



Proactive by Design

ROYAL RIVER FISH PASSAGE STUDIES SUMMARY REPORT

**Royal River Watershed
Yarmouth, North Yarmouth, New Gloucester,
Pownal, Durham, Gray, and Auburn, Maine**



January 17, 2018

PREPARED FOR:

The Nature Conservancy, Maine Chapter
Brunswick, Maine

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1.0 INTRODUCTION

This Project Summary Report (Report) summarizes GZA GeoEnvironmental, Inc.'s (GZA)'s review of prior project reports and work completed in the Royal River watershed. GZA prepared this Report for The Nature Conservancy – Maine Chapter (TNC-Maine) in conformance with the limitations provided in **Appendix A**. In addition, GZA met with Matthew Craig of Casco Bay Estuary Partnership and Landis Hudson of Maine Rivers to present an initial draft to receive input which has been incorporated into this report.

1.1 PROJECT OBJECTIVE

Considerable historical information and data have been compiled in the Royal River watershed since 1958. The objective of this Report is to extract the key points from the available historical studies as well as summarize the work that TNC-Maine and others have completed on the Royal River to evaluate restoration of fish passage between Casco Bay and the upper Royal River watershed since 2008. This information has been summarized in a format that is accessible to the public. The information provided herein and on the accompanying Fact Sheet (**Appendix B**) may be used by project partners to provide talking points and informational handouts for project stakeholders and the media as they move additional restoration efforts forward.

1.2 SCOPE OF SERVICES

GZA's Scope of Services to develop this Report consisted of reviewing existing information specified by TNC-Maine, interviewing past project consultants, and soliciting input from project partners. It should be noted that this scope of services does not include additional data collection, engineering review, or rendering professional opinions on the data that has been collected. The following data-gathering activities were completed under this scope of services:

Review of the following Royal River Restoration Project data and reports:

- Royal River Alliance correspondence with United States Fish and Wildlife Service and Federal Energy Regulatory Commission Filing, 2017;
- *Fishway Assessment and Cost Analysis Report*, Inter-Fluve, 2017;
- Sediment chemical analysis report and Maine Department of Environmental Protection review and comment;
- *Royal River Restoration Project: Phase II Analysis and Reporting*, Stantec Consulting Services (Stantec), 2013;
- *Summary of Recreational Changes Associated with Dam Removal & River Restoration*, Maine Rivers, 2013;
- *Fisheries and Aquatic Habitat Restoration Feasibility Study*, Stantec, 2010;
- *Royal River Corridor Master Plan*, Royal River Corridor Steering Committee, 2008;
- *Royal River Water Quality Monitoring Report, 1993-1999*, Friends of the Royal River, 2001;
- *Anadromous Fish Restoration in the Royal River*, Maine Department of Marine Resources, 1981; and
- *Royal River Drainage Fish Management*, Maine Department of Inland Fisheries and Game, 1958.



Interviews with project consultants who have developed fish passage restoration assessments, analyses, and recommendation between 2010 and 2016 as well as local organizations who have been involved in restoration assessments:

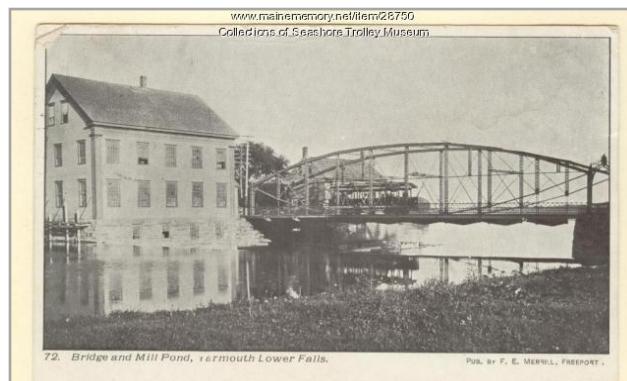
- Michael Chelminski, Stantec Consulting Services (Stantec) (May 2017)
- Michael Burke, Inter-Fluve (June 2017)
- Landis Hudson, Maine Rivers (September 2017)
- Matthew Craig, Casco Bay Estuary Partnership (August and September 2017)

Following publication of the Draft Report, GZA received comments and edits from project partners and TNC-Maine. This document incorporates comments and edits received.

2.0 ENVIRONMENTAL SETTING AND HISTORICAL USE SUMMARY

The Royal River watershed encompasses approximately 142 square miles in south-central Maine (**Figure 1**), and the River's headwaters are in Sabbathday Lake in New Gloucester. It flows through the City of Auburn and then southeast through northern Cumberland County until discharging into Casco Bay in the Town of Yarmouth after a run of approximately 39 miles. The Bridge Street Dam is situated approximately 2.2 miles upstream of the mouth of the River at Casco Bay. The Royal River is classified by Maine Department of Environmental Protection (Maine DEP) as a Class B river suitable for recreation, power generation, and as a drinking water source if treated. The Royal River currently meets Class B standards according to Maine DEP. The Yarmouth Water District currently holds water supply rights to the Royal River; however, they currently do not use it as a drinking water source.

Historically the river provided spawning habitat for Atlantic salmon, shad, and alewife; however, according to a late 19th century discussion of United States fisheries (Goode, 1887), “[The Royal River] ... was frequented by salmon regularly and in considerable numbers at the beginning of the present century; but they have long been shut out by dams.” The dams referenced by Goode powered industry within Yarmouth including paper, textiles, lumber, tanneries, poultry processing, and iron forging. In the early 1800s, 14 mills within Yarmouth were located below Elm Street and were using power generated from the River. Forest Paper Company operated at Bakers Falls from 1874 to 1923, and the grounds are now a public park. Historically, the Royal River was spanned by at least eight man-made dams (Maine Department of Inland Fisheries and Game, now Maine Department of Inland Fisheries and Wildlife [IF&W], 1958); however, only the Bridge Street Dam and East Elm Street Dam remained in Yarmouth by 2005 (Maine State Planning Office, 2005). These dams continue to span the river today.

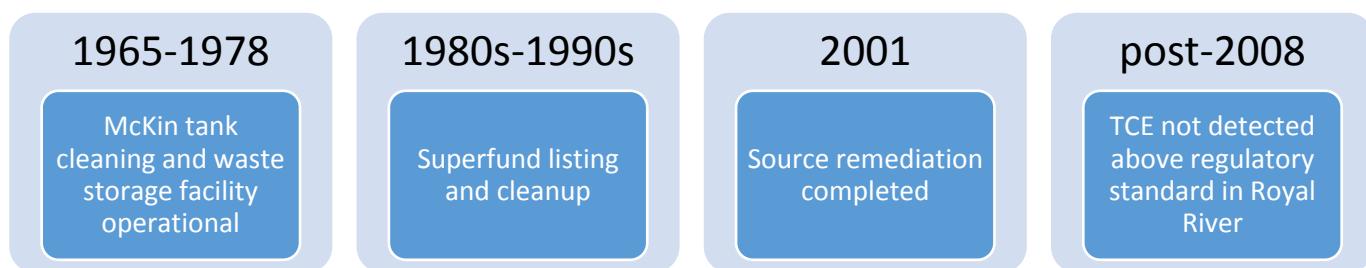


Yarmouth Lower Falls,
about 1903

Photo Credit: Seacoast
Trolley Museum



In the upper watershed, the McKin Company operated a tank cleaning and waste storage facility between 1965 and 1978¹. It was listed as a Superfund site and cleanup occurred for soil and groundwater contaminated with chlorinated solvents in the 1980s and 1990s with trichloroethylene identified as a contaminant of concern in soil and groundwater. As of 2001 source remediation had been completed and a groundwater ordinance has been implemented that prohibits withdrawing or using groundwater within the groundwater ordinance zone. According to the United States Environmental Protection Agency's 5-year review of the McKin Company Superfund Site completed in 2013, the Royal River has not had trichloroethene (TCE) detected above the regulatory standard since 2008.



3.0 SUMMARY OF PRIOR WORK

3.1 HISTORICAL FISHERIES

George Brown Goode (1887) provided a summary of the fisheries within the Casco Bay watershed in *The Fisheries and Fishery Industries of the United States* published by the United States Commission of Fish and Fisheries. Goode noted that as of 1887, Casco Bay and its tributaries (including the Royal River) possessed no river fisheries of great monetary value; however, smelts, shad, eels, salmon, tom-cods, and alewives were fished commercially at that time. Smelts were primarily taken from weirs, with one noted in Yarmouth, that were constructed in the 1870s and 1880s. As noted in Section 2.0, the Royal River was noted to be “frequented by salmon regularly and in considerable numbers at the beginning of the [1800s].” Due to dams, salmon have not been caught in the Royal or the Presumpscot since at least the 1850s.

Maine IF&W completed a fish management survey in 1958 that included a fish population survey and identification of fish spawning areas (see **Section 3.2**). The report also included an evaluation of obstructions to fish passage and possible pollution sources that may influence fish distribution. It should be noted that the conditions under which the 1958 assessment were completed are not representative of current-day conditions on the Royal River. For example, fish ladders were constructed at the East Elm Street and Bridge Street dams after 1958, and the River received direct discharges of untreated sewage at the time of the 1958 assessment.

3.1.1 Historical Fish Barriers

Maine IF&W identified 13 fish barriers within the Royal River Watershed in 1958. Barriers are features in stream channels that are believed to prevent or limit fish movement within the system. Locations, types, and descriptions of these barriers that continue to exist in 2017 are provided on **Table 1**. It was determined that fishway construction at two dams and barrier removal in three areas would allow complete fish passage to the portion of

¹ <https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0101027>



New Gloucester west of Route 202 known historically as Upper Gloucester. These fish passage improvements were recommended to open spawning areas upstream of the current barriers.

Table 1. Man-Made Fish Barriers identified in 1958 that are Present in 2017

Type	Name and Location	Notes
Dam	Smith Dam (Hayes Dam, East Elm Street Dam) Royal River	Natural ledge barrier, cement cap, and 10-foot vertical spillway on the west shore blocked all fish passage.
Dam	Upper Yarmouth Dam (Bridge Street Dam) Royal River	Hydroelectric dam built of reinforced concrete dam that has been retrofitted with a Denil-type fishway that allows passage at certain flows.
Dam	Jordan Dam Royal River	Stone-work dam in Upper Gloucester that impounds approximately 8 feet of water that is home to warm-water game fish.
Dam	Old Dam Collyer Brook	Stone slab sluiceway that does not currently impound water, but blocks fish passage due to debris accumulation.
Dam	Pownal State School Dam Collyer Brook	Concrete and steel dam that impounds approximately 7 feet of water that supplied water to the former Pownal State School (now Pineland Farms).
Dam	Runaround Pond Dam Chandler Brook	Concrete and wood dam at Runaround Pond outlet. (Note: a bypass channel is also located adjacent to the dam.)
Manmade	Stone Roadbed Chandler Brook	Large boulders to serve as a jeep or wagon crossing located under the high-tension power lines that impedes all fish passage during low flow.

3.1.2 Historical Fish Populations

The 1958 IF&W report identified Sabbathday Lake as the only lake in the watershed suitable for trout habitat. Two other lakes, Lily Pond in New Gloucester and Runaround Pond in Durham, were identified as warm water fisheries. Crystal Lake is also located in the watershed but was not discussed in the 1958 report. Fish identified in the watershed in 1958 included: landlocked salmon (*Salmo salar*), (native) brook trout, (introduced) brown trout (*Salmo trutta*), smallmouth bass (*Micropterus dolomieu*), chain pickerel (*Esox niger*), hornpout (*Ameiurus nebulosus*), smelt (*Osmerus mordax*), alewife (*Alosa pseudoharengus*), eel (*Anguilla rostrata*), white sucker (*Catostomus commersonii*), minnows, fallfish (*Semotilus corporalis*), creek chub (*Semotilus atromaculatus*), common shiner (*Luxilus cornutus*), golden shiner (*Notemigonus crysoleucas*), redbelly dace (*Phoxinus eos*), blacknose dace (*Rhinichthys atratulus*), pearl dace (*Semotilus marginata*), and pumpkinseed sunfish (*Lepomis gibbosus*). Management of the Royal River for alewives was not considered as part of the 1958 IF&W study because large lake areas for spawning were deemed to be lacking in the watershed, and removing fish passage barriers to allow alewife passage was considered cost-prohibitive.

In their 1958 study, IF&W concluded that brown trout were well established in the Royal River below Upper Gloucester and in Collyer Brook below Pownal School Dam, that these areas should be managed as a brown trout fishery, and that area between Upper Gloucester and Sabbathday Lake should be managed as a brook trout fishery. Atlantic salmon habitat was determined to be very limited in the watershed, and IF&W recommended that no attempts be made to re-establish Atlantic salmon in the watershed.

In 1974 the Department of Marine Resources (DMR) began efforts to restore anadromous fish to the Royal River with emphasis on alewife and American shad (*Alosa sapidissima*). The following timeline for this restoration effort was compiled from DMR reports:



- 1974 & 1979: Denil fishways (symmetrical baffles that allow fish to swim around the dam) were installed at the Bridge Street (1974) and Elm Street (1979) dams.
- 1977: Alewives stocked in Sabbathday Lake.
- 1978: Adult American shad were stocked, and fall trapping indicated that juvenile shad were migrating downstream.
- 1981: No adult shad were observed to be returning to the River. Alewife run was estimated at more than 50,000 ascending adults.
- 1982-1983: the first good returns of adult shad were expected. The alewife run decreased by half to 24,160.
- 1988: Alewife run had decreased to 6,106 adults.

The reasons for the shad collapse and alewife run decline was not determined and should be noted as a data gap to be considered as part of any overall restoration plan.

3.2 HABITAT QUALITY

Much of the historical information regarding habitat quality is available in the 1958 IF&W report. There has been little follow up assessment completed at the watershed-wide scale. However, the restoration and feasibility study work completed between 2010 and 2017 includes discussion of current habitat conditions near the East Elm Street and Bridge Street dam impoundments. An additional habitat assessment was conducted in 2014-15 by DMR for Chandler Brook and described in a 2015 memorandum (Enterline 2015).

The 1958 IF&W report stated that the Royal River watershed contains poor Atlantic salmon (*Salmon salar*) habitat. The report further concluded that the limited spawning and nursery areas were not adequate to produce a self-sustaining and satisfactory fishery. The gravel and riffle areas are most suitable for brook trout (*Salvelinus fontinalis*) or brown trout (*Salmo trutta*). Additionally, the established and more adaptable brown trout population in the Lower Royal River watershed would out-compete Atlantic salmon for available space, food, spawning, and nursery areas. IF&W concluded that nearly 90 percent of the spawning and nursery areas in the main river are located below the natural barriers in Upper Gloucester, and more than 90 percent of the spawning and nursery areas in the tributaries are accessible to fish moving up the main river. **Table 2** summarizes the findings of the 1958 assessment.



Bridge Street Dam during drawdown, 2010

Photo Credit: Stantec Consulting Services



Table 2. Spawning and nursery areas identified in 1958

Location	Stream Segment	Notes
Main River	Sabbathday Lake to Cobb's Bridge	<ul style="list-style-type: none">Average mid-summer temperature: 70 degrees Fahrenheit (°F) to 66 °F (upstream to downstream) with good flows.1.6 miles of fair spawning and nursery area for trout, limited spawning and nursery areas suitable for Atlantic salmon.
Main River	Cobb's Bridge to Yarmouth	<ul style="list-style-type: none">River becomes wide, deep, and "clay-erosion color"Less than 400 feet of spawning gravel with only limited spawning area and no nursery area for Atlantic salmon.
Collyer Brook	Dry Mills to Route Royal River	<ul style="list-style-type: none">Water temperature is approximately 55-60 °FLong, shallow, sand-bottom areas with swift water and deep pools with spawning gravel for trout in upper portion.Approximately 3,000 feet of good brown trout spawning and nursery area is present downstream of Pownal State School.
Chandler Brook and Kenny Brook	Runaround Pond to Ledge falls	<ul style="list-style-type: none">Water temperatures between Runaround Pond and Sawmill Dam are too high to support a trout fishery (78 °F).Chandler Brook from North Pownal to Ledge Falls has barriers to fish passage, but good nursery areas and spawning gravel.Watershed is clay-sand farmland restricting natural gravel formation, but sections of stream have favorable water temperatures (62 to 65 °F).
Small Tributaries	20 small spring-fed brooks	Provide additional cool-water flow to the Royal River and supply adequate habitat for resident trout.

3.3 WATER QUALITY

Pollution and its effects on fish²

Historical data indicates potential industrial sources of pollution to the Royal River: the McKinn facility in Gray and various mills and industry below the East Elm Street Dam in Yarmouth. Throughout the first part of the 20th century, raw sewage was also a potential concern in the watershed. The 1958 IF&W report did not identify pollution that was "extensive enough to be harmful to existing fish life" despite impacting recreation and aesthetics in the watershed (IF&W, 1958). The IF&W report noted numerous sewage outfalls along the length of the Royal River, and the Pownal State School (later known as the Pineland Hospital and Training Center) was identified as the largest contributor of raw sewage to the Royal River above Gray Station. Additionally, chicken processing waste was reported to enter the river in Yarmouth at the Upper Dam (now East Elm Street Dam). Based on their study, IF&W concluded that no additional sources of pollution should be allowed to enter the Royal River or its tributaries.

The Friends of the Royal River, funded through a grant from the Maine Coastal Program of the Maine State Planning Office, completed a volunteer-based water quality monitoring in the river between 1993 and 1999. They developed a water quality monitoring report that summarized biweekly dissolved oxygen, turbidity, and bacteria. These data suggested that the mean turbidity and coliform bacteria values changed little over the monitoring period; however, some bacteria results exceeded Maine DEP's Class B criterion. Early morning dissolved oxygen

² At the time of this report, these pollution sources had been removed and/or mitigated. There is currently no known raw sewage or process waste discharged to the Royal River.



concentrations at the monitoring sites frequently met the Class B criterion of 75 percent saturation, but there were periods where monitoring sites did not meet the criterion for coliform.

The annual mean of samples collected from six of the eight sites along the Main Stem of the Royal River met the Class B criteria for both dissolved oxygen and total coliform throughout the monitoring period. Collyer Brook, the most developed subwatershed, showed the highest bacteria concentrations but also the highest dissolved oxygen concentrations in the watershed. Chandler Brook and two of the three sites within East Chandler Brook had uniformly low dissolved oxygen. Chandler Brook showed consistently low *E. coli* counts and had no exceedances of the Class B criterion while East Chandler Brook had one site that showed an apparent decreasing dissolved oxygen and increasing mean *E. coli* counts that exceeded the Class B criterion.



Fishing on the Royal River

Photo Credit: Royal River Conservation Trust

The Friends of the Royal River (now known as Royal River Conservation Trust) determined that sections of the Royal River were in compliance with Class B water quality criteria; however, water quality varied significantly between the subwatersheds. These variations, however, were not observed within the subwatersheds, and the authors concluded that most parameters exhibited little change within each subwatershed over the seven years of the monitoring program. The recommendations documented in this report included non-point source (NPS) surveys, stream crossing assessments, and erosion control projects; continued stream chemistry and added biological monitoring; and, municipal and community outreach to encourage stormwater best management practices, development review, and land conservation efforts. Due in part to this study, Friends of the Royal River convened the Royal River Youth Conservation Corps to undertake erosion control and water quality improvement projects to reduce nutrient inputs to the River.

3.4 SEDIMENT QUANTITY AND QUALITY

Due to a dam's ability to trap sediment within its impoundment, there has been considerable effort to assess the amount of sediment that could be mobilized following a dam removal as well as the chemical makeup of the sediment in order to assess the potential impacts on downstream receptors. The following sections discuss the amount and chemical makeup of the sediment.

3.4.1 Sediment Quantity

Two types of sediment quantity studies have been completed on the Royal River over the past 10 years: sediment volume estimates (Stantec 2010, 2015) and sediment mobility assessments (completed by Field Geology Services and included in Stantec's 2015 report).

According to Stantec's 2010 *Fisheries and Aquatic Habitat Restoration* study, the Bridge Street dam does not appear to trap large quantities of sediment in its impoundment. According to Stantec's 2015 sediment volume estimate, Yarmouth Harbor accumulates approximately 10,000 cubic yards of sediment per year and the estimated volume in the Bridge Street impoundment is approximately 6,000 cubic yards.

In 2013 Stantec completed a follow-up study *Royal River Restoration Project Phase II Analysis and Reporting* (Phase II). The Phase II included document review, a topographic survey, sediment sampling, geomorphic and hydrologic assessments, and a hydraulic desktop study. Each assessment was completed to evaluate potential impacts of



East Elm Street Dam removal. Stantec's report concluded that there is approximately 110,000 cubic yards of potentially mobile sediments in the East Elm Street Dam impoundment.

As part of the Phase II, Stantec retained Field Geology Services of Farmington, Maine to complete a study entitled *Potential Impacts of Dam Removal on Sediment Production and Sediment Transport on the Royal River, Maine* that was included as Appendix D in Stantec's 2013 Phase II Report. This study evaluated the fluvial geomorphology of the Royal River in order to assess the potential effects that removing the East Elm Street Dam would have on sediment production and transport. Field Geology concluded that:

- Dam removal would draw down the impoundment by nearly 6 feet at low flow conditions. This drawdown would likely result in a short-term increase in bank erosion for sandy soils.
- Over a longer-term timeline, dam removal may result in increased bank erosion due to naturally migrating channel alignments. However, evidence from non-impounded reaches suggest that an extensive long-term increase in bank erosion is not expected.
- Modeling suggests that the East Elm Street impoundment has limited potential for sediment storage during large flood events; therefore, removing the dam is unlikely to increase sediment delivery to the harbor during large storm events.
- If the dam were removed, more sediment could be mobilized during smaller storm events due to the increased bank erosion and channel migration during these events. These storm events could result in changes in channel morphology in the former impoundment such as pool infilling and bar and riffle development.
- The sediment mobilization during smaller storm events is expected to have a limited impact on sedimentation in the harbor due to the relative small scale of this sedimentation versus the considerably large impact during the large storm events. As noted above, the sediment delivery during large events is unlikely to change with dam removal; therefore, the overall sedimentation rate is expected to remain relatively constant.

Based on Field Geology Services' study, Stantec predicted that following the initial flush of sediment there could be an increase of sediment delivery to Yarmouth Harbor during smaller storms, but there would be less effect during the higher magnitude storms (i.e., a 100-year return interval storm event). This would be a change from current conditions; however, this adjustment would mirror a river system sediment transport model rather than the current impoundment sediment transport model.

3.4.2 Sediment Quality

Stantec published the results of limited sampling from upstream and downstream of the East Elm Street and Bridge Street dam impoundments as Appendix F to their 2010 *Fisheries and Aquatic Habitat Restoration Feasibility Study* and the 2013 sediment quality evaluation as Appendix C to their Phase II report. In 2010, one sample downstream of the Bridge Street dam exceeded the screening benchmarks for mercury and the polycyclic aromatic hydrocarbons (PAHs) phenanthrene and pyrene. As a result, the 2013 supplemental study included sampling and analysis of five samples upstream of the East Elm Street Dam. The 2013 samples were analyzed for contaminants such as volatile petroleum hydrocarbons (VPH), volatile organic compounds (VOCs), pesticides, PAHs, polychlorinated biphenyl (PCB) aroclors, and metals. Stantec compared the analytical results to screening benchmarks to evaluate potential risk to aquatic organisms. The benchmarks were developed from the National



Oceanic and Atmospheric Administration (NOAA) screening tables, the United States Environmental Protection Agency benchmarks, and consensus-based sediment quality guidelines developed by MacDonald et al. (2000).

- VPHs, VOCs, PAHs, PCB aroclors, and metals were not detected above the sediment screening benchmarks.
- The maximum concentration for the organopesticide 4,4'-DDD exceeded its screening benchmark, and other pesticides in the DDT group were detected above laboratory detection limits but below screening benchmarks. There are no risk-level benchmarks for the detected organopesticides. Stantec determined that there was no adverse impact or risk of harm to aquatic organisms due to the limited detections and minimal exceedance.

Stantec concluded that there appears to be minimal potential risk to aquatic life in the Royal River based on their 2010 sampling program. They conducted follow-up sampling in December 2013 upstream of the Bridge Street Dam to further assess constituents detected in the 2010 samples. Stantec collected 10 samples from depths ranging from 0 to 6.5 feet below the sediment surface. Results were as follows:

- One sample exceeded the Threshold Effects Concentration (TEC) benchmark for mercury.
- Six samples exceeded at least one TEC benchmark for PAHs.

Maine DEP reviewed the sediment analysis program and results and provided the following comments:

- Generally, the study was properly designed based on previous studies of amount and contamination of sediment in the impoundment above the Bridge Street Dam.
- Contaminant concentrations in bulk sediment samples were compared to appropriate sediment quality guidelines.
- Proper reporting levels were used and the blank and laboratory control sample analyses were acceptable.
- Only one station (S-5) out of ten showed a slight (insignificant) exceedance of the TEC for mercury below which effects on biota are unlikely well below the probable effects concentration (PEC), above which effects are likely.
- Previous studies showed concentrations of sediment mercury were higher downstream in the estuary, where the US Army Corps of Engineers concluded the bioassay effects were less than the 20% mortality allowed.
- Two stations (S-4 and S-5) of ten showed exceedances of the PEC for PAHs which indicates a local source near those areas. The overall concentration of the whole body of sediment behind the dam (i.e., the mean of all ten stations), would be much lower, below the PEC if not the TEC.
- That there is some contamination of PAHs is not surprising given the industrial history and current vehicle traffic and other human activity in the watershed.



Maine DEP's comments are consistent with Stantec's conclusion of minimal potential risk to aquatic life related to impounded sediments at the East Elm Street Dam.

3.5 RESTORATION ALTERNATIVES

In 2008, the Town of Yarmouth began moving forward with the development planning process, and they contracted Stantec to evaluate alternatives for fish passage restoration within the Royal River watershed. Between 2010 and 2016, project consultants Stantec and Inter-Fluve evaluated the following options:

- Repair the existing fishways at the two dams;
- Construct new fishways at the two dams;
- Remove the two dams.

The following sections describe Stantec's and Inter-Fluve's assessment of each of the alternatives and its impact on fisheries, wetlands, hydraulics and hydrology, infrastructure, recreation, archeological resources, and anticipated future uses.

3.5.1 Restoration Alternatives: Repairing Existing Fishways and Constructing New Fishways

Repairing the fishways or constructing new fishways at the two dams would meet the overall goal of restoring fish passage in the lower Royal River. These options would result in a moderate beneficial impact on fisheries and recreational (fishing) uses while also not changing the current recreational (i.e., boating) opportunities within the East Elm Street impoundment. Repairs to, or replacement of, the fishways would have no appreciable impact on current conditions for hydraulics and hydrology, wetlands and wildlife, existing infrastructure, archaeological resources associated with existing infrastructure, and future use of the dams for flood control or hydropower. The current hydraulics and hydrology of the river would see no impact with these alternatives.

During May 2017, Inter-Fluve published a study that assessed the fish passage potential for both the Bridge Street and East Elm Street dams. Inter-Fluve identified and compared costs for four alternative approaches to enhance fish passage at each site. Inter-Fluve considered alewife, American eel, American shad, blueback herring, sea-run brook trout, rainbow smelt, sea lamprey, and striped bass. Inter-Fluve completed their field assessment in September 2016 and concluded the following related to the existing fish passage facilities:

- The Bridge Street Dam fishway is passing water, but it is not functioning in such a way as to allow for targeted fish communities to pass both upstream and downstream due to periodic high velocities as well as lack of passage for juvenile eels and potential for injury to fish migrating downstream.



Bridge Street Dam

Photo credit: Maine Rivers



- The East Elm Street Dam fishway is in disrepair and is not functional. If the fishway were restored to fully operational status, it would exhibit nearly identical trends to the Bridge Street fishway. Therefore, the East Elm Street Dam fishway, in its current condition, is also a likely constraint on the restoration of the target fish communities.

Inter-Fluve's 2017 study evaluated potential costs of rebuilding the fishways to accommodate targeted species versus installing new fishways and found that constructing a new fishway was less expensive than rehabilitating the existing fishway at both the Bridge Street and East Elm Street Dams.

3.5.2 Restoration Alternatives: Dam Removal

Both Stantec and Inter-Fluve have completed studies that assess the feasibility, cost, and potential impact of removing the East Elm Street and Bridge Street dams to restore fish passage in the lower Royal River. Removing both dams provides the most benefit to the fisheries out of the options assessed in Stantec's 2013 Phase II study. The hydraulics and hydrology were expected to show a combination of minor benefits and minor impacts depending on the assessment criteria, and groundwater is expected to see minor impacts due to the changing river hydrology potentially changing groundwater conditions. Dam removal was predicted to provide a major adverse impact to recent (i.e., 1800s and 1900s) archaeological resources. Impact of the dams on earlier archaeological resources was not assessed.

Stantec's data suggests that removing East Elm Street Dam could impact existing upstream infrastructure (i.e., higher river flows resulting in potential scouring near bridge abutments). This is a common issue across Maine, and is typically addressed by increasing scour protection at the base of the bridge. Removal of the Bridge Street Dam would have the potential to provide both major adverse impacts (i.e., hydraulics and fisheries) as well as major beneficial impacts (i.e., fisheries and infrastructure) depending on the criteria assessed. Each of the dams' removal would have a major adverse impact on future use of the dam for either hydropower or flood storage. Current wetlands and wildlife conditions are expected to be slightly to moderately adversely affected by the dam removal; however Stantec concluded that there could be some moderate benefits to wetlands and wildlife as well if the East Elm Street dam were removed.

Stantec also completed an infrastructure management cost summary that determined that removal of the Bridge Street and East Elm Street dams had the lowest potential net capitalized cost to the Town (\$80,000 to \$200,000) while installing fish passage at the two dams had the highest potential net capitalized cost (\$720,000 to \$2,100,000). Stantec noted that the dam removal option did not consider ongoing maintenance or repair costs, removal and disposal of contaminated materials, or historical and cultural resource considerations. Stantec further assumed that significant grant funding would be available for dam removal activities, thereby reducing the Town's cost by 60 percent or more.

Inter-Fluve's completed a cost analysis as part of their 2017 study and concluded that no action had the lowest overall cost. Their assessment concluded that for the Bridge Street site, no action had the lowest cost. Dam removal at Bridge Street was the second lowest cost followed by the nature-like fishway alternative as the highest cost. For the East Elm Street dam, no action also had the lowest cost. The nature-like fishway alternative had the second lowest cost followed by the technical fishway alternative.

3.6 HYDROPOWER ACTIVITY AND MANAGEMENT

The Bridge Street Dam includes hydropower turbines in the basement of the Sparhawk Mill, and water is diverted from the impoundment to the Mill via penstocks where some is used for power generation. The Town of



Yarmouth has owned the dam, right-of-way, and flowage rights to maintain or lower the existing water levels since 1973. Currently the hydropower operations in the Sparhawk Mill are managed by the Mill's property manager, and the operation holds and exemption from the Federal Energy Regulatory Commission (FERC) because it produces very little power. According to Landis Hudson of Maine Rivers, the hydropower operations were developed under a subsidy program in the 1980s; however, it has not been an economically viable source of power due to low flows.

During February 2017, the Royal River Conservation Trust received notification from the Town of Yarmouth that an interested party at the Sparhawk Mill had secured a cancellation of a power purchase agreement that would allow the owner to enter into negotiations to reinvest in the hydroelectric generating capacity at the Bridge Street Dam. The owner had notified the Town that he intended to begin negotiations with the Town Council about re-establishing flowage rights or lease terms for the town-owned dam. The Royal River Conservation Trust provided comments to the United States Fish & Wildlife Service regarding the FERC filing that reiterated their commitment to restoring fish passage in the Royal River. Further information on this process has not been made publicly available as of the date of this report.



Side Channel at Royal River Park

Photo Credit: GZA GeoEnvironmental

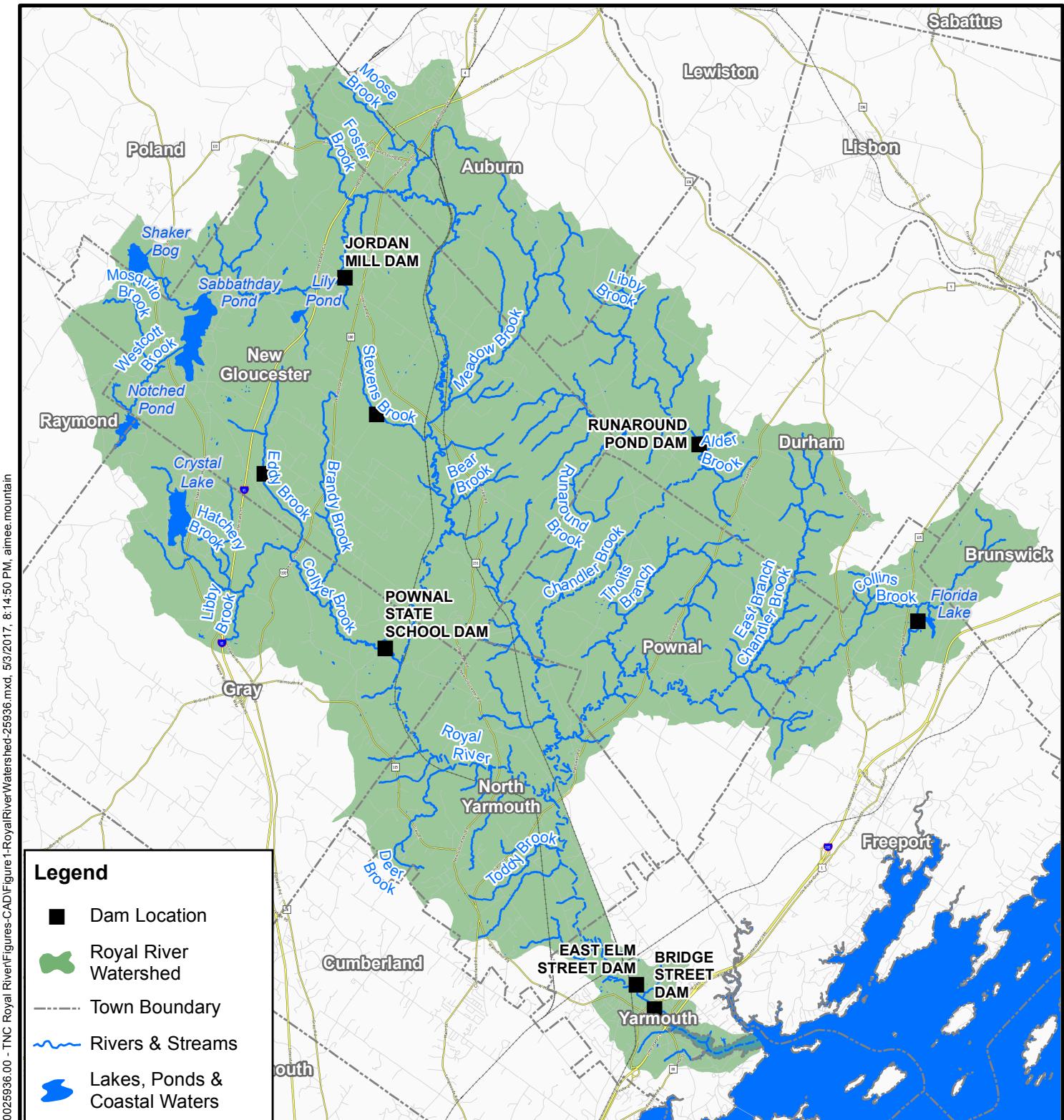


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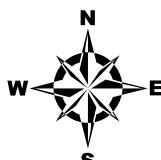


Figure 1
Watershed Plan



Legend

- Dam Location
- Royal River Watershed
- - - Town Boundary
- ~~~~ Rivers & Streams
- Lakes, Ponds & Coastal Waters



LOCUS

SOURCES:

- MAINE OFFICE OF GIS (MEGIS)
- MAINE DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY (DCAF)
- MAINE COASTAL PROGRAM
- UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)
- NATURAL RESOURCES CONSERVATION SERVICE (NRCS)
- UNITED STATES GEOLOGICAL SURVEY (USGS)

Data Supplied by :



0 1.25 2.5 5 7.5

Miles



PROJ. MGR.: KHM
DESIGNED BY: KHM
REVIEWED BY: DMZ
OPERATOR: ADM
DATE: 05-03-2017

ROYAL RIVER WATERSHED PLAN

JOB NO.
09.0025936.00

THE NATURE CONSERVANCY MAINE

FIGURE NO.
1



Appendix A - Limitations



USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Proposal for Services and/or Report and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).
3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made. Specifically, GZA does not and cannot represent that the Site contains no hazardous material, oil, or other latent condition beyond that observed by GZA during its study. Additionally, GZA makes no warranty that any response action or recommended action will achieve all of its objectives or that the findings of this study will be upheld by a local, state or federal agency.
4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

COMPLIANCE WITH CODES AND REGULATIONS

5. We used reasonable care in identifying and interpreting applicable codes and regulations necessary to execute our scope of work. These codes and regulations are subject to various, and possibly contradictory, interpretations. Interpretations and compliance with codes and regulations by other parties is beyond our control.

INTERPRETATION OF DATA

6. Our opinions are based on available information as described in the Report, and on our professional judgment. Additional observations made over time, and/or space, may not support the opinions provided in the Report.

ADDITIONAL INFORMATION

7. In the event that the Client or others authorized to use this report obtain additional information on environmental or hazardous waste issues at the Site not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the conclusions stated in this report.

ADDITIONAL SERVICES

8. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that



conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

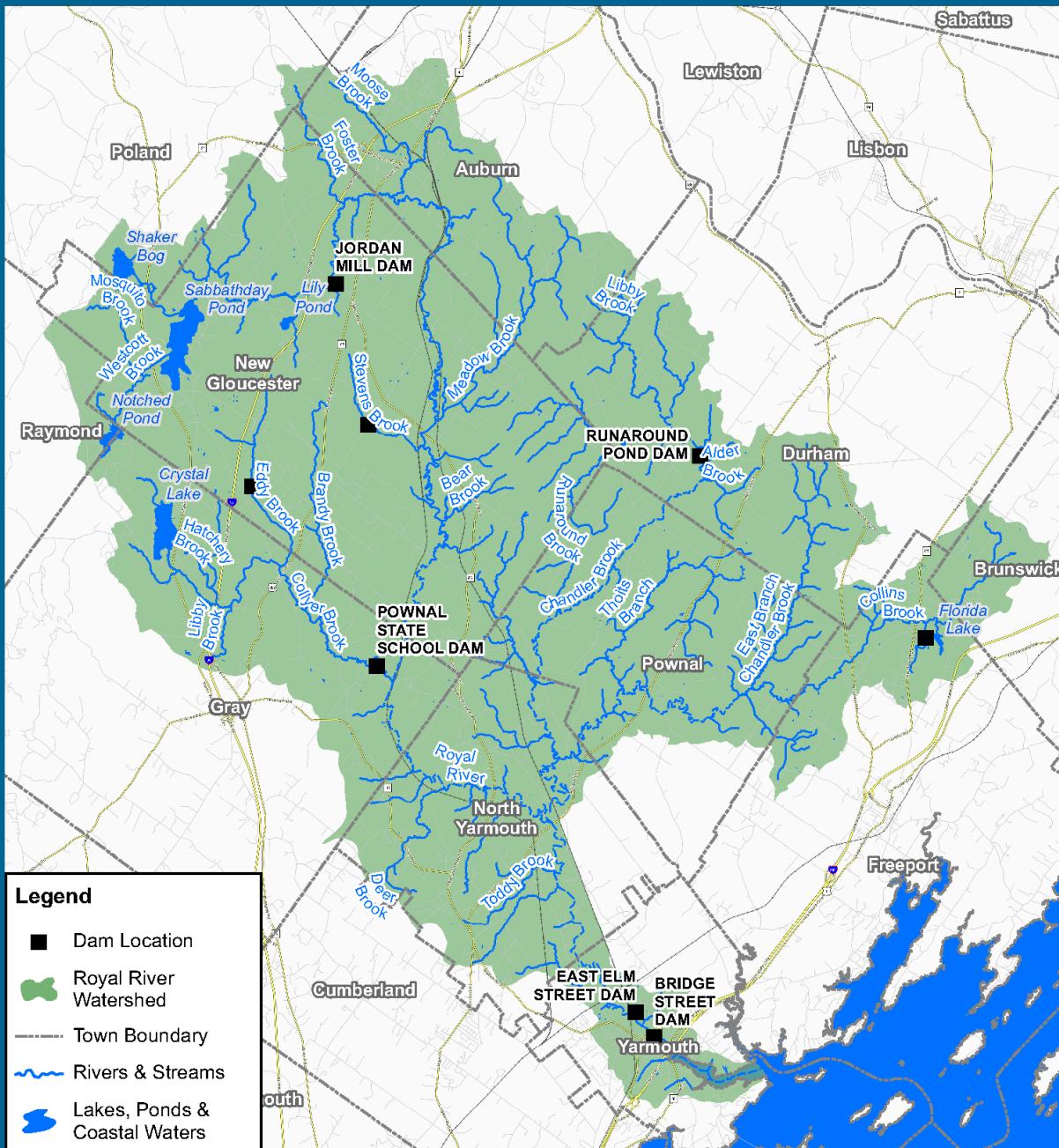
CONCEPTUAL SITE MODEL

9. Our opinions were developed, in part, based upon a comparison of site data to conditions anticipated within our Conceptual Site Model (CSM). The CSM is based on available information, and professional judgment. There are rarely sufficient data to develop a unique CSM. Therefore observations over time, and/or space, may vary from those depicted in the CSM provided in this report. In addition, the CSM should be evaluated and refined (as appropriate) whenever significant new information and/or data is obtained.



Appendix B – Royal River Conservation Project Fact Sheet

Royal River and Surrounding Area



Legend

- Dam Location
- Royal River Watershed
- Town Boundary
- Rivers & Streams
- Lakes, Ponds & Coastal Waters



SOURCES:
MAINE OFFICE OF GIS (MEGIS)
MAINE DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY (DACF)
MAINE COASTAL PROGRAM
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)
UNITED STATES GEOLOGICAL SURVEY (USGS)

0 1.25 2.5 5 7.5
Miles



Local Organizations Working in the Royal River Watershed:

Casco Bay Estuary Partnership, First Parish Church of Yarmouth, Friends of Casco Bay, Maine Rivers, Royal River Conservation Trust, The Nature Conservancy, Town of Yarmouth, Trout Unlimited Sebago Chapter

Royal River Fish Passage Studies Summary



Royal River at the East Elm Street Dam *Photo Credit: GZA GeoEnvironmental*

Royal River Watershed Information

The Royal River starts at the outlet of Sabbathday Lake in New Gloucester and flows to Casco Bay in the Town of Yarmouth. It has two primary man-made barriers to sea-run fish who attempt to swim upstream to spawn: The Bridge Street Dam and the East Elm Street Dam. Middle Falls is located between the dams and may be an additional barrier due to either natural configuration or historical alteration.

The Royal River was dammed beginning in 1674. Grain, paper, textiles, lumber, tanneries, poultry processing, and iron forging industries were all associated with at least 8 man-made dams spanning the river. By 2005 only the Bridge Street Dam and East Elm Street Dam remained in the lower portion of the river.

There are reports of Atlantic salmon spawning in the Royal River in the 1800s; however, by 1887, a report by the United States Commission of Fish and Fisheries indicated that there were no economically valuable fisheries remaining due to the dams restricting access upstream.

The River is suitable for sea-run as well as sport fish populations. Several studies have identified brook trout habitat, and Maine Department of Inland Fisheries and Wildlife currently stocks brown trout. The fish passage barriers at the Bridge Street and East Elm Street dams restrict the runs of striped bass, sea-run trout, alewife, shad, rainbow smelt, American eel, and sea lamprey.

Historical Fisheries

- There was an 1821 citizen-led petition to the Maine State Legislature to protest the lack of fish passage at the Royal River dams because of their impact on shad, salmon, and river herring.
- In the 1880s, there were small shad, alewife, and eel fisheries on the river. In an 1887 report, the Royal River was noted to have had a large Atlantic salmon population in the early 1800s that had disappeared by the 1850s.
- Maine Inland Fisheries & Wildlife did not identify any salmon or other sea-run fish in the Royal in their 1958 study.
- Fishways were constructed on the Bridge Street and East Elm Street Dams in the 1970s, and Maine Department of Marine Resources began stocking shad and alewives in the river. However, after growing the alewife run to an estimated 50,000 fish, the effort was deemed to be unsuccessful, and stopped in 1981.
- There has been no comprehensive study of sea-run fish or their habitats in the Royal River to date.

Hydropower Activity and Management

- The Sparhawk Mill hydropower facility was developed in the 1980s under a subsidized hydropower program.
- To date there has been little economically-viable power generation due to the low flows in the river.
- In 2016, the Town received inquiries from a local entrepreneur to gauge interest in redevelopment of the hydropower facilities at Sparhawk Mill. The Town signaled interest, and is awaiting more information about potential to increase electricity generation.
- In 2017 Royal River Conservation Trust provided comments to US Fish and Wildlife Service regarding a Federal Energy Regulatory Commission filing for the Sparhawk Mill that reiterates RRCT's commitment to restoring fish passage.



Bridge Street Dam during dewatering conditions

Photo Credit: Maine Rivers

Royal River Restoration Progress

Habitat Quality

- The geology of the watershed has provided gravel and sandy riffles suitable for trout and salmon spawning and nursery areas.
- Portions of the river historically provided spawning habitat for Atlantic salmon.
- Small spring-fed brooks provide cool water to help support resident trout populations.
- Currently there are brown trout and brook trout populations within the river.
- It is unknown what potential habitat may be under the current dam impoundments.
- In the lower watershed, the dams have converted portions of the river into lake-like systems rather than riverine systems. They restrict the natural erosion and deposition that one would expect in a natural river system.
- The Elm Street Dam alters habitat for nearly 9 miles upstream.



Side channel at Royal River Park

Photo Credit: GZA GeoEnvironmental

Water Quality

- According to Maine DEP, the river currently meets water quality standards.
- Volunteer monitoring in the 1990s engaged the community within the watershed. The monitoring identified areas where water quality has been degraded, but showed little variability over the monitoring duration.
- Limited development in the upper watershed has protected water quality.
- Increased future development in the watershed could result in poor water quality from polluted runoff.

Sediment Conditions

- Currently the dams do not capture much sediment moving downstream. It is anticipated that removing the Elm Street Dam would result in increased sediment loads until stored sediments in the impoundment reach an equilibrium, after which sediment loading to the harbor would stabilize.
- Dam removal would cause the current impoundments to revert to river-like habitat conditions with natural sediment transport and deposition.
- There is an estimated 110,000 cubic yards of potentially mobile sediment behind the East Elm Street Dam and approximately 6,000 cubic yards of sediment behind the Bridge Street Dam.
- Project consultants and Maine DEP have concluded that the Bridge Street Dam's impounded sediments do not pose a risk to human health or the environment.

