accounts or funds but does not represent a commitment by the City to spend funds or incur debt for the projects listed in the CIP but rather acts as a guide for current budgeting and future planning. The CIP is generally presented to the City Council by the City Manager in April of the current fiscal year.

The following table lists the 2022-2027 Capital Improvement Program by program areas and source of funds.

| **Projects:** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **City Departments** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **Six Year Total** |
| Assessing | - | - | - | - | - | - | - |
| Building Zoning & Licensing | - | - | - | - | - | - | - |
| City Clerk | - | - | - | - | - | - | - |
| City Manager | 27,000 | 27,000 | 27,000 | 27,000 | - | - | 108,000 |
| Dispatch Center | 900,000 | - | - | - | - | - | 900,000 |
| Economic Development | 105,000 | 600,000 | - | - | - | - | 705,000 |
| Emergency Management | 250,000 | - | - | - | - | - | 250,000 |
| Fire Department | 295,000 | 1,600,000 | 3,965,000 | 85,000 | 2,185,000 | 4,170,000 | 12,300,000 |
| Library | - | - | - | - | - | - | - |
| MIS | 1,050,000 | 475,000 | 325,000 | 475,000 | 325,000 | 100,000 | 2,750,000 |
| Planning | 35,000 | 60,000 | - | - | - | - | 95,000 |
| Police Department | 359,000 | 190,000 | 190,000 | 190,000 | 190,000 | - | 1,119,000 |
| Public Buildings | 715,000 | 860,000 | 40,000 | 40,000 | 40,000 | 40,000 | 1,735,000 |
| Public Works Departments | 3,796,000 | 12,715,000 | 7,810,000 | 8,075,000 | 5,571,000 | 8,425,000 | 46,392,000 |
| Recreation Department | 34,184 | - | - | - | - | - | 34,184 |
| School Department | 1,423,000 | 675,000 | 325,000 | 10,000 | - | - | 2,433,000 |
| **Total City CIP** | **8,989,184** | **17,202,000** | **12,682,000** | **8,902,000** | **8,311,000** | **12,735,000** | **68,821,184** |
| Arena Fund | 80,000 | 500,000 | - | - | - | - | 580,000 |
| Community Center | 305,000 | 80,000 | - | - | - | - | 385,000 |
| Granite Ridge Development | - | 275,000 | - | 100,000 | 2,825,000 | 2,800,000 | 6,000,000 |
| Granite State Business Park | - | - | - | - | 250,000 | 2,500,000 | 2,750,000 |
| Sewer Department | 2,381,000 | 8,665,000 | 6,725,000 | 12,350,000 | 23,050,000 | 5,650,000 | 58,821,000 |
| Water Department | 2,379,000 | 6,640,000 | 4,125,000 | 5,325,000 | 2,525,000 | 2,675,000 | 23,669,000 |
| **Total Enterprise & Special Revenue Funds** | **5,145,000** | **16,160,000** | **10,850,000** | **17,775,000** | **28,650,000** | **13,625,000** | **92,205,000** |
| | | | | | | | |
| **GRAND TOTAL** | **14,134,184** | **33,362,000** | **23,532,000** | **26,677,000** | **36,961,000** | **26,360,000** | **161,026,184** |
| **Funding Sources:** | | | | | | | |
| Bond: City/School | 5,954,000 | 12,255,000 | 9,110,000 | 5,575,000 | 5,171,000 | 9,950,000 | 48,015,000 |
| Bond: Water/Sewer/Arena | 4,370,000 | 15,105,000 | 10,650,000 | 17,475,000 | 25,375,000 | 8,125,000 | 81,100,000 |
| Cash: City/School | 3,393,184 | 4,325,000 | 3,295,000 | 3,300,000 | 3,140,000 | 2,785,000 | 20,238,184 |
| Cash: Water/Sewer/Arena | 390,000 | 200,000 | 200,000 | 200,000 | 200,000 | 200,000 | 1,390,000 |
| Dedicated Revenue | - | 365,000 | 250,000 | - | - | - | 615,000 |
| Grant | 27,000 | 27,000 | 27,000 | 27,000 | - | - | 108,000 |
| State Highway Fund | | 1,000,000 | - | 100,000 | 1,765,000 | 2,800,000 | 5,665,000 |
| TIF Bond | - | 85,000 | - | - | 1,310,000 | 2,500,000 | 3,895,000 |
| **GRAND TOTAL** | **14,134,184** | **33,362,000** | **23,532,000** | **26,677,000** | **36,961,000** | **26,360,000** | **161,026,184** |

Exhibit H

**Debt Five-Year Period**

City and District General Obligation Long-Term Debt [1]

| Purpose | 6/30/2021 | 6/30/2020 | 6/30/2019 | 6/30/2018 | 6/30/2017 |
|---|---|---|---|---|---|
| Public Impovements | $ 25,685,479 | $ 29,004,639 | $ 26,420,231 | $ 27,124,309 | $ 30,340,107 |
| Water [2] | 17,147,246 | 18,958,110 | 17,378,109 | 17,455,585 | 20,233,593 |
| Sewer [2] | 19,268,113 | 22,111,543 | 18,456,026 | 930,942 | 20,739,393 |
| Arena | 1,501,250 | 1,644,635 | 822,105 | 18,520,879 | 1,039,778 |
| School [3] | 16,074,338 | 17,798,746 | 18,483,554 | 18,205,081 | 19,047,505 |
| TIF District - 162-K [4] | 2,300,000 | 2,670,000 | 2,955,000 | 3,325,000 | 3,695,000 |
| TIF District - 205:4-c [5] | 2,939,578 | 3,151,440 | 3,354,474 | 3,548,680 | 3,734,059 |
| Total | $ 84,916,005 | $ 95,339,113 | $ 87,869,499 | $ 89,110,476 | $ 98,829,435 |

*(1) Excludes lease or installment purchase obligations, overlapping debt, unfunded pension liabiltiy and industrial revenue bonds. All school debt is attributable to District: obligations other than school debt are attributable to the City*

*(2) Water and Sewer includes Drinking Water and Clean Water State Revolving Fund loans.*

*(3) State School Building Aid grants totaling $91,767 are to be received to offset school debt over a period of years subject to the annual appropriation of the state legislature*

*(4) Debt incurred under RSA 162k will be supported by a special tax increment but remains a general obligation of the City*

*(5) Debt incurred under RSA 205:4-c will be support by a special tax increment but remains a general obligation of the City*

**Property Valuations and Tax Rates**

| Tax Year | Local Assessed Valuations | Equalized[1] Assessed Valuation | Ratio Local Assessed Valuation to Equalized Assessed | Local Tax Rate | Estimated Full Value Tax Rate |
|---|---|---|---|---|---|
| 4/1/2021 | 2,891,460,189 | 3,697,519,423 | 78.2 | 24.65 | |
| 4/1/2020 | 2,852,513,915 | 3,057,356,822 | 93.3 | 24.61 | |
| 4/1/2019 | 2,724,627,077 | 2,727,354,431 | 99.9 | 24.90 | 23.54 |
| 4/1/2018 | 2,379,982,314 | 2,632,505,102 | 86.9 | 27.52 | 23.08 |
| 4/1/2017 | 2,325,351,307 | 2,447,738,218 | 95.0 | 26.33 | 24.18 |
| 4/1/2016 | 2,111,147,346 | 2,366,757,114 | 89.2 | 28.26 | 24.06 |
| 4/1/2015 | 2,075,354,791 | 2,236,767,624 | 92.5 | 28.15 | 25.28 |
| 4/1/2014 | 2,054,879,239 | 2,130,203,184 | 96.2 | 27.47 | 25.71 |
| 4/1/2013 | 2,072,597,235 | 2,084,600,826 | 99.7 | 26.36 | 25.50 |
| 4/1/2012 | 2,033,953,864 | 2,042,860,241 | 100 | 25.68 | 25.14 |

*(1) Determined annually by the State Department of Revenue Administration.*

Exhibit H

**Comparative Property Tax Collection Statistics**

| Tax Year | | | Fiscal Year End 6/30 | Local Tax Rate | Net Tax Levy[1] | Collected End of Fiscal Year | % of Net Levy Collected | Collected as of 6/30/2021 | % of Net Levy Collected |
|---|---|---|---|---|---|---|---|---|---|
| 2021 | 4/1/2021 | 3/31/2022 | 2022 | $ 12.31 | $ 34,662,377 | N/A | N/A | $19,681,303 | 56.9% |
| 2020 | 4/1/2020 | 3/31/2021 | 2021 | 24.61 | 68,438,739 | $67,559,817 | 98.7% | 67,559,817 | 98.7% |
| 2019 | 4/1/2019 | 3/31/2020 | 2020 | 24.90 | 66,169,796 | 65,584,327 | 99.1% | 65,584,327 | 99.1% |
| 2018 | 4/1/2018 | 3/31/2019 | 2019 | 27.52 | 63,834,824 | 63,450,851 | 99.4% | 63,450,851 | 99.4% |
| 2017 | 4/1/2017 | 3/31/2018 | 2018 | 26.33 | 60,524,791 | 60,354,110 | 99.7% | 60,354,110 | 99.7% |
| 2016 | 4/1/2016 | 3/31/2017 | 2017 | 28.26 | 58,196,003 | 58,084,496 | 99.8% | 58,084,496 | 99.8% |
| 2015 | 4/1/2015 | 3/31/2016 | 2016 | 28.15 | 56,938,119 | 56,862,874 | 99.9% | 56,862,874 | 99.9% |
| 2014 | 4/1/2014 | 3/31/2015 | 2015 | 27.47 | 55,068,779 | 55,015,260 | 99.9% | 55,015,260 | 99.9% |
| 2013 | 4/1/2013 | 3/31/2014 | 2014 | 26.36 | 53,324,262 | 53,280,094 | 99.9% | 53,280,094 | 99.9% |
| 2012 | 4/1/2012 | 3/31/2013 | 2013 | 25.68 | 50,952,912 | 50,919,633 | 99.9% | 50,919,633 | 99.9% |

(1) As of June 30, 2021, Tax Year 2021, the City billed the first installment which is based on one-half of the previous year tax rate.

**Principal Taxpayers**

**As of 4/1/21 (Tax Year 2021) for Fiscal Year Ending June 30, 2021 (TOP TEN)**

| Property Owner | Type of Business | Taxable Valuation | % of New Assessed Valuation |
|---|---|---|---|
| Public Service of NH | Utility | 96,345,500 | 3.42% |
| Waste Management of NH | Solid Waste Disposal | 65,064,100 | 2.31% |
| FMH Health Services, LLC | Medical | 54,998,600 | 1.95% |
| Northern Utilities Inc. | Utility | 34,284,900 | 1.22% |
| Waterstone Rochester LLC | Retail | 32,598,093 | 1.16% |
| Rochester Crossing LLC | Retail | 24,627,798 | 0.87% |
| 200 Washington St LLC | Apartment Complex | 17,601,500 | 0.63% |
| Lilac Community LP | Mobile Home Park | 13,929,237 | 0.49% |
| Infinity Roch. Property - Wal Mart | Retail | 13,904,100 | 0.49% |
| Village at Clark Brook LLC | Mobile Home Park | 12,707,400 | 0.45% |

**Pension Plans**

The City contributes to the New Hampshire Retirement System ("NHRS" or the "Plan"), a cost-sharing multiple-employer defined benefit pension plan administered by the NHRS Board of Trustees. The Plan provides service, disability, death and vested retirement allowances to plan members and beneficiaries. Benefit provisions are established and may be amended by the New Hampshire State legislature. The NHRS issues a publicly available financial report that includes financial statements and required supplementary information for NHRS. That report may be obtained by writing to New Hampshire Retirement System, 4 Chenell Drive, Concord, New Hampshire 03301. Reference is hereby made to the State of New Hampshire Information Statement dated March 26, 2021 which has been filed with the Municipal Securities Rulemaking Board pursuant to Securities and Exchange Commission Rule 15c2-12.

Covered public safety employees are required to contribute 11.55% (Police) and 11.8% (Fire) of their covered salary, whereas teachers and general employees are required to contribute 7.0% of their covered salary. The City is required to contribute at an actuarially determined rate. In fiscal year 2021, the City's contribution rates for the covered payroll of police officers, fire employees, teachers, and general employees were 28.43%, 30.09%, 17.80%, and 11.17%, respectively. The City's contribution for fiscal year 2021 was $7,029,188.86* and $10,896,640.00 is budgeted in fiscal year 2022.
*Includes medical subsidy.

**Other Post-Employment Benefits**

The City does not explicitly provide or subsidize the costs of retiree health care coverage for its employees, (including those employed by the Rochester School District.) The City does however provide an implicit rate subsidy since the inherently higher health care costs for retired employees are not directly reflected in the determination of the premium rates paid by those retirees.

As of 6/30/2021 the actuarial accrued liability for this implicit rate subsidy includes;

| | |
|---|---|
| Current Retirees | $ 2,219,932 |
| Future Retirees | 8,173,745 |
| Total | $10,393,677 |

This liability is unfunded at this time. The City made pay-go cash contributions of $427,863 towards this liability. The NHRS Medical Subsidy for the School is $4,630,584. The NHRS Medical Subsidy net OPEB liability is $2,556,452. The Grand Total NHRS is $7,187,036.

**Bond Authorized – Unissued**

As of June 30, 2021, the City has authorized but unissued debt for the following:

| | |
|---|---|
| City (1) | $23,837,480.28 |
| School | 3,078,570.30 |
| Water | 13,469,991.75 |
| Sewer | 35,879,489.48 |
| TIF Districts: | |
| 162-K (2)<br>205:4-c (3)<br>NHFBA (4) | 11,430,000 |
| **Total** | **$ 87,695,531.81** |

(1) *Includes authorizations for Arena of $250,000*
(2) *Granite Ridge TIF District – Phase 2 $7,430,000*
(3) *Granite State Business Park $1,000,000*
(4) *145 Airport Rd Development $3,000,000*

**Legal Requirements for Approval of Borrowing**

Bonds and serial notes are authorized on behalf of the City by a minimum of two-thirds vote of all City Council members. The general debt limit of the City of Rochester is 3% of "base valuation" determined annually by the State Department of Revenue Administration Board of Taxation. The Rochester School District's debt limit is 7% of the City's "base valuation," which is not counted in the computation of the City's 3% general limitation. Water and Sewer projects undertaken by order of the Water Supply and Pollution Control, Division of the State Department of Environmental Service, are excluded from the measure of indebtedness as is debt that is supported by grant and user fees. Non-compulsory water projects are subject to a debt limit of 10% of the "base valuation". Parking meters and facilities may have debt to an amount not exceeding ½ of one percent of the base valuation excluded from the general debt limit.

The "base valuation" consists of the City's equalized assessed valuation plus property formerly taxed by the City prior to enactment of the State Business Profits Tax Law. For Rochester, the "base valuation" for computing the debt limit is $3,086,674,502. The following is a schedule of outstanding overall and net bonded debt of the City and the District as of June 30, 2021, and of the related debt limitations.

| **Purpose** | **Debt Outstanding** | **Debt Limit as % of Valuation** | **Statutory Debt Limit** | **Debt Margin** |
|---|---|---|---|---|
| General(1) (2) (3) (4) | $32,426,307.22 | 3.00% | $ 92,600,235.06 | $ 62,473,927.84 |
| Water | 17,147,246.03 | 10.00% | 308,667,450.20 | 291,520,204.17 |
| School | 16,074,338.34 | 7.00% | 216,067,215.14 | 199,992,876.80 |

Below Debt Not Subject to Statutory Debt Limitations:

| | |
|---|---|
| Sewer | $19,268,112.98 |

(1) Includes Arena Fund Debt $1,501,249.75
(2) Includes TIF 205C District Debt $2,939,578.38
(3) Includes Granite TIF 162K District Debt $2,300,000.00 which is excluded from the debt margin calculation
(4) Includes City CWSRF loans outstanding in the amount of $225,088.68

Exhibit I

## City of Rochester

Outstanding Net Indebtedness as of May 17-2022

| Item | Description | Non-School Purposes | School Purposes | Total |
|---|---|---|---|---|
| 1 | **Gross Debt** | | | |
| a | 20 Year LTD Schedule as of 6-30-21 | 71,841,666.23 | 16,074,338.34 | 87,916,004.57 |
| b | New Bonded Debt Issued 7/1/21 to 5/17/22 | 3,245,800.00 | 288,200.00 | 3,534,000.00 |
| | 20 Year LTD Schedule as of 5/17/2022 | 75,087,466.23 | 16,362,538.34 | 91,450,004.57 |
| | | | | |
| | Tax Anticipation Note | - | - | - |
| | SRF New Loans | 13,830,757.09 | - | 13,830,757.09 |
| | SRF Drawdowns | 172,512.84 | | 172,512.84 |
| | Less Principal Pmts 07/01/2021 thru 5/17/2022 | (8,463,566.41) | (1,537,415.40) | (10,000,981.81) |
| | **Gross Debt** | **80,627,169.75** | **14,825,122.94** | **95,452,292.69** |
| | | | | |
| 2 | **Deductions from Gross Debt** | | | |
| a | Unmatured Tax Anticipation Notes | - | - | - |
| b | Notes issued in anticipation of grant of federal or state aid | - | - | - |
| c | Debts incurred for supplying inhabitants with water or for the | 15,669,652.58 | - | 15,669,652.58 |
| | construction, enlargement, improvement or maintenance of | | | |
| | water works | | | |
| d | Debts incurred to finance the cost of sewage systems or | - | - | - |
| | enlargements or improvements thereof | | | |
| e | Debts incurred to finance new sewerage systems or sewage | 30,866,513.21 | - | 30,866,513.21 |
| | disposal works when the costs thereof is to be financed by | | | |
| | sewer rent or sewer assessments | | | |
| f | Debts incurred under RSA 31:10 | - | - | - |
| g | Debts incurred to finance energy production projects (RSA 33:6-b) | - | - | - |
| h | Debts incurred to finance small scale power facilities (RSA 33:6-b) | - | - | - |
| i | Debts incurred to finance acquisition of military base (RSA 33:6-c) | - | - | - |
| j | Debts incurred for waste site cleanups (RSA 33:6-d) | - | - | - |
| k | Debts or obligations of Issuer to solid waste management district | - | - | - |
| | (RSA 33:6-e) | | | |
| l | Debts incurred outside the statutory debt limit (indicating the law | - | - | - |
| | under which such debt was issued) | | | |
| m | Sinking Funds and cash applicable solely to the payment of debts | - | - | - |
| n | Tax-increment financings pursuant to RSA 162-K | 2,769,500.00 | - | 2,769,500.00 |
| o | Debts incurred for broadband infrastructure (RSA 33:6-f) | | | |
| | **Total Deductions (a through o)** | **49,305,665.79** | **-** | **49,305,665.79** |
| | | | | |
| | | | | |
| 3 | **Net Indebtedness ("1" minus "2")** | | | |
| a | **Net Indebtedness -20 Year Debt Schedule as of 5-17-22** | **31,321,503.96** | **14,825,122.94** | **46,146,626.90** |
| | | | | |
| 4 | **Amount of Proposed BAN/Bond Issue** | | | |
| | BAN | - | - | - |
| | GOB -NHMBB-July-22 | 23,834,496.14 | - | 23,834,496.14 |
| | Total Amount of Proposed BAN/Bond Issue | 23,834,496.14 | - | 23,834,496.14 |
| | | | | |

New Hampshire
Department of
Revenue Administration

**2021**
**MS-1**

Exhibit J



# Rochester
## Summary Inventory of Valuation

**Reports Required:** RSA 21-J:34 as amended, provides for certification of valuations, appropriations, estimated revenues and such other information as the Department of Revenue Administration may require upon reports prescribed for that purpose.

**Note:** The values and figures provided represent the detailed values that are used in the city/towns tax assessments and sworn to uphold under Oath per RSA 75:7.

**For assistance please contact:**
NH DRA Municipal and Property Division
(603) 230-5090
http://www.revenue.nh.gov/mun-prop/

| Assessor |
|---|
| Jonathan Rice (City of Rochester) |

**Municipal Officials**

| Name | Position | Signature |
|---|---|---|
| Marybeth Walker | BOA, Chair | Marybeth Walker |
| Gabrielle Nadeau | BOA, Member | Gabrielle Nadeau |
| Chad Roberge | BOA, Member | |

**Preparer**

| Name | Phone | Email |
|---|---|---|
| Jonathan Rice | 332-5109 | assessor@rochesternh.net |

Preparer's Signature

| **Land Value Only** | | **Acres** | **Valuation** |
|---|---|---|---|
| 1A | Current Use RSA 79-A | 10,594.85 | $1,115,289 |
| 1B | Conservation Restriction Assessment RSA 79-B | 0.00 | $0 |
| 1C | Discretionary Easements RSA 79-C | 0.00 | $0 |
| 1D | Discretionary Preservation Easements RSA 79-D | 0.41 | $21,500 |
| 1E | Taxation of Land Under Farm Structures RSA 79-F | 0.00 | $0 |
| 1F | Residential Land | 8,323.01 | $440,047,000 |
| 1G | Commercial/Industrial Land | 3,858.63 | $192,389,400 |
| **1H** | **Total of Taxable Land** | **22,776.90** | **$633,573,189** |
| 1I | Tax Exempt and Non-Taxable Land | 3,846.53 | $44,287,700 |

| **Buildings Value Only** | | **Structures** | **Valuation** |
|---|---|---|---|
| 2A | Residential | 0 | $1,419,241,775 |
| 2B | Manufactured Housing RSA 674:31 | 0 | $174,179,325 |
| 2C | Commercial/Industrial | 0 | $527,986,800 |
| 2D | Discretionary Preservation Easements RSA 79-D | 8 | $86,500 |
| 2E | Taxation of Farm Structures RSA 79-F | 0 | $0 |
| **2F** | **Total of Taxable Buildings** | **0** | **$2,121,494,400** |
| 2G | Tax Exempt and Non-Taxable Buildings | 0 | $270,432,300 |

| **Utilities & Timber** | | **Valuation** |
|---|---|---|
| 3A | Utilities | $136,392,600 |
| 3B | Other Utilities | $0 |
| 4 | Mature Wood and Timber RSA 79:5 | $0 |
| **5** | **Valuation before Exemption** | **$2,891,460,189** |

| **Exemptions** | | **Total Granted** | **Valuation** |
|---|---|---|---|
| 6 | Certain Disabled Veterans RSA 72:36-a | 2 | $508,300 |
| 7 | Improvements to Assist the Deaf RSA 72:38-b V | 0 | $0 |
| 8 | Improvements to Assist Persons with Disabilities RSA 72:37-a | 0 | $0 |
| 9 | School Dining/Dormitory/Kitchen Exemption RSA 72:23-IV | 0 | $0 |
| 10A | Non-Utility Water & Air Pollution Control Exemption RSA 72:12 | 0 | $0 |
| 10B | Utility Water & Air Polution Control Exemption RSA 72:12-a | 0 | $0 |
| **11** | **Modified Assessed Value of All Properties** | | **$2,890,951,889** |

| **Optional Exemptions** | | **Amount Per** | **Total** | **Valuation** |
|---|---|---|---|---|
| 12 | Blind Exemption RSA 72:37 | $75,000 | 19 | $1,259,300 |
| 13 | Elderly Exemption RSA 72:39-a,b | $0 | 359 | $26,955,742 |
| 14 | Deaf Exemption RSA 72:38-b | $0 | 0 | $0 |
| 15 | Disabled Exemption RSA 72:37-b | $75,000 | 99 | $5,429,500 |
| 16 | Wood Heating Energy Systems Exemption RSA 72:70 | $0 | 0 | $0 |
| 17 | Solar Energy Systems Exemption RSA 72:62 | $0 | 0 | $0 |
| 18 | Wind Powered Energy Systems Exemption RSA 72:66 | $0 | 0 | $0 |
| 19 | Additional School Dining/Dorm/Kitchen Exemptions RSA 72:23 | $0 | 0 | $0 |
| 19A | Electric Energy Storage Systems RSA 72:85 | $0 | 0 | $0 |
| 19B | Renewable Generation Facilities & Electric Energy Systems | $0 | 0 | $0 |
| **20** | **Total Dollar Amount of Exemptions** | | | **$33,644,542** |
| **21A** | **Net Valuation** | | | **$2,857,307,347** |
| **21B** | **Less TIF Retained Value** | | | **$42,585,219** |
| **21C** | **Net Valuation Adjusted to Remove TIF Retained Value** | | | **$2,814,722,128** |
| **21D** | **Less Commercial/Industrial Construction Exemption** | | | **$0** |
| **21E** | **Net Valuation Adjusted to Remove TIF Retained Value and Comm/Ind Construction** | | | **$2,814,722,128** |
| **22** | **Less Utilities** | | | **$136,392,600** |
| **23A** | **Net Valuation without Utilities** | | | **$2,720,914,747** |
| **23B** | **Net Valuation without Utilities, Adjusted to Remove TIF Retained Value** | | | **$2,678,329,528** |

**Utility Value Appraiser**

Chief Assessor

The municipality **DOES NOT** use DRA utility values. The municipality **IS NOT** equalized by the ratio.

| Electric Company Name | Distr. | Distr. (Other) | Gen. | Trans. | Valuation |
|---|---|---|---|---|---|
| PSNH DBA EVERSOURCE ENERGY | $56,251,300 | $1,902,600 | | $36,828,300 | $94,982,200 |
| SPAULDING AVE INDUSTRIAL COMPLEX LLC | | | $195,000 | | $195,000 |
| WM RENEWABLE ENERGY LLC | | $6,791,900 | | | $6,791,900 |
| | **$56,251,300** | **$8,694,500** | **$195,000** | **$36,828,300** | **$101,969,100** |

| Gas Company Name | Distr. | Distr. (Other) | Gen. | Trans. | Valuation |
|---|---|---|---|---|---|
| GRANITE STATE GAS TRANSMISSION INC | $500 | | | | $500 |
| NORTHERN UTILITIES INC | $34,423,000 | | | | $34,423,000 |
| | **$34,423,500** | | | | **$34,423,500** |

New Hampshire
Department of
Revenue Administration

**2021**
**MS-1**

Exhibit J

| Veteran's Tax Credits | Limits | Number | Est. Tax Credits |
|---|---|---|---|
| Veterans' Tax Credit RSA 72:28 | $300 | 1,421 | $425,625 |
| Surviving Spouse RSA 72:29-a | $2,000 | 41 | $81,000 |
| Tax Credit for Service-Connected Total Disability RSA 72:35 | $2,000 | 94 | $188,000 |
| All Veterans Tax Credit RSA 72:28-b | | | |
| Combat Service Tax Credit RSA 72:28-c | | | |
| | | **1556** | **$694,625** |

**Deaf & Disabled Exemption Report**

| Deaf Income Limits | |
|---|---|
| **Single** | |
| **Married** | |

| Deaf Asset Limits | |
|---|---|
| **Single** | |
| **Married** | |

| Disabled Income Limits | |
|---|---|
| **Single** | $35,000 |
| **Married** | $50,000 |

| Disabled Asset Limits | |
|---|---|
| **Single** | $100,000 |
| **Married** | $100,000 |

**Elderly Exemption Report**

First-time Filers Granted Elderly Exemption for the Current Tax Year

| Age | Number |
|---|---|
| 65-74 | 9 |
| 75-79 | 6 |
| 80+ | 11 |

Total Number of Individuals Granted Elderly Exemptions for the Current Tax Year and Total Number of Exemptions Granted

| Age | Number | Amount | Maximum | Total |
|---|---|---|---|---|
| 65-74 | 122 | $75,000 | $9,150,000 | $6,929,900 |
| 75-79 | 86 | $100,000 | $8,600,000 | $6,017,142 |
| 80+ | 151 | $125,000 | $18,875,000 | $14,008,700 |
| | 359 | | **$36,625,000** | **$26,955,742** |

| Income Limits | |
|---|---|
| **Single** | $35,000 |
| **Married** | $50,000 |

| Asset Limits | |
|---|---|
| **Single** | $100,000 |
| **Married** | $100,000 |

**Has the municipality adopted an exemption for Electric Energy Systems? (RSA 72:85)**
**Granted/Adopted?** No **Properties:**

**Has the municipality adopted an exemption for Renewable Gen. Facility & Electric Energy Storage? (RSA 72:87)**
**Granted/Adopted?** No **Properties:**

**Has the municipality adopted Community Tax Relief Incentive? (RSA 79-E)**
**Granted/Adopted?** Yes **Structures:** 8

**Has the municipality adopted Taxation of Certain Chartered Public School Facilities? (RSA 79-H)**
**Granted/Adopted?** No **Properties:**

**Has the municipality adopted Taxation of Qualifying Historic Buildings? (RSA 79-G)**
**Granted/Adopted?** No **Properties:**

**Has the municipality adopted the optional commercial and industrial construction exemption? (RSA 72:76-78 or RSA 72:80-83)**
**Granted/Adopted?** No **Properties:**
**Percent of assessed value attributable to new construction to be exempted:**
**Total Exemption Granted:**

**Has the municipality granted any credits under the low-income housing tax credit tax program? (RSA 75:1-a)**
**Granted/Adopted?** Yes **Properties:** 3
**Assessed value prior to effective date of RSA 75:1-a:** 11,413,982
**Current Assessed Value:** $10,174,532

New Hampshire
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Revenue Administration

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**MS-1**

Exhibit J

| Current Use RSA 79-A | Total Acres | Valuation |
|---|---|---|
| Farm Land | 1,652.82 | $546,125 |
| Forest Land | 6,923.21 | $480,103 |
| Forest Land with Documented Stewardship | 1,023.99 | $68,083 |
| Unproductive Land | 630.10 | $13,065 |
| Wet Land | 364.73 | $7,913 |
| | **10,594.85** | **$1,115,289** |

| Other Current Use Statistics | | |
|---|---|---|
| Total Number of Acres Receiving 20% Rec. Adjustment | **Acres:** | 3,748.91 |
| Total Number of Acres Removed from Current Use During Current Tax Year | **Acres:** | 51.71 |
| Total Number of Owners in Current Use | **Owners:** | 255 |
| Total Number of Parcels in Current Use | **Parcels:** | 431 |

| Land Use Change Tax | | | |
|---|---|---|---|
| Gross Monies Received for Calendar Year | | | $162,314 |
| Conservation Allocation | **Percentage:** 85.00% | **Dollar Amount:** | |
| Monies to Conservation Fund | | | $137,314 |
| Monies to General Fund | | | $25,000 |

| Conservation Restriction Assessment Report RSA 79-B | Acres | Valuation |
|---|---|---|
| Farm Land | | |
| Forest Land | | |
| Forest Land with Documented Stewardship | | |
| Unproductive Land | | |
| Wet Land | | |

| Other Conservation Restriction Assessment Statistics | | |
|---|---|---|
| Total Number of Acres Receiving 20% Rec. Adjustment | **Acres:** | |
| Total Number of Acres Removed from Conservation Restriction During Current Tax Year | **Acres:** | |
| Owners in Conservation Restriction | **Owners:** | |
| Parcels in Conservation Restriction | **Parcels:** | |

## Discretionary Easements RSA 79-C

| | Acres | Owners | Assessed Valuation |
|---|---|---|---|

## Taxation of Farm Structures and Land Under Farm Structures RSA 79-F

| Number Granted | Structures | Acres | Land Valuation | Structure Valuation |
|---|---|---|---|---|

## Discretionary Preservation Easements RSA 79-D

| Owners | Structures | Acres | Land Valuation | Structure Valuation |
|---|---|---|---|---|
| 6 | 8 | 0.41 | $21,500 | $86,500 |

| Map | Lot | Block | % | Description |
|---|---|---|---|---|
| 111 | 48 | 0 | 25 | Bank Barn - 230sf |
| 117 | 99 | 0 | 50 | Flat Barn - 1914sf |
| 117 | 99 | 0 | 50 | Flat Barn - 380sf |
| 127 | 36 | 0 | 25 | Bank Barn - 2592sf |
| 206 | 1 | 0 | 50 | Flat Barn - 2778sf |
| 217 | 48 | 0 | 25 | Flat Barn - 2520sf |
| 232 | 10 | 0 | 50 | Bank Barn - 2400sf |
| 232 | 35 | 0 | 50 | Bank Barn - 2501sf |

| Tax Increment Financing District | Date | Original | Unretained | Retained | Current |
|---|---|---|---|---|---|
| Granite Ridge 162K: Tif 3 | 6/17/2014 | $60,431,438 | $0 | $36,161,843 | $96,593,281 |
| Granite State 162K: Tif 1 | 9/4/2012 | $14,071,975 | | $6,423,376 | $20,495,351 |
| RHA/NHBFA A205:46: Tif 2 | 9/4/2012 | $193,900 | $30,541,200 | $0 | $30,735,100 |

| Revenues Received from Payments in Lieu of Tax | Revenue | Acres |
|---|---|---|
| State and Federal Forest Land, Recreational and/or land from MS-434, account 3356 and 3357 | | |
| White Mountain National Forest only, account 3186 | | |

| Payments in Lieu of Tax from Renewable Generation Facilities (RSA 72:74) | Amount |
|---|---|
| *This municipality has not adopted RSA 72:74 or has no applicable PILT sources.* | |

| Other Sources of Payments in Lieu of Taxes (MS-434 Account 3186) | Amount |
|---|---|
| Rochester Housing Authority | $50,159 |
| RESL Limited Partnership | $24,617 |
| Southern NH Habitat for Humanity Inc | $5,276 |
| Encore Mill Limited Partnership | $34,729 |
| RHA CSMII Limited Partnership | $11,191 |
| SNHS Elderly Housing II Inc | $53,035 |
| SNHS Elderly Housing III Inc | $31,399 |
| Marsh View Housing LP | $12,567 |
| Energy Campus Dev/UNH | $2,859 |
| RHA/NHBFA A205:46 | $810,733 |
| SIG SAUER | $50,000 |
| | **$1,086,565** |

## Notes

**New Hampshire**
*Department of Revenue Administration*

**2021**
**$24.65**

Exhibit K

# Tax Rate Breakdown
# Rochester

| Municipal Tax Rate Calculation | | | |
|---|---|---|---|
| Jurisdiction | Tax Effort | Valuation | Tax Rate |
| Municipal | $22,208,530 | $2,814,722,128 | **$7.89** |
| County | $7,077,793 | $2,814,722,128 | **$2.51** |
| Local Education | $34,917,459 | $2,814,722,128 | **$12.41** |
| State Education | $4,928,157 | $2,678,329,528 | **$1.84** |
| **Total** | **$69,131,939** | | **$24.65** |

| Village Tax Rate Calculation | | | |
|---|---|---|---|
| Jurisdiction | Tax Effort | Valuation | Tax Rate |
| **Total** | | | |

| Tax Commitment Calculation | |
|---|---|
| Total Municipal Tax Effort | $69,131,939 |
| War Service Credits | ($694,625) |
| Village District Tax Effort | |
| Total Property Tax Commitment | $68,437,314 |

James P. Gerry

12/1/2021

James P. Gerry
Director of Municipal and Property Division
New Hampshire Department of Revenue Administration

# Appropriations and Revenues

## Municipal Accounting Overview

| Description | Appropriation | Revenue |
|---|---|---|
| Total Appropriation | $69,373,906 | |
| Net Revenues (Not Including Fund Balance) | | ($45,429,930) |
| Fund Balance Voted Surplus | | ($2,786,000) |
| Fund Balance to Reduce Taxes | | $0 |
| War Service Credits | $694,625 | |
| Special Adjustment | $0 | |
| Actual Overlay Used | $355,929 | |
| **Net Required Local Tax Effort** | **$22,208,530** | |

## County Apportionment

| Description | Appropriation | Revenue |
|---|---|---|
| Net County Apportionment | $7,077,793 | |
| **Net Required County Tax Effort** | **$7,077,793** | |

## Education

| Description | Appropriation | Revenue |
|---|---|---|
| Net Local School Appropriations | $64,744,507 | |
| Net Cooperative School Appropriations | | |
| Net Education Grant | | ($24,898,891) |
| Locally Retained State Education Tax | | ($4,928,157) |
| **Net Required Local Education Tax Effort** | **$34,917,459** | |
| State Education Tax | $4,928,157 | |
| State Education Tax Not Retained | $0 | |
| **Net Required State Education Tax Effort** | **$4,928,157** | |

# Valuation

## Municipal (MS-1)

| Description | Current Year | Prior Year |
|---|---|---|
| Total Assessment Valuation with Utilities | $2,814,722,128 | $2,777,583,937 |
| Total Assessment Valuation without Utilities | $2,678,329,528 | $2,663,300,537 |
| Commercial/Industrial Construction Exemption | $0 | $0 |
| Total Assessment Valuation with Utilities, Less Commercial/Industrial Construction Exemption | $2,814,722,128 | $2,777,583,937 |

## Village (MS-1V)

| Description | Current Year |
|---|---|

Exhibit K

# Rochester

## Tax Commitment Verification

### 2021 Tax Commitment Verification - RSA 76:10 II

| Description | Amount |
|---|---|
| Total Property Tax Commitment | $68,437,314 |
| 1/2% Amount | $342,187 |
| Acceptable High | $68,779,501 |
| Acceptable Low | $68,095,127 |

If the amount of your total warrant varies by more than 1/2%, the MS-1 form used to calculate the tax rate might not be correct. The tax rate will need to be recalculated. Contact your assessors immediately and call us at 603.230.5090 before you issue the bills. See RSA 76:10, II

| | |
|---|---|
| **Commitment Amount** | |
| Less amount for any applicable Tax Increment Financing Districts (TIF) | |
| **Net amount after TIF adjustment** | |

**Under penalties of perjury, I verify the amount above was the 2021 commitment amount on the property tax warrant.**

| | |
|---|---|
| **Tax Collector/Deputy Signature:** | **Date:** |

## Requirements for Semi-Annual Billing

### Pursuant to RSA 76:15-a

76:15-a Semi-Annual Collection of Taxes in Certain Towns and Cities - I. Taxes shall be collected in the following manner in towns and cities which adopt the provisions of this section in the manner set out in RSA 76:15-b. A partial payment of the taxes assessed on April 1 in any tax year shall be computed by taking the prior year's assessed valuation times 1/2 of the previous year's tax rate; provided, however, that whenever it shall appear to the selectmen or assessors that certain individual properties have physically changed in valuation, they may use the current year's appraisal times 1/2 the previous year's tax rate to compute the partial payment.

| Rochester | Total Tax Rate | Semi-Annual Tax Rate |
|---|---|---|
| Total 2021 Tax Rate | $24.65 | $12.33 |

| Associated Villages |
|---|
| No associated Villages to report |

# Fund Balance Retention

| | |
|---|---|
| **Enterprise Funds and Current Year Bonds** | **$25,858,862** |
| **General Fund Operating Expenses** | **$90,438,453** |
| **Final Overlay** | **$355,929** |

DRA has provided a reference range of fund balance retention amounts below. Please utilize these ranges in the determination of the adequacy of your municipality's unrestricted fund balance, as currently defined in GASB Statement 54. Retention amounts, as part of the municipality's stabilization fund policy [1], should be assessed dependent upon your governments own long-term forecasts and special circumstances. Please note that current best practices published by GFOA recommend, at a minimum, that "...general purpose governments, regardless of size, maintain unrestricted fund balance in their general fund of no less than two months of regular general fund operating revenues or regular general fund operating expenditures." [2],[3]

[1] The National Advisory Council on State and Local Budgeting (NACSLB), (1998), *Framework for Improved State and Local Government Budgeting: Recommended Budget Practices (4.1)*, pg. 17.
[2] Government Finance Officers Association (GFOA), (2009), *Best Practice: Determining the Appropriate Level of Unrestricted Fund Balance in the General Fund.*
[3] Government Finance Officers Association (GFOA), (2011), *Best Practice: Replenishing General Fund Balance.*

| 2021 Fund Balance Retention Guidelines: Rochester | |
|---|---|
| Description | Amount |
| **Current Amount Retained (29.18%)** | **$26,389,647** |
| 17% Retained *(Maximum Recommended)* | $15,374,537 |
| 10% Retained | $9,043,845 |
| 8% Retained | $7,235,076 |
| 5% Retained *(Minimum Recommended)* | $4,521,923 |

***NOTICE: The current fund balance retained amount is above the maximum recommended threshold.***

Exhibit L

**2022 New Hampshire Local Area Unemployment Statistics**

Released: April 21, 2022

Source: New Hampshire Employment Security, Economic & Labor Market Information Bureau, www.nhes.nh.gov/elmi

Estimates are Not Seasonally Adjusted

| | Jan-22 | Feb-22 | Mar-22 | Apr-22 | May-22 | Jun-22 | Jul-22 | Aug-22 | Sep-22 | Oct-22 | Nov-22 | Dec-22 | Ann Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rochester City | | | | | | | | | | | | | |
| Labor Force | 17,420 | 17,680 | 17,760 | | | | | | | | | | |
| Employment | 16,870 | 17,280 | 17,390 | | | | | | | | | | |
| Unemployment | 550 | 400 | 370 | | | | | | | | | | |
| Rate | 3.1% | 2.2% | 2.1% | | | | | | | | | | |
| Salem Town | | | | | | | | | | | | | |
| Labor Force | 18,850 | 18,800 | 18,920 | | | | | | | | | | |
| Employment | 18,040 | 18,200 | 18,360 | | | | | | | | | | |
| Unemployment | 810 | 600 | 560 | | | | | | | | | | |
| Rate | 4.3% | 3.2% | 3.0% | | | | | | | | | | |
| Sandown Town | | | | | | | | | | | | | |
| Labor Force | 4,250 | 4,220 | 4,270 | | | | | | | | | | |
| Employment | 4,100 | 4,130 | 4,170 | | | | | | | | | | |
| Unemployment | 150 | 90 | 100 | | | | | | | | | | |
| Rate | 3.5% | 2.1% | 2.2% | | | | | | | | | | |
| Seabrook Town | | | | | | | | | | | | | |
| Labor Force | 5,070 | 5,040 | 5,070 | | | | | | | | | | |
| Employment | 4,790 | 4,830 | 4,880 | | | | | | | | | | |
| Unemployment | 280 | 210 | 190 | | | | | | | | | | |
| Rate | 5.6% | 4.1% | 3.7% | | | | | | | | | | |
| Somersworth City | | | | | | | | | | | | | |
| Labor Force | 6,710 | 6,790 | 6,840 | | | | | | | | | | |
| Employment | 6,500 | 6,650 | 6,690 | | | | | | | | | | |
| Unemployment | 210 | 140 | 150 | | | | | | | | | | |
| Rate | 3.1% | 2.1% | 2.2% | | | | | | | | | | |
| Stratham Town | | | | | | | | | | | | | |
| Labor Force | 4,560 | 4,550 | 4,560 | | | | | | | | | | |
| Employment | 4,440 | 4,470 | 4,480 | | | | | | | | | | |
| Unemployment | 120 | 80 | 80 | | | | | | | | | | |
| Rate | 2.5% | 1.8% | 1.8% | | | | | | | | | | |
| Swanzey Town | | | | | | | | | | | | | |
| Labor Force | 3,870 | 3,930 | 3,920 | | | | | | | | | | |
| Employment | 3,750 | 3,860 | 3,850 | | | | | | | | | | |
| Unemployment | 120 | 70 | 70 | | | | | | | | | | |
| Rate | 3.0% | 1.8% | 1.8% | | | | | | | | | | |
| Weare Town | | | | | | | | | | | | | |
| Labor Force | 5,860 | 5,870 | 5,920 | | | | | | | | | | |
| Employment | 5,710 | 5,790 | 5,830 | | | | | | | | | | |
| Unemployment | 150 | 80 | 90 | | | | | | | | | | |
| Rate | 2.5% | 1.3% | 1.5% | | | | | | | | | | |
| Windham Town | | | | | | | | | | | | | |
| Labor Force | 8,080 | 8,140 | 8,180 | | | | | | | | | | |
| Employment | 7,850 | 7,960 | 8,000 | | | | | | | | | | |
| Unemployment | 230 | 180 | 180 | | | | | | | | | | |
| Rate | 2.9% | 2.2% | 2.2% | | | | | | | | | | |

**2022 New Hampshire Local Area Unemployment Statistics** Exhibit L Released: April 21, 2022

Source: New Hampshire Employment Security, Economic & Labor Market Information Bureau, www.nhes.nh.gov/elmi Estimates are Not Seasonally Adjusted

| | Jan-22 | Feb-22 | Mar-22 | Apr-22 | May-22 | Jun-22 | Jul-22 | Aug-22 | Sep-22 | Oct-22 | Nov-22 | Dec-22 | Ann Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wolfeboro Town | | | | | | | | | | | | | |
| Labor Force | 2,710 | 2,730 | 2,730 | | | | | | | | | | |
| Employment | 2,610 | 2,650 | 2,660 | | | | | | | | | | |
| Unemployment | 100 | 80 | 70 | | | | | | | | | | |
| Rate | 3.6% | 2.8% | 2.7% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Unemployment Rates*** | | | | | | | | | | | | | |
| UNITED STATES | 4.4% | 4.1% | 3.8% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| NEW ENGLAND | 4.7% | 4.2% | 3.7% | | | | | | | | | | |
| CONNECTICUT | 5.0% | 5.0% | 4.3% | | | | | | | | | | |
| MAINE | 4.3% | 4.2% | 4.1% | | | | | | | | | | |
| MASSACHUSETTS | 5.0% | 4.3% | 3.8% | | | | | | | | | | |
| NEW HAMPSHIRE | 3.5% | 2.5% | 2.4% | | | | | | | | | | |
| RHODE ISLAND | 4.5% | 4.5% | 3.0% | | | | | | | | | | |
| VERMONT | 3.5% | 2.8% | 2.4% | | | | | | | | | | |
| *All estimates are by place of residence and are not seasonally adjusted. | | | | | | | | | | | | | |
| **Seasonally Adjusted**** | | | | | | | | | | | | | |
| SEASONALLY ADJUSTED | | | | | | | | | | | | | |
| NEW HAMPSHIRE | | | | | | | | | | | | | |
| Labor Force | 755,530 | 756,660 | 758,620 | | | | | | | | | | |
| Employment | 733,380 | 736,190 | 740,030 | | | | | | | | | | |
| Unemployment | 22,150 | 20,470 | 18,590 | | | | | | | | | | |
| Rate | 2.9% | 2.7% | 2.5% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| **Seasonally Adjusted Unemployment Rates:** | | | | | | | | | | | | | |
| UNITED STATES | 4.0% | 3.8% | 3.6% | | | | | | | | | | |
| | | | | | | | | | | | | | |
| NEW ENGLAND | 4.6% | 4.3% | 4.0% | | | | | | | | | | |
| CONNECTICUT | 5.3% | 4.9% | 4.6% | | | | | | | | | | |
| MAINE | 4.1% | 4.0% | 3.6% | | | | | | | | | | |
| MASSACHUSETTS | 4.8% | 4.7% | 4.3% | | | | | | | | | | |
| NEW HAMPSHIRE | 2.9% | 2.7% | 2.5% | | | | | | | | | | |
| RHODE ISLAND | 4.2% | 3.9% | 3.4% | | | | | | | | | | |
| VERMONT | 3.0% | 2.9% | 2.7% | | | | | | | | | | |

**Seasonally adjusted rates are not available for substate areas.

Exhibit M

## City of Rochester Tax Collector's Office

**April 30, 2022**

| Tax | | Annual | Collected | | Uncollected | |
|---|---|---|---|---|---|---|
| Year | | Warrant | Amount | % | Amount | % |
| **2021** | **Warrant** | **69,388,398** | 68,096,512.20 | 98.14% | 1,291,885.80 | 1.86% |
| 2020 | | 68,438,739 | 67,885,216.54 | 99.19% | 553,522.46 | 0.81% |
| 2019 | | 66,169,796 | 65,787,744.07 | 99.42% | 382,051.93 | 0.58% |
| 2018 | | 63,834,824 | 63,650,407.04 | 99.71% | 184,416.96 | 0.29% |
| 2017 | | 60,524,791 | 60,394,401.70 | 99.78% | 130,389.30 | 0.22% |
| 2016 | | 58,196,003 | 58,104,015.04 | 99.84% | 91,987.96 | 0.16% |
| 2015 | | 56,938,119 | 56,885,978.48 | 99.91% | 52,140.52 | 0.09% |
| 2014 | | 55,068,779 | 55,024,260.29 | 99.92% | 44,518.71 | 0.08% |
| 2013 | | 53,324,262 | 53,290,805.30 | 99.94% | 33,456.70 | 0.06% |
| 2012 | | 50,952,912 | 50,925,434.37 | 99.95% | 27,477.63 | 0.05% |
| 2011 | | 48,856,892 | 48,834,261.41 | 99.95% | 22,630.59 | 0.05% |
| 2010 | | 47,308,832 | 47,289,156.32 | 99.96% | 19,675.68 | 0.04% |
| 2009 | | 46,898,827 | 46,886,102.29 | 99.97% | 12,724.71 | 0.03% |
| 2008 | | 46,522,769 | 46,515,550.97 | 99.98% | 7,218.03 | 0.02% |
| 2007 | | 42,964,450 | 42,958,773.45 | 99.99% | 5,676.55 | 0.01% |
| 2006 | | 40,794,160 | 40,791,488.55 | 99.99% | 2,671.45 | 0.01% |
| 2005 | | 38,024,453 | 38,023,111.86 | 100.00% | 1,341.14 | 0.00% |
| 2004 | | 36,065,496 | 36,063,969.69 | 100.00% | 1,526.31 | 0.00% |
| 2003 | | 33,310,579 | 33,309,167.95 | 100.00% | 1,411.05 | 0.00% |
| 2002 | | 29,725,878 | 29,724,928.84 | 100.00% | 949.16 | 0.00% |
| 2001 | | 26,943,136 | 26,942,673.85 | 100.00% | 462.15 | 0.00% |
| | | | | **Total Uncoll:** | **2,868,134.79** | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Exhibit N**

# HOUSEHOLD INCOME QUINTILE UPPER LIMITS

United States Census Bureau

**Note: This is a modified view of the original table produced by the U.S. Census Bureau. This download or printed version may have missing information from the original table.**

| | United States | |
|---|---|---|
| **Label** | **Estimate** | **Margin of Error** |
| Quintile Upper Limits: | | |
| Lowest Quintile | 26,685 | ±55 |
| Second Quintile | 51,136 | ±99 |
| Third Quintile | 81,496 | ±144 |
| Fourth Quintile | 130,545 | ±198 |
| Lower Limit of Top 5 Percent | 247,124 | ±453 |

Exhibit O

# HOUSEHOLD INCOME QUINTILE UPPER LIMITS

**Note: This is a modified view of the original table produced by the U.S. Census Bureau. This download or printed version may have missing information from the original table.**

| | Rochester city, New Hampshire | |
|---|---|---|
| **Label** | **Estimate** | **Margin of Error** |
| Quintile Upper Limits: | | |
| Lowest Quintile | 27,532 | ±2,168 |
| Second Quintile | 51,696 | ±2,678 |
| Third Quintile | 76,251 | ±5,470 |
| Fourth Quintile | 110,925 | ±5,158 |
| Lower Limit of Top 5 Percent | 182,785 | ±8,740 |

**Exhibit P**

# SHARES OF AGGREGATE HOUSEHOLD INCOME BY QUINTILE

United States Census Bureau

**Note: This is a modified view of the original table produced by the U.S. Census Bureau. This download or printed version may have missing information from the original table.**

| | United States | |
|---|---|---|
| **Label** | **Estimate** | **Margin of Error** |
| Quintile Share of Aggregate Income: | | |
| Lowest Quintile | 3.14 | ±0.01 |
| Second Quintile | 8.44 | ±0.01 |
| Third Quintile | 14.28 | ±0.03 |
| Fourth Quintile | 22.56 | ±0.02 |
| Highest Quintile | 51.57 | ±0.03 |
| Top 5 Percent | 23.35 | ±0.04 |

**Exhibit Q**

# SHARES OF AGGREGATE HOUSEHOLD INCOME BY QUINTILE

United States Census Bureau

**Note: This is a modified view of the original table produced by the U.S. Census Bureau. This download or printed version may have missing information from the original table.**

| | Rochester city, New Hampshire | |
|---|---|---|
| **Label** | **Estimate** | **Margin of Error** |
| Quintile Share of Aggregate Income: | | |
| Lowest Quintile | 3.99 | ±0.48 |
| Second Quintile | 9.75 | ±0.77 |
| Third Quintile | 16.04 | ±0.94 |
| Fourth Quintile | 23.13 | ±1.31 |
| Highest Quintile | 47.09 | ±2.76 |
| Top 5 Percent | 21.16 | ±3.53 |

Table: ACSST1Y2019.S1701

**Exhibit R**

| | United States | | | | | |
|---|---|---|---|---|---|---|
| | **Total** | | **Below poverty level** | | **Percent below poverty level** | |
| **Label** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** |
| Population for whom poverty status is determined | 320,118,791 | ±24,954 | 39,490,096 | ±242,000 | 12.3% | ±0.1 |
| AGE | | | | | | |
| Under 18 years | 71,633,453 | ±39,859 | 12,000,470 | ±134,475 | 16.8% | ±0.2 |
| Under 5 years | 19,002,162 | ±24,352 | 3,457,689 | ±51,835 | 18.2% | ±0.3 |
| 5 to 17 years | 52,631,291 | ±38,914 | 8,542,781 | ±98,380 | 16.2% | ±0.2 |
| Related children of householder under 18 years | 71,326,895 | ±42,129 | 11,716,595 | ±134,827 | 16.4% | ±0.2 |
| 18 to 64 years | 195,703,010 | ±30,404 | 22,504,357 | ±113,070 | 11.5% | ±0.1 |
| 18 to 34 years | 71,922,088 | ±37,978 | 10,417,120 | ±73,212 | 14.5% | ±0.1 |
| 35 to 64 years | 123,780,922 | ±48,286 | 12,087,237 | ±74,285 | 9.8% | ±0.1 |
| 60 years and over | 73,579,563 | ±66,617 | 7,162,352 | ±46,169 | 9.7% | ±0.1 |
| 65 years and over | 52,782,328 | ±26,315 | 4,985,269 | ±36,715 | 9.4% | ±0.1 |
| SEX | | | | | | |
| Male | 156,743,490 | ±42,059 | 17,473,451 | ±123,014 | 11.1% | ±0.1 |
| Female | 163,375,301 | ±45,562 | 22,016,645 | ±137,887 | 13.5% | ±0.1 |
| RACE AND HISPANIC OR LATINO ORIGIN | | | | | | |
| White alone | 231,191,647 | ±101,215 | 23,828,085 | ±203,823 | 10.3% | ±0.1 |
| Black or African American alone | 40,291,288 | ±78,962 | 8,557,464 | ±86,813 | 21.2% | ±0.2 |
| American Indian and Alaska Native alone | 2,749,899 | ±33,996 | 633,584 | ±19,354 | 23.0% | ±0.7 |
| Asian alone | 18,274,780 | ±40,507 | 1,761,321 | ±35,380 | 9.6% | ±0.2 |
| Native Hawaiian and Other Pacific Islander alone | 608,300 | ±17,929 | 100,256 | ±10,523 | 16.5% | ±1.7 |
| Some other race alone | 16,016,665 | ±120,620 | 2,935,304 | ±60,267 | 18.3% | ±0.3 |
| Two or more races | 10,986,212 | ±119,885 | 1,674,082 | ±38,384 | 15.2% | ±0.3 |

**Exhibit R**

| | United States | | | | | |
|---|---|---|---|---|---|---|
| | **Total** | | **Below poverty level** | | **Percent below poverty level** | |
| **Label** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** |
| Hispanic or Latino origin (of any race) | 59,226,212 | ±22,870 | 10,201,081 | ±106,111 | 17.2% | ±0.2 |
| White alone, not Hispanic or Latino | 192,289,025 | ±32,778 | 17,352,095 | ±147,912 | 9.0% | ±0.1 |
| EDUCATIONAL ATTAINMENT | | | | | | |
| Population 25 years and over | 221,309,178 | ±69,454 | 22,277,293 | ±100,474 | 10.1% | ±0.1 |
| Less than high school graduate | 24,684,741 | ±124,554 | 5,769,908 | ±52,665 | 23.4% | ±0.2 |
| High school graduate (includes equivalency) | 58,978,752 | ±181,385 | 7,703,553 | ±55,245 | 13.1% | ±0.1 |
| Some college, associate's degree | 63,469,132 | ±124,428 | 5,781,713 | ±44,040 | 9.1% | ±0.1 |
| Bachelor's degree or higher | 74,176,553 | ±238,708 | 3,022,119 | ±35,088 | 4.1% | ±0.1 |
| EMPLOYMENT STATUS | | | | | | |
| Civilian labor force 16 years and over | 165,157,929 | ±158,642 | 11,009,125 | ±71,784 | 6.7% | ±0.1 |
| Employed | 157,766,768 | ±156,792 | 8,918,835 | ±62,296 | 5.7% | ±0.1 |
| Male | 82,669,669 | ±91,074 | 3,886,120 | ±43,570 | 4.7% | ±0.1 |
| Female | 75,097,099 | ±105,995 | 5,032,715 | ±43,140 | 6.7% | ±0.1 |
| Unemployed | 7,391,161 | ±47,457 | 2,090,290 | ±29,774 | 28.3% | ±0.4 |
| Male | 3,965,365 | ±36,702 | 1,018,900 | ±16,758 | 25.7% | ±0.4 |
| Female | 3,425,796 | ±32,910 | 1,071,390 | ±20,116 | 31.3% | ±0.5 |
| WORK EXPERIENCE | | | | | | |
| Population 16 years and over | 256,651,001 | ±52,263 | 28,665,305 | ±140,560 | 11.2% | ±0.1 |
| Worked full-time, year-round in the past 12 months | 115,316,851 | ±128,608 | 2,879,476 | ±32,746 | 2.5% | ±0.1 |
| Worked part-time or part-year in the past 12 months | 55,905,879 | ±142,919 | 8,345,468 | ±63,452 | 14.9% | ±0.1 |

**Exhibit R**

| | United States | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | | Below poverty level | | Percent below poverty level | | |
| Label | Estimate | Margin of Error | Estimate | Margin of Error | Estimate | Margin of Error | |
| Did not work | 85,428,271 | ±150,402 | 17,440,361 | ±112,546 | 20.4% | ±0.1 | |
| ALL INDIVIDUALS WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS | | | | | | | |
| 50 percent of poverty level | 17,602,164 | ±126,927 | (X) | (X) | (X) | (X) | |
| 125 percent of poverty level | 52,189,901 | ±299,896 | (X) | (X) | (X) | (X) | |
| 150 percent of poverty level | 65,139,120 | ±335,989 | (X) | (X) | (X) | (X) | |
| 185 percent of poverty level | 84,162,461 | ±410,280 | (X) | (X) | (X) | (X) | |
| 200 percent of poverty level | 92,655,786 | ±420,869 | (X) | (X) | (X) | (X) | 28.94% |
| 300 percent of poverty level | 143,196,072 | ±488,803 | (X) | (X) | (X) | (X) | |
| 400 percent of poverty level | 187,401,509 | ±435,812 | (X) | (X) | (X) | (X) | |
| 500 percent of poverty level | 221,484,622 | ±368,116 | (X) | (X) | (X) | (X) | |
| UNRELATED INDIVIDUALS FOR WHOM POVERTY STATUS IS DETERMINED | 63,367,537 | ±165,049 | 15,147,496 | ±85,504 | 23.9% | ±0.1 | |
| Male | 31,102,291 | ±114,229 | 6,650,045 | ±58,989 | 21.4% | ±0.2 | |
| Female | 32,265,246 | ±88,999 | 8,497,451 | ±47,268 | 26.3% | ±0.1 | |
| 15 years | 83,618 | ±5,420 | 82,208 | ±5,378 | 98.3% | ±0.8 | |
| 16 to 17 years | 204,953 | ±8,533 | 194,244 | ±8,321 | 94.8% | ±0.9 | |
| 18 to 24 years | 6,838,105 | ±61,734 | 3,197,531 | ±47,239 | 46.8% | ±0.4 | |
| 25 to 34 years | 13,454,841 | ±75,922 | 2,309,930 | ±31,903 | 17.2% | ±0.2 | |
| 35 to 44 years | 7,718,960 | ±50,822 | 1,499,258 | ±19,931 | 19.4% | ±0.2 | |
| 45 to 54 years | 7,978,652 | ±49,774 | 1,812,966 | ±22,813 | 22.7% | ±0.2 | |
| 55 to 64 years | 10,455,530 | ±54,536 | 2,724,824 | ±29,640 | 26.1% | ±0.3 | |
| 65 to 74 years | 8,654,115 | ±44,737 | 1,756,993 | ±22,093 | 20.3% | ±0.2 | |
| 75 years and over | 7,978,763 | ±37,753 | 1,569,542 | ±21,215 | 19.7% | ±0.2 | |
| Mean income deficit for unrelated individuals (dollars) | 7,363 | ±22 | (X) | (X) | (X) | (X) | |

**Exhibit R**

| | United States | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Total** | | **Below poverty level** | | **Percent below poverty level** | | |
| **Label** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** | **Estimate** | **Margin of Error** | |
| Worked full-time, year-round in the past 12 months | 28,435,494 | ±110,218 | 986,970 | ±18,256 | 3.5% | ±0.1 | |
| Worked less than full-time, year-round in the past 12 months | 12,969,793 | ±65,338 | 4,594,315 | ±42,343 | 35.4% | ±0.3 | |
| Did not work | 21,962,250 | ±91,281 | 9,566,211 | ±63,777 | 43.6% | ±0.2 | |

**Exhibit S**

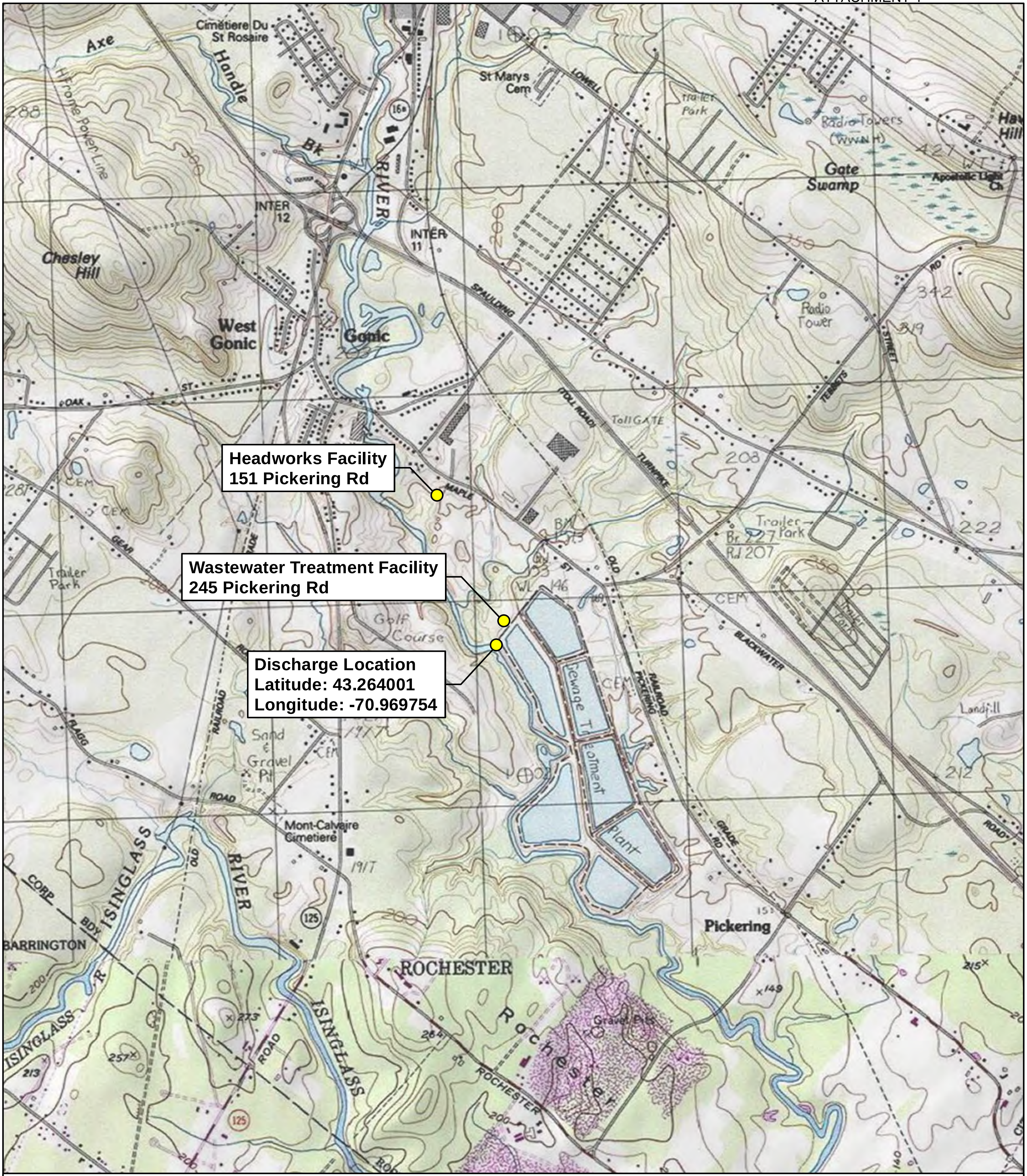
| Label (Grouping) | Rochester | Rochest | Rochester | Roch | Rochester | Rochester city, New Har | |
|---|---|---|---|---|---|---|---|
| Population for whom poverty status is determined | **30,771** | ±186 | 2,743 | ±595 | 8.90% | ±1.9 | |
| AGE | | | | | | | |
| Under 18 years | 6,043 | ±550 | 533 | ±265 | 8.80% | ±4.5 | |
| Under 5 years | 1,037 | ±260 | 96 | ±84 | 9.30% | ±7.6 | |
| 5 to 17 years | 5,006 | ±516 | 437 | ±244 | 8.70% | ±4.9 | |
| Related children of householder under 18 years | 6,022 | ±550 | 512 | ±262 | 8.50% | ±4.5 | |
| 18 to 64 years | 18,981 | ±629 | 1,621 | ±349 | 8.50% | ±1.8 | |
| 18 to 34 years | 6,107 | ±560 | 723 | ±248 | 11.80% | ±3.9 | |
| 35 to 64 years | 12,874 | ±639 | 898 | ±231 | 7.00% | ±1.7 | |
| 60 years and over | 7,848 | ±644 | 738 | ±268 | 9.40% | ±3.2 | |
| 65 years and over | 5,747 | ±549 | 589 | ±253 | 10.20% | ±4.1 | |
| SEX | | | | | | | |
| Male | 15,584 | ±511 | 1,235 | ±331 | 7.90% | ±2.1 | |
| Female | 15,187 | ±533 | 1,508 | ±383 | 9.90% | ±2.5 | |
| RACE AND HISPANIC OR LATINO ORIGIN | | | | | | | |
| White alone | 28,976 | ±551 | 2,584 | ±587 | 8.90% | ±2.0 | |
| Black or African American alone | 218 | ±148 | 91 | ±125 | 41.70% | ±40.7 | |
| American Indian and Alaska Native alone | 9 | ±19 | 0 | ±25 | 0.00% | ±98.9 | |
| Asian alone | 478 | ±269 | 38 | ±77 | 7.90% | ±18.6 | |
| Native Hawaiian and Other Pacific Islander alone | 109 | ±118 | 0 | ±25 | 0.00% | ±25.3 | |
| Some other race alone | 204 | ±128 | 3 | ±4 | 1.50% | ±2.1 | |
| Two or more races | 777 | ±278 | 27 | ±32 | 3.50% | ±4.4 | |
| Hispanic or Latino origin (of any race) | 956 | ±306 | 101 | ±119 | 10.60% | ±11.9 | |
| White alone, not Hispanic or Latino | 28,507 | ±538 | 2,488 | ±566 | 8.70% | ±1.9 | |
| EDUCATIONAL ATTAINMENT | | | | | | | |
| Population 25 years and over | 22,213 | ±549 | 1,834 | ±354 | 8.30% | ±1.6 | |
| Less than high school graduate | 1,825 | ±319 | 352 | ±192 | 19.30% | ±9.1 | |
| High school graduate (includes equivalency) | 8,261 | ±744 | 822 | ±244 | 10.00% | ±2.8 | |
| Some college, associate's degree | 7,470 | ±581 | 471 | ±206 | 6.30% | ±2.5 | |
| Bachelor's degree or higher | 4,657 | ±526 | 189 | ±128 | 4.10% | ±2.6 | |
| EMPLOYMENT STATUS | | | | | | | |
| Civilian labor force 16 years and over | 16,832 | ±832 | 908 | ±254 | 5.40% | ±1.5 | |
| Employed | 15,975 | ±823 | 674 | ±216 | 4.20% | ±1.3 | |
| Male | 8,458 | ±449 | 353 | ±176 | 4.20% | ±2.0 | |
| Female | 7,517 | ±645 | 321 | ±141 | 4.30% | ±1.8 | |
| Unemployed | 857 | ±309 | 234 | ±162 | 27.30% | ±14.4 | |
| Male | 342 | ±222 | 99 | ±116 | 28.90% | ±21.2 | |
| Female | 515 | ±219 | 135 | ±108 | 26.20% | ±19.4 | |
| WORK EXPERIENCE | | | | | | | |
| Population 16 years and over | 25,563 | ±587 | 2,321 | ±444 | 9.10% | ±1.7 | |
| Worked full-time, year-round in the past 12 mor | 12,079 | ±795 | 206 | ±145 | 1.70% | ±1.2 | |
| Worked part-time or part-year in the past 12 mc | 5,751 | ±694 | 646 | ±224 | 11.20% | ±3.6 | |
| Did not work | 7,733 | ±659 | 1,469 | ±385 | 19.00% | ±4.4 | |
| ALL INDIVIDUALS WITH INCOME BELOW THE FOLLOWING POVERTY RATIOS | | | | | | | PERCENTAGE |
| 50 percent of poverty level | 972 | ±440 | (X) | (X) | (X) | (X) | 3.16% |
| 125 percent of poverty level | 4,060 | ±855 | (X) | (X) | (X) | (X) | 13.19% |

# Exhibit S

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 150 percent of poverty level | 5,468 | ±929 | (X) | (X) | | (X) | (X) | 17.77% |
| 185 percent of poverty level | 6,941 | ±964 | (X) | (X) | | (X) | (X) | 22.56% |
| 200 percent of poverty level | 8,353 | ±995 | (X) | (X) | | (X) | (X) | 27.15% |
| 300 percent of poverty level | 13,094 | ±1,062 | (X) | (X) | | (X) | (X) | 42.55% |
| 400 percent of poverty level | 18,002 | ±1,111 | (X) | (X) | | (X) | (X) | 58.50% |
| 500 percent of poverty level | 22,749 | ±929 | (X) | (X) | | (X) | (X) | 73.93% |
| UNRELATED INDIVIDUALS FOR WHOM POVERTY STATU | 7,259 | ±747 | | 1,419 | ±331 | 19.50% | ±4.2 | |
| Male | 3,290 | ±495 | | 616 | ±257 | 18.70% | ±6.7 | |
| Female | 3,969 | ±561 | | 803 | ±250 | 20.20% | ±6.0 | |
| 15 years | 0 | ±25 | | 0 | ±25 | - | ** | |
| 16 to 17 years | 21 | ±23 | | 21 | ±23 | 100.00% | ±64.7 | |
| 18 to 24 years | 938 | ±335 | | 233 | ±159 | 24.80% | ±13.3 | |
| 25 to 34 years | 1,155 | ±265 | | 200 | ±142 | 17.30% | ±12.2 | |
| 35 to 44 years | 912 | ±268 | | 106 | ±89 | 11.60% | ±10.0 | |
| 45 to 54 years | 1,079 | ±324 | | 131 | ±85 | 12.10% | ±7.4 | |
| 55 to 64 years | 1,143 | ±240 | | 264 | ±108 | 23.10% | ±9.2 | |
| 65 to 74 years | 1,085 | ±242 | | 271 | ±166 | 25.00% | ±13.3 | |
| 75 years and over | 926 | ±304 | | 193 | ±161 | 20.80% | ±16.2 | |
| Mean income deficit for unrelated individuals (dollar | 4,334 | ±845 | (X) | (X) | | (X) | (X) | |
| Worked full-time, year-round in the past 12 months | 3,523 | ±627 | | 183 | ±146 | 5.20% | ±4.2 | |
| Worked less than full-time, year-round in the past 12 | 1,458 | ±357 | | 378 | ±165 | 25.90% | ±10.5 | |
| Did not work | 2,278 | ±361 | | 858 | ±279 | 37.70% | ±8.9 | |

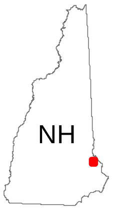
# ATTACHMENT 4

## WWTF Site Location Map – Revised Figure 2




**Site Location Map**
**Rochester WWTF**

Rochester, New Hampshire




Data Sources:
City of Rochester, NH
ArcGIS Online

1 in = 2,000 ft

0 1,000 2,000 ft

This map is intended for planning purposes only.
All features shown should be considered approximate.
Map created by: DC, Rochester, NH
Date: 5/17/2022
Path: \\roch-fileshare\dpwshare$\GIS\DPW\WasteWater\DischargePlan\SiteLocationMap.mxd