Royal River, Yarmouth, Maine Section206, Aquatic Ecosystem Restoration

Appendix C: Hydrology & Hydraulics Appendix (Part 1)

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June 24, 2024
Rev. 02SEP24

US Army Corps of Engineers®
New England District

YARMOUTH
MAINE

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1.0 PURPOSE AND SCOPE

The purpose of this study is to assess feasibility-level Continuing Authorities Program (CAP) Section 206 aquatic ecosystem restoration alternatives in the Royal River. This entails the assessment of two low head dams (Bridge Street and East Elm Street Dams) and one natural fall (Middle Falls) on the river and 7.01 miles of the waterway, from the head-of-tide to the upstream limit of the East Elm Street Dam impoundment. Both dams have nonfunctioning/minimally functioning fishways. The project has the potential to restore access to approximately 32 miles of river habitat on the mainstem Royal River for migratory fish species, providing the fish with upstream access to historic reproductive habitat for adults and nursery habitat for the development of eggs and juvenile life stages. The project could also restore access to aquatic organisms along many additional miles of habitat within the tributaries of the Royal River. A cost effectiveness and incremental cost analysis is contained in the main report.

This appendix presents hydrologic information, feasibility-level hydraulic analyses of aquatic organism passage modifications (including with- and without-dam conditions), and discussion of the results of the dam removal alternatives. The analyses include an evaluation of the study reach, including historical storms and previous studies, flow development, hydraulic modeling of existing conditions, and modeling to support evaluation of alternatives. Sections included in the report are: a description of the study area, study procedures including aquatic organism passage/dam removal alternatives and results, and a summary.

2.0 AUTHORITY

This aquatic ecosystem restoration study was conducted under the authority of Section 206 of the Water Resources Development Act (WRDA) of 1996. This authority allows the U.S. Army Corps of Engineers (USACE), in cooperation with its project sponsor and partners, to develop aquatic ecosystem restoration and protection projects that improve the quality of the environment, and that are in the public's interest while being cost effective. The Aquatic Ecosystem Restoration Program focuses on restoration of ecosystem structure and function necessary to support aquatic organism and wildlife habitat.

Section 206 of the Water Resources Development Act of 1996 PL 104-303 entitled Aquatic Ecosystem Restoration, states in part,

> "The Secretary [of the Army] may carry out an aquatic ecosystem restoration and protection project if the secretary determines that the project – will restore the quality of the environment and is in the public interest; and is cost-effective."

3.0 DESCRIPTION OF THE STUDY AREA

3.1 GENERAL

The study area (shown in **Figure 1**) is located on the Royal River in the town of Yarmouth, Maine, at approximately latitude 43^{o} 45’ N., and longitude 70^{o} 11’ W. in Cumberland County. The Royal River is in the Presumpscot Basin (HUC-8 watershed 01060001) which is in the Saco River Basin (HUC-4 watershed 0106). The Hydrologic Unit is located entirely in Water Resource Region (i.e., HUC-2 watershed) number 01, the New England Region. The entire Royal River watershed drains an area of 143 square miles and flows 39 miles predominately north to south from headwaters at Sabbathday Lake in New Gloucester, ME to its mouth near Parker Point in Casco Bay (Atlantic Ocean).

Figure 1: Royal River Watershed. Study Area Circled in Red.

The watershed is sparsely developed woodland and contains some hilly terrain. The watershed includes many bodies, including lakes and ponds (e.g., Crystal Lake, Runaround Pond and Sabbathday Lake) and tributaries such as Chandler Brook, Collyer Brook and Collins Brook. The total fall in the Royal River from Sabbathday Lake to the ocean is approximately 300 feet, or an overall average of 7.7 feet per mile, however approximately 70 feet of the drop is accounted for in the mile above the head-of-tide.

There are four sets of rapids along the Royal River in the mile of its course upstream of the head-of -tide. These are numbered First through Fourth, with the Fourth being the farthest upstream and the First being the closest to the ocean as shown in **Figure 2**.

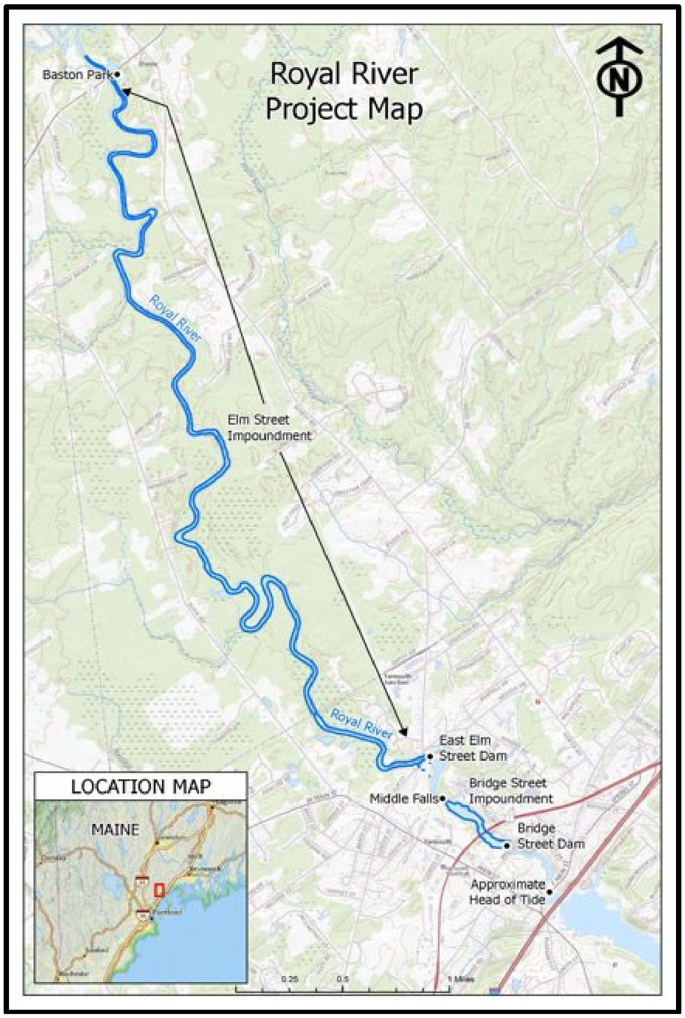


Figure 2: Royal River Study Area

At the **First Falls** of the Royal River, at Grist Mill Park, is located at the approximate **Head-of-Tide**. The river falls approximately 10 feet over a distance of 200 feet. Historically, the river power had been used at this location for mills since 1674, and later for hydroelectric power, however no damming surface remains at the site.

At **Bridge Street**, there is a run-of-river dam in Yarmouth at the **Second Falls** of the Royal River. The location has provided power for the material industry since 1847Under normal conditions, the impoundment is approximately 1,800-feet in length, with a maximum depth of 25 feet, with a normal impounded volume of approximately 100 acre-feet. There is a fish ladder structure at the dam, designed to promote fish passage by allowing for fish passage of 25 feet vertically over a distance of 90 feet. Additionally, there is a non-functional hydroelectric facility at the dam.

The **Third Falls** (**Middle Falls**) at Factory Island has historically powered a grist mill, carding mill, nail mill, soda pulp-and-paper mill. Following a fire in 1931, the complex fell into disuse and the remains of the buildings existed until they were removed by the Marine Corps in 1971.

The **Fourth Falls** of the Royal River is located 900 feet upstream of the Third Falls, at Gooch Island and **East Elm Street**. A dam at this location has been historically used to supply water and power for local industries. A historic mill race, **Foundry Channel**, is in this vicinity allowing some of the Royal River flows to bypass the dam.

3.2 PROJECT AREAS

3.2.1 Bridge Street Dam

The Bridge Street Dam is located approximately 2000 feet upstream from the head-of-tide in the Royal River, near East Main Street and the State Route 88 Bridge (**Figure 3**). This site is known as the Second Falls of the Royal River in Yarmouth, Maine. The dam is constructed on visible metamorphic bedrock 250 ft upstream from Bridge Street.

The dam is a gravity type run-of-river structure spanning the full width of the river. It is constructed of masonry and reinforced concrete. The structure is approximately 275 feet in length and is 10-feet in height. In the most recent inspection report, the dam is described from left to right as being comprised of “a 102 foot-long non-flow section, an approximately 10-foot-wide by 8-foot-high right sluice bay section with stoplogs, an approximately 130-foot-long ungated spillway section and a 7.5-foot-wide by 10-foot-high left sluice bay section with stoplogs” (Johnson 2014).The dam has a sloped upstream face and a vertical downstream face. The spillway is located near the center of the dam, approximately 75 feet long. Low-flow sluiceways are cast into either end of the spillway and are controlled by removable weir planks.

The Bridge Street Dam was originally constructed in 1870 to provided low-head water to the adjacent Sparhawk Mill through a metal penstock (**Figure 4)**. The Sparhawk Mill Hydropower plant was a FERC operated dam until 2019. The intake structure and 200-foot-long welded steel penstock from the original hydroelectric plant, are still in place.

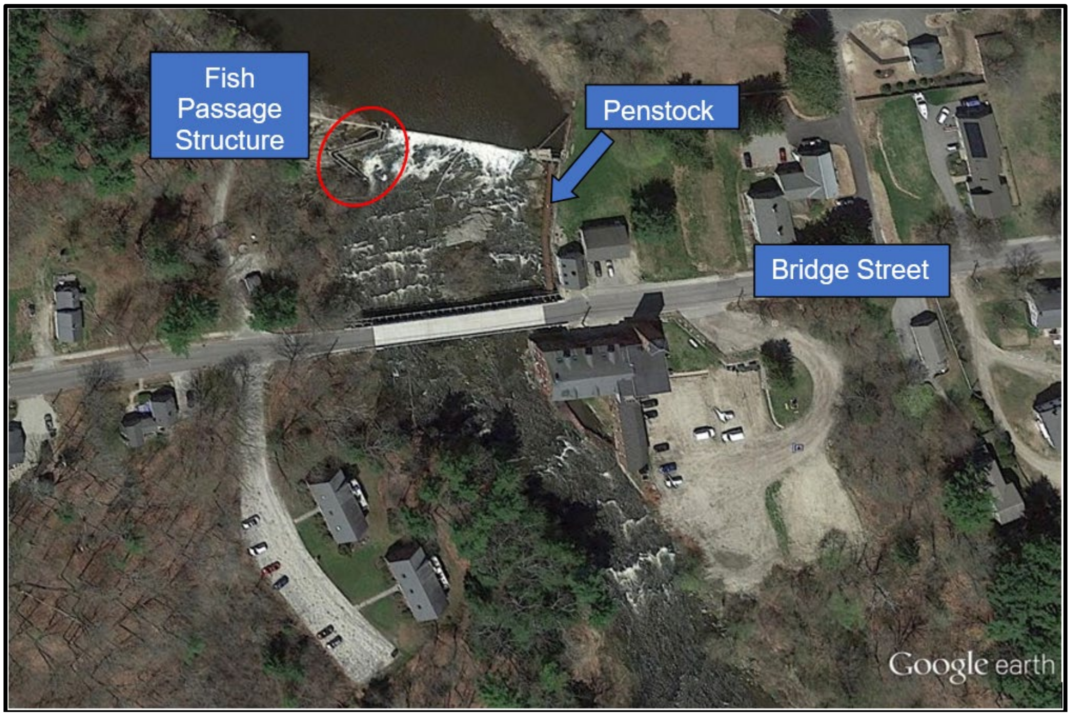


Figure 3: Aerial View of the Bridge Street Dam

Figure 4: Bridge Street Dam, Royal River, Yarmouth, Maine

In an effort to improve fish passage, a concrete Denil-type fish ladder was built into the southwest end of the dam's spillway in 1974 (**Figure 5**). The fishway consists of two 3-foot wide concrete segments with 19 baffles each and "a 13-foot long, 120 degree turning pool" that separates the two segments The design of the fish ladder does not match current design recommendations. It is suitable for alewife but is problematic for other native anadromous species (Interfluve, 2018).

The effectiveness of the structure is dependent on many conditions including water flow, regular maintenance, and debris removal. For many years, the fish passage structure was inoperable due to damage and lack of maintenance. In recent years, a local group of volunteers have repaired the fish ladder. Their efforts have shown some success, as they have filmed fish moving through the fish ladder in 2024, though individual fish passage is measured in tens of fish (Royal River Fish Passage, 2024).

Figure 5: Denil-type fish ladder at the Bridge Street Dam

The dam and fish ladder are currently owned by the town of Yarmouth.

The impoundment above the Bridge Street Dam Impoundment extends from the dam upstream to the Middle Falls 2000 feet upstream. The overall length of the impoundment is 2,000 ft. The surface area of the impoundment at normal pool level is approximately 9 acres, with a maximum depth of 15 ft (Stantec, 2015).

3.2.2 East Elm Street Dam

The East Elm Street Dam is located approximately a-half mile upstream of the Bridge Street Dam and 0.23 miles upstream of Middle Falls. The area is also known as the Fourth Falls and Gooch's Falls. The Dam is a stone, run-of-river, gravity-type structure approximately 250 feet in length (including abutments), with a 12-foot structural height (**Figure 6**). The dam is built on a bedrock outcropping that is an extension of Gooch Island, immediately east of the dam (**Figure 7**). The structure of the dam consists of "a loose-laid, large-granite-block structure, a sloping concrete overlay on the upstream side, and a concrete overlay on portions of the downstream side." (Powers, 2009)

Figure 6: Aerial view of the East Elm Street Dam at Royal River Park

Figure 7: East Elm Street Dam, Royal River, Yarmouth, Maine

Gooch Island splits the Royal into a main channel (west of Gooch Island), and a narrower back channel (east of Gooch Island). The entire length of the dam serves as a spillway, which has a granite block crest (Stantec 2010).

In 1979, a concrete Denil-type fishway was built by the Maine Department of Marine Resources at the southern end of the dam (**Figure 8**). The fishway has a 1:6 slope and includes a concrete chute with slanted wooden baffles, trash racks and a slide control gate at the upstream inlet (Petrovsky, 2019). The structure is 3-foot wide with three segments. The first and second segments are separated by “a 16-foot long, 90 degree turning pool”, while the second and third segments are separated by a 180-degree turning pool. The structure allows an 11ft rise from entrance to exit.

Similar to the Bridge Street fish passage structure, the structure at East Elm Street Dam eventually fell into disrepair and was not functional. In recent years, a local group of volunteers have repaired the fish ladder.

The dam and fish ladder are currently owned by the town of Yarmouth.

Figure 8: Denil-type Fish Ladder near the East Elm Street Dam

3.2.3 Middle Falls

Middle Falls is a natural barrier to aquatic organism passage that is located between the Bridge Street and East Elm Street Dam. This feature is 2000 ft upstream of Bridge Street Dam. The area was formerly the site of the Forest Paper Company mill, which spanned the river from the south shore to Factory Island (**Figure 9**).

“At this site, the river bifurcates around Factory Island with the main channel (and falls) on river right and a small side channel on the east side of Factory Island that also connects the head and tailwaters of the falls” (USFWS 2017).

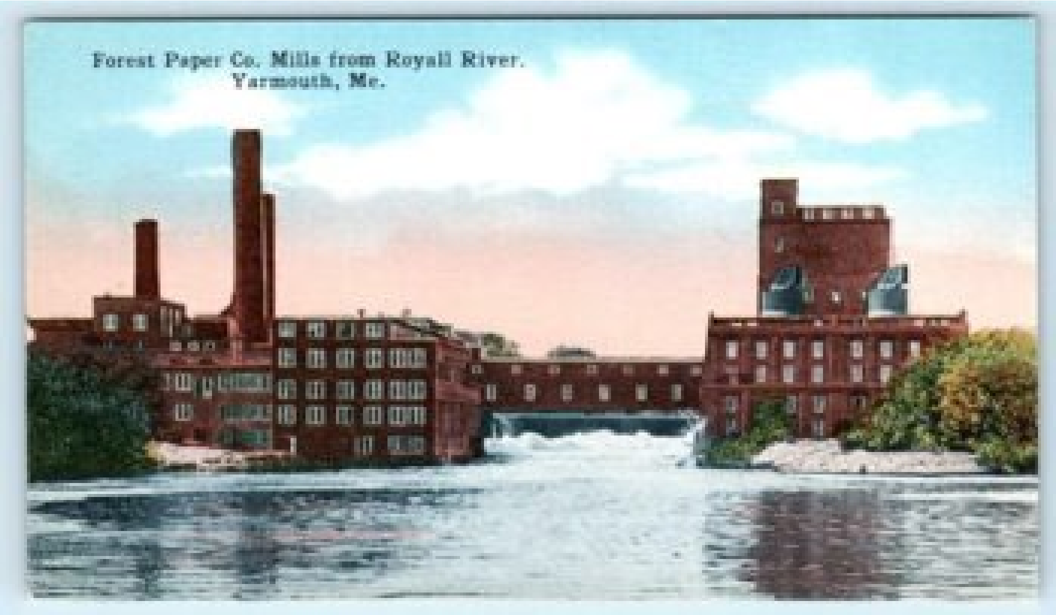


Figure 9: The Forest Paper Company Mill formerly at Middle Falls

Prior to 2012, remnants of the mill complex encroached into the river channel, including a stone structure spanning the channel to the north of Factory Island and large granite blocks in the side channel. In the 2010 report written by Stantec, it was suggested that this encroachment into the river channel likely impacts fish passage at this site.

In 2012, the town of Yarmouth led an effort to clear the remnants for the mill structure from the side channel to partially or substantially improved passage through that section of the river. Dozens of granite blocks, weighing approximately 6,000 lbs., were pulled out of the river channel. In all approximately 70 tons of rock were removed from the river channel, improving fish passed in a 0.9 miles section of the Royal River (Maine Rivers, 2012)

Figure 10 and **Figure 11** show current conditions at the Middle Falls.

Figure 10: Aerial view of the Middle Falls

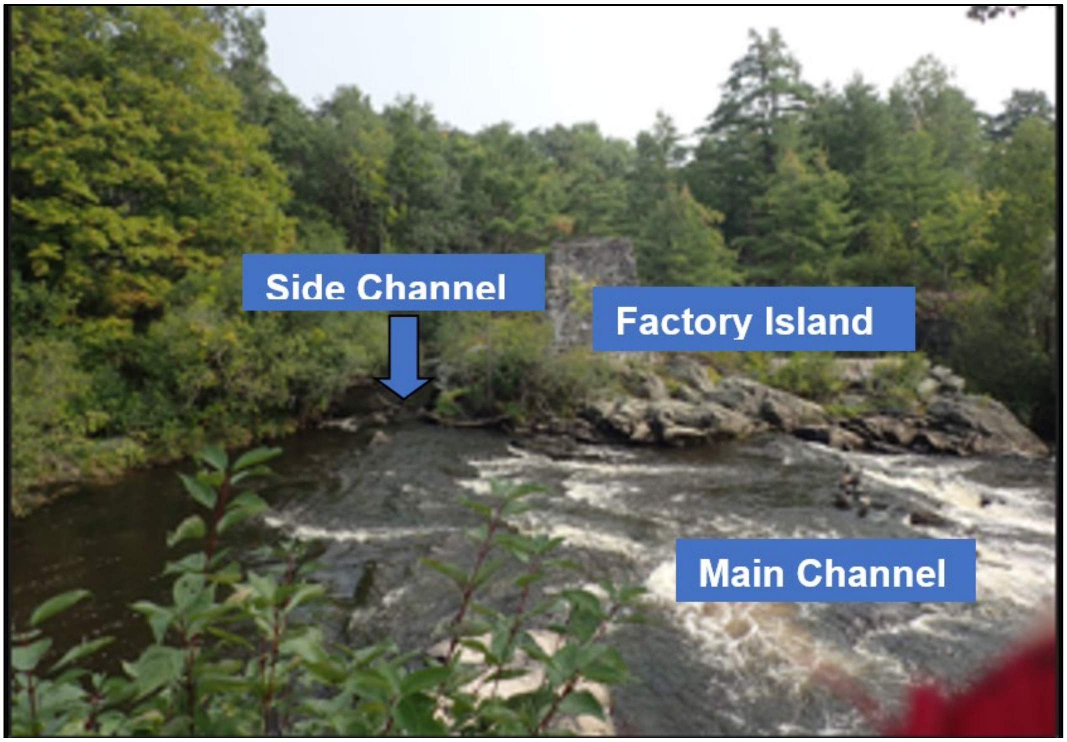


Figure 11: The Middle Falls Site with the remnants of the Forest Paper Company Mill

During the summer of 2017, the U.S. Fish and Wildlife Service (USFWS) surveyed the bypass to assess potential for passage in this side channel. In a letter written by the agency describing their finding, the agency indicated that “the side channel appears passable over most of its length though water depths were shallow at the time of this survey. Two locations that may hinder fish movement were identified.” The agency suggested that these impediments could be removed and that “Significant improvements to the passage conditions at these sites might be accomplished through alternations to the ledge outcroppings and/or movement of large rocks. This work might be accomplished in 3 to 5 days by a small crew with access to a generator, compressor, pneumatic hammer, and grip hoists. These enhancements would be relatively low cost and should be considered viable alternative.” (USFWS 2017)

3.3 LOCATIONS OF INTEREST

3.3.1 Federal Navigation Project

At the downstream end of the study area, downstream of the Head-of-Tide and the northbound Interstate-295 bridge, is a 2-mile-long estuary that ranges from 300 feet to 1,200 feet in width. A federal channel has ensured navigation access from Casco Bay to this vicinity since at least the 1870’s. This channel was enlarged in the 1960’s along with creation of an 8-acre anchorage, collectively identified as the Federal Navigation Project (FNP) (**Figure 12**). Private interests also operate several commercial marinas in the estuary.

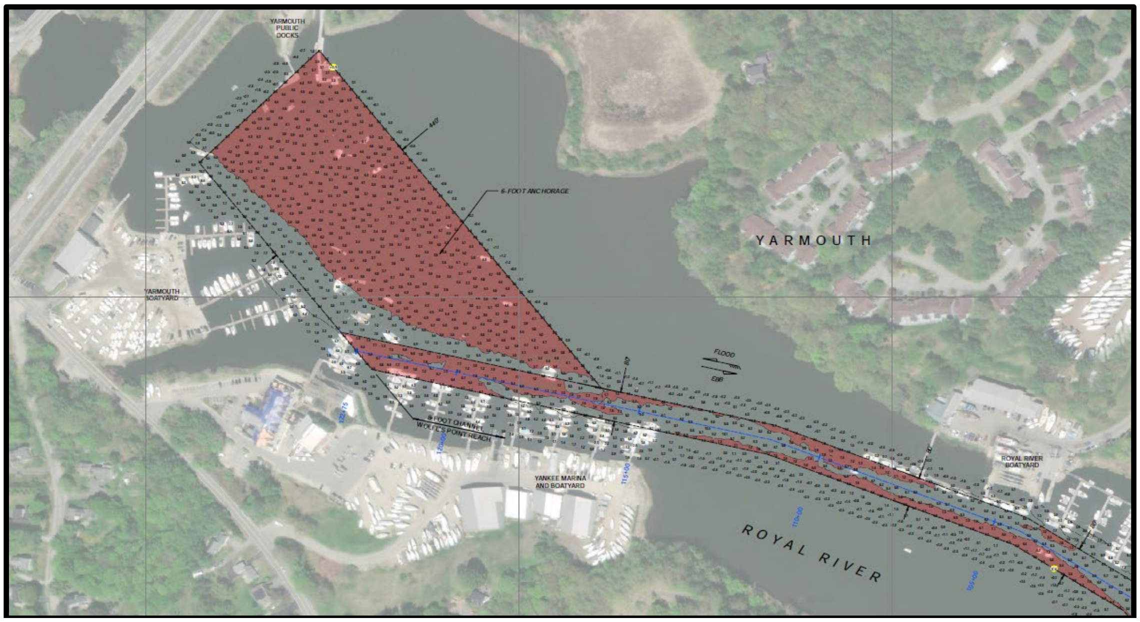


Figure 12: Royal River Federal Navigation Project

3.3.2 Baston Park / Route 9

Near the upstream limits of the Elm Street Dam impoundment in North Yarmouth, Baston Park and the Memorial Highway (Route 9) bridge effectively represent the upstream study limits (**Figure 13**). Situated at an oxbow of the Royal River, Baston Park provides recreational opportunities along with the nearby Old Town House Park. Potentially, Baston Park could be sensitive to changes in water levels as conceptual plans are being developed for hand-carry boat access after site improvements.

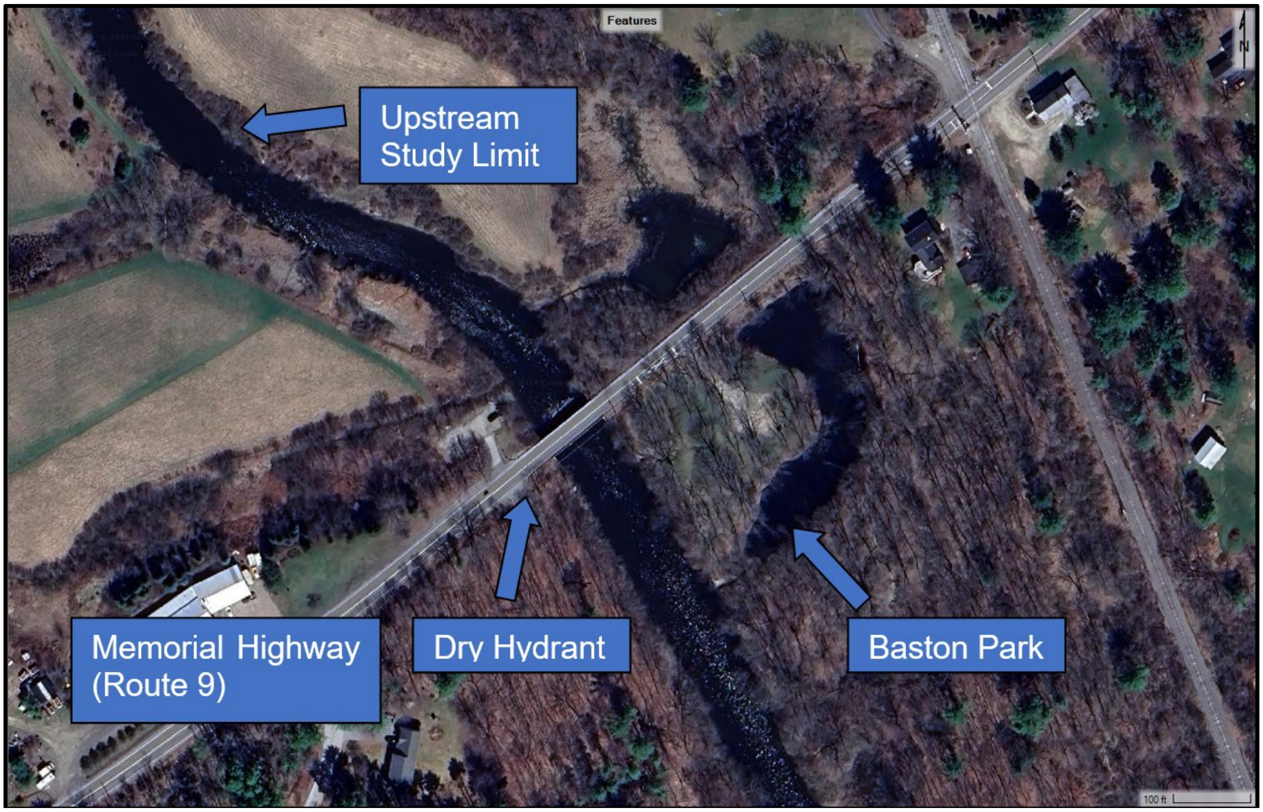


Figure 13: Baston Park and Memorial Highway (Route 9)

Additionally, the Route 9 bridge infrastructure includes a dry hydrant for rural fire fighting. The dry hydrant allows fire crews to draw water directly from Royal River and potentially could also be sensitive to changes in water levels.

3.4 CLIMATOLOGY

The area has a variable climate, and frequently experiences periods of heavy precipitation produced by local thunderstorms, and larger weather systems of tropical and extratropical origin. The area lies in the path of the prevailing "westerlies" which generally travel across the country in an easterly or northeasterly direction, producing frequent weather changes. The climate is characterized as moderate, and the mean annual temperature is 48 degrees Fahrenheit (°F). Temperatures range from an average 24°F in January to an average of 70°F in July. The average yearly rainfall is about 48 inches and the average yearly snowfall is approximately 69 inches.

3.5 HISTORICAL STORMS

The flood of record occurred on March 13, 1977, and had a peak discharge of 11,500 cfs and an estimated recurrence interval in excess of 1-percent annual chance (FEMA, 2024). Other notable floods on Royal River were March 1936, September 1954, March 1977, March 1983, May 1989, April 1990, and August 1991 (**Figure 14**).

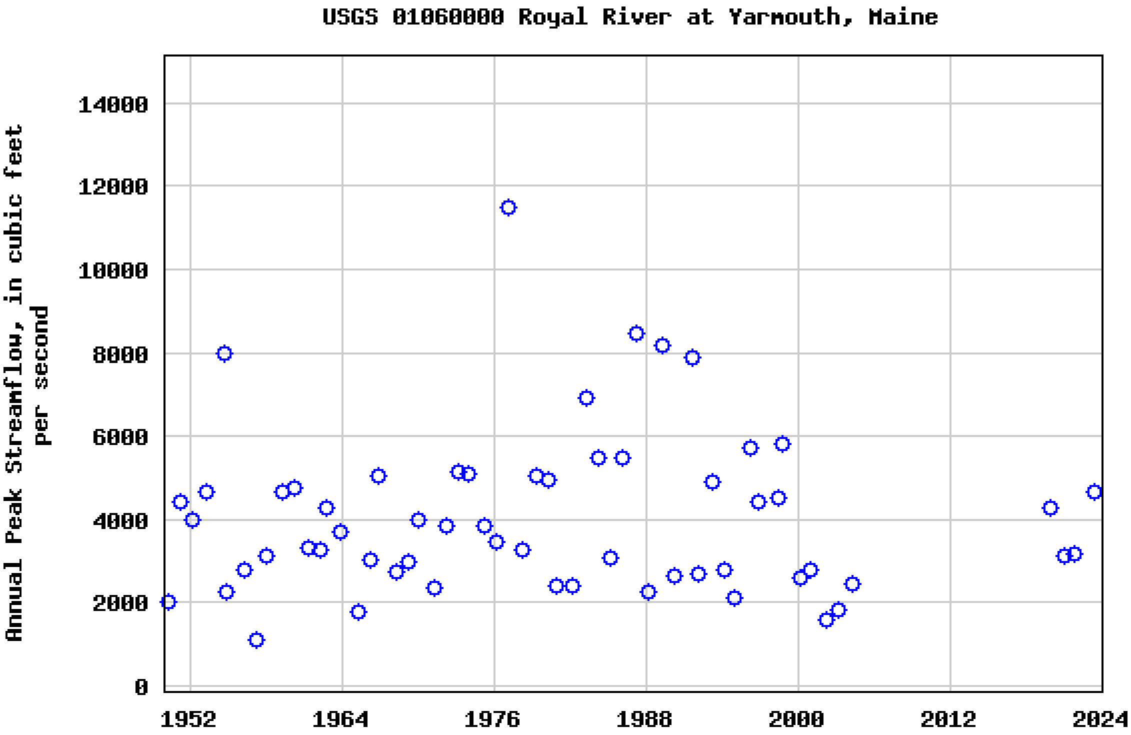
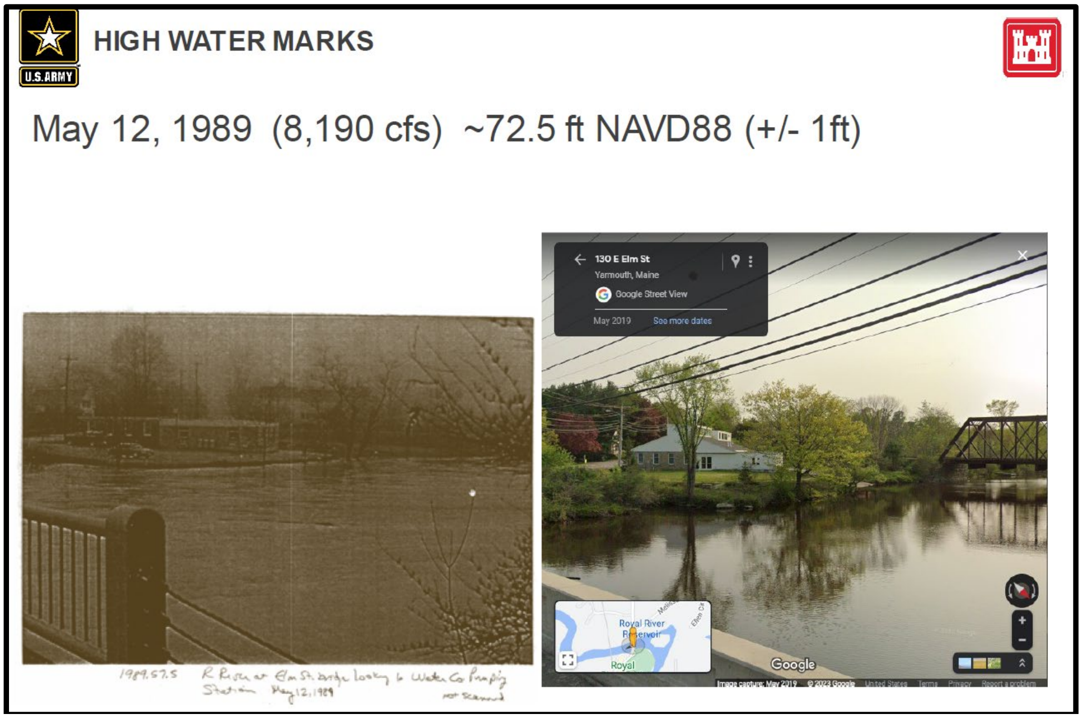


Figure 14: Annual Peak Streamflow USGS 01060000 Royal River

In general, high-water marks from the historical storms are not available for model calibration/validation. A high water mark was approximated from historic photograph of the May 1989 flood event (**Figure 15**) however it is a poor quality reference point because it was not surveyed or memorialized, the downstream bridge has changed during the interim, and it is unknown if the photo was taken during the peak of the storm.



HIGH WATER MARKS

May 12, 1989 (8,190 cfs) ~72.5 ft NAVD88 (+/- 1ft)

Figure 15: Royal River May 12, 1989 Flooding (8,190 cfs)

3.6 PRIOR STUDIES

3.6.1 Studies Completed by USACE

Federal Interest Determination Report (2020): The New England District, USACE completed a report that investigated the federal interested in pursuing an aquatic ecosystem restoration study on the Royal River. USACE conducted an initial appraisal and determined there is a Federal interest for an Aquatic Ecosystem Restoration project at this location along the Royal River. The purpose of the proposed project was identified as assessing the first two dams above the head of tide on the Royal River owned by the Town of Yarmouth: the Bridge Street Dam and the East Elm Street Dam.

Sediment Sampling and Testing in Support of Project Feasibility Study (January 2024): In October of 2023, the New England District collected sediment samples from the Royal River downstream of the Bridge Street Dam and upstream of the East Elm Street Dam. This study presents the results of this sediment sampling.

3.6.2 Studies Completed by Others

Considerable historical information and scientific data has been collected in the Royal River watershed since 1958. This list provides a summary of recent studies that provided key hydrologic and hydraulic information within the study area.

Fisheries & Aquatic Habitat Restoration Feasibility Study, Royal River Restoration Project Yarmouth, Maine (2010): Stantec Consulting Services Inc. completed this study for the town of Yarmouth, ME. This report describes the feasibility study designed to evaluate the potential of fisheries and Aquatic habitat restoration of the Royal River. The 2010 report provides opportunities and constraints associated with the restoration of fisheries and aquatic habitat.

Royal River Restoration Project: Phase II Analysis and Reporting (September 2013): Stantec Consulting Services Inc. completed this study for the town of Yarmouth, ME. The Phase II report presents the potential changes in the Royal River upstream from the East Elm Street Dam if the dam was removed, based on hydraulic modeling. The report addressed changes in water surface levels, recreational opportunities, sediment delivery to Yarmouth Harbor resulting from dam removal. The one-dimensional steady flow hydraulic model (HEC-RAS version 4.1.0) includes bathymetric and topographic data, hydrologic information, as well as channel and structure information based on data collected in Phases I & II. The report also provided the results of sediment sampling that occurred in 2010 to assess the presence of environmental contaminants in sediment in the East Elm Street Dam Impoundment. An excerpt of this model is displayed in **Figure 16**.

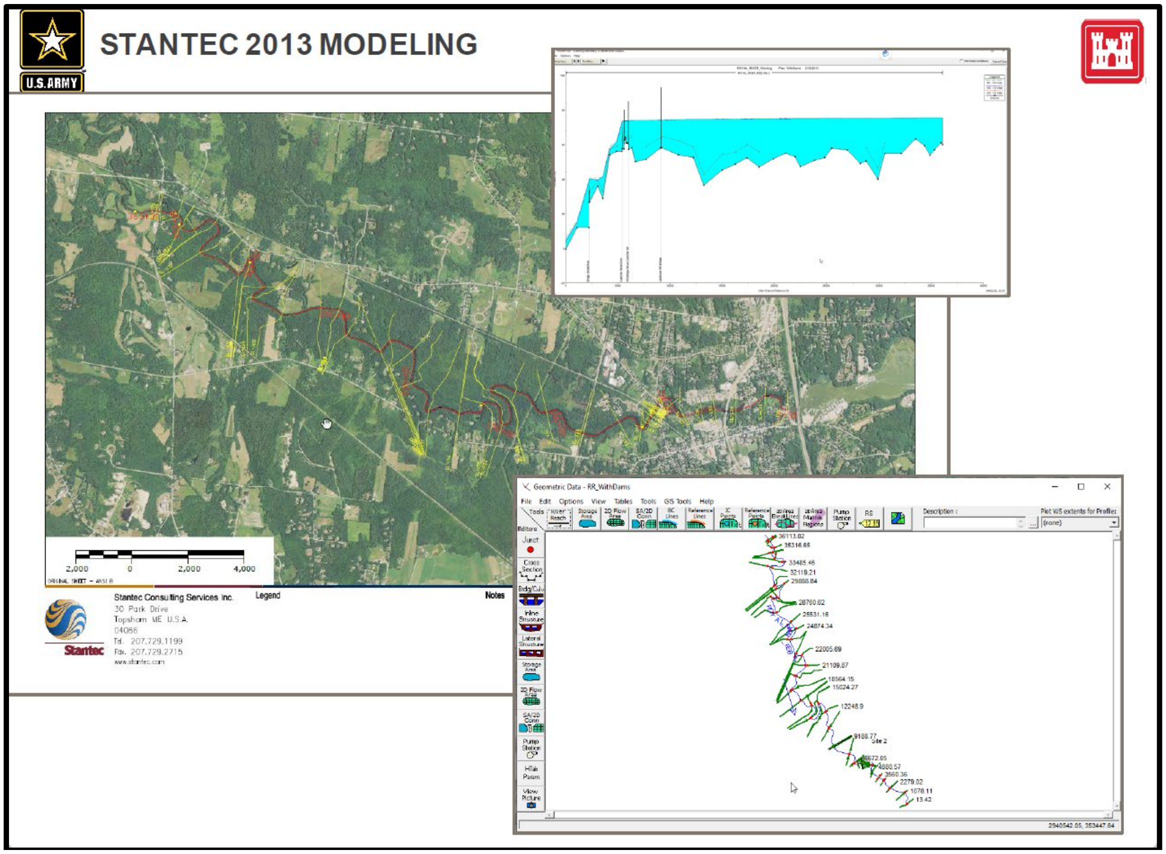


Figure 16: Stantec 2013 HEC-RAS Model and Topographic Workmap

Potential Impacts of Dam Removal on Sediment Production and Sediment Transport on the Royal River, ME (Field Geological Services, May 2013): Commissioned for and included as an appendix in the Stantec 2013 report, Field Geological Services (FGS) provides an evaluation of sediment transportation on the Royal River and noted that “dam removal is unlikely to significantly increase sediment transport through the impoundment area and sediment delivery to the harbor.” In addition, FGS provides fluvial geomorphological assessment of Royal River in the reach between East Elm Street Dam and the upstream end of the study area.

Estimated Sediment Volume: Bridge Street Dam Impoundment (June 2015): Stantec Consulting Services Inc. completed this study for the town of Yarmouth, ME. This report presented information on the composition, volume, and potential mobility of sediment accumulated upstream of the Bridge Street Dam on the Royal River. This report estimated the volume of accumulated sediment in the impoundment was 5,040 CY which included a 20% contingency to account for observed localized sediment deposits observed upstream from the Sparhawk Mill hydroelectric facility trash racks and adjacent to the stormwater outfalls. The study concluded that the volume of accumulate sediment found the Bridge Street Dam impoundment would not change due to high-water events and was representative of the typical volume of sediment that would be found behind the dam.

Sediment Sampling and Analysis, Bridge Street Dam Impoundment, Royal River, Yarmouth, Maine (March 2016): Stantec Consulting Services Inc. completed this study for the Nature Conservancy. This report presents methods and results of a sediment sampling study in the impoundment formed by the Bridge Street Dam. The study investigates the potential for remobilization of sediment and environmental contaminants in the impoundment if the dam is removed.

Fishway Assessment and Cost Analysis Report, Royal River, Yarmouth ME (January 2018): This report was completed by Interfluve for The Nature Conservancy. The report describes a detailed assessment of the potential for fish passage at the Bridge Street and East Elm Street dams on the Royal River. It identified four alternative approaches to enhance fish passage and assesses the cost of each alternative. These alternatives include no action, retrofit/rebuilt technical fishway, nature-like fishway, and dam removal.

Royal River Fish Passage Studies Summary Report. Royal River Watershed, Yarmouth, North Yarmouth, New Gloucester, Pownal, Durham, Gray, and Auburn, Maine (January 2018): This report was prepared by GZA GeoEnvironmental, Inc. for the Nature Conservancy. This document provides a review of prior project reports and work completed in the Royal River Watershed, with the objective to identify key points from historical studies and to evaluate restoration of fish passage between Casco Bay and the upper Royal River watershed.

Flood Insurance Study for Cumberland County, Maine (All Jurisdictions) (2024): This update by FEMA for the National Flood Insurance Program includes information for the Royal River. A scan of the effective Royal River hydraulic model was obtained from the

FEMA Engineering Library along with a topographic workmap. The FEMA hydraulic modeling was developed by FEMA in September 1979 utilizing HEC-2, which is a predecessor to the HEC-RAS software. Due to the shallow bedrock of the Royal River streambed, the FEMA study provided valuable channel survey information for this study despite being more than 40-years old. An excerpt of this study is shown in **Figure 17**, with more selections of the FEMA study provided in **Attachment A**.

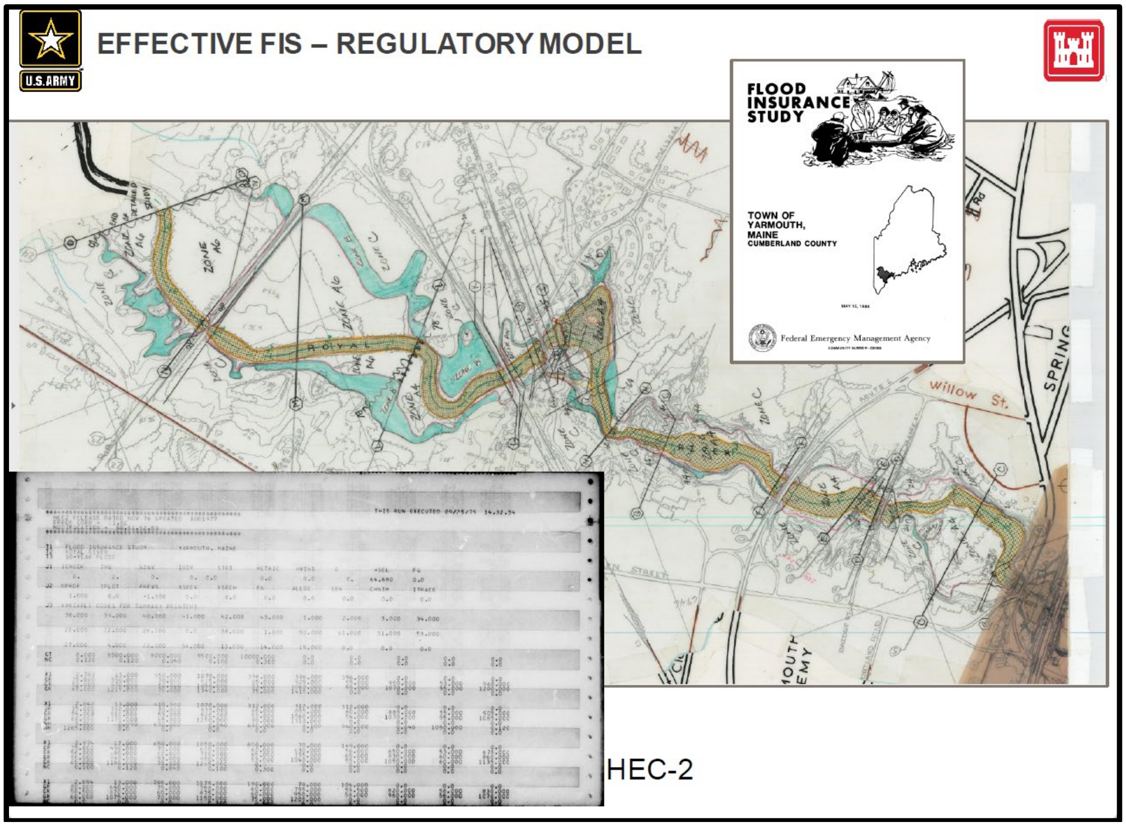


Figure 17: Effective FEMA Regulatory HEC-2 Model and Topographic workmap

4.0 ALTERNATIVES

As described more fully in the main report, full and partial dam removal measures were evaluated at both the Bridge Street Dam and the East Elm Street Dam sites. The hydraulic performance of these measures were deemed similar in many aspects, with only localized differences at the dam sites, leading to a generally neutral hydraulic basis for Tentatively Selected Plan (TSP). Specifically, alternatives and measures that were modeled are shown in **Table 1** below.

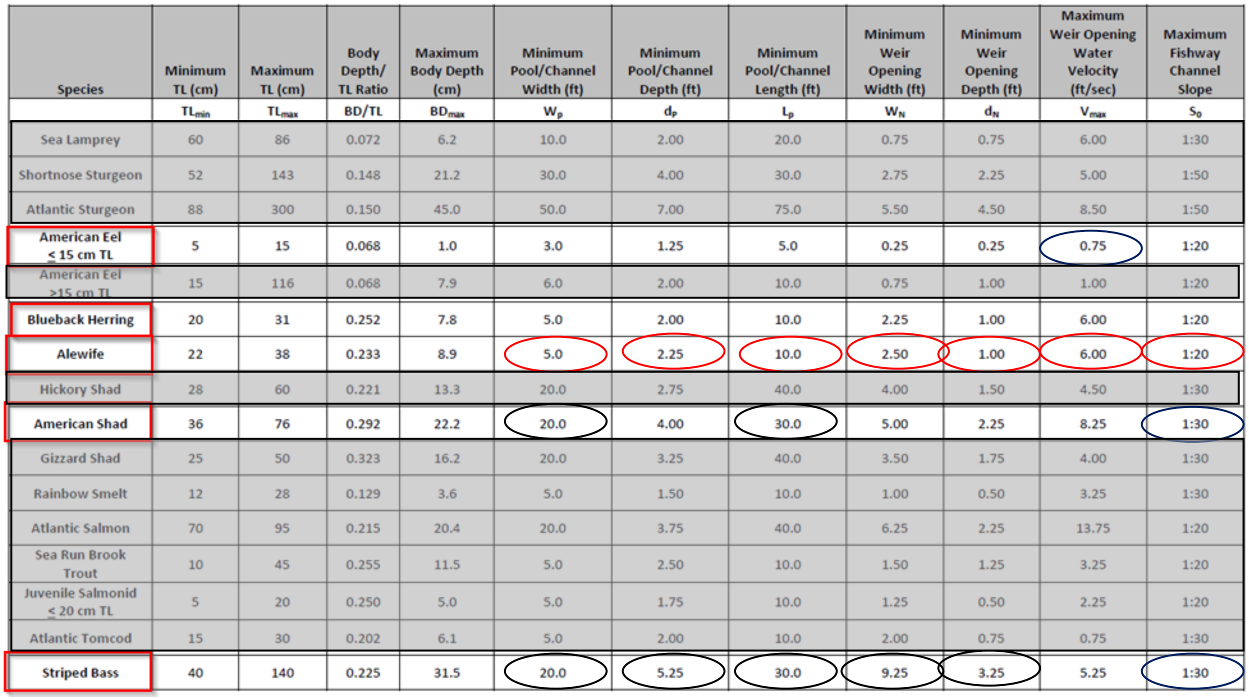
Table 1: Array of Modeled Alternatives & Measures

Alternative	Description	Model Plans
Alternative 1	No Action Alternative – Existing Conditions	'Ex_7Q10 - 25cfs_0ftTW' (p32) 'EX_MeanQ_120cfs_0ft_TW' (p18) 'EX_USGS2yr_3643cfs_0ft_TW' (p38) 'EX_10yr_6480cfs_0ft_TW' (p22) 'EX_10DEC_23DECC19' (p25) 'EX_100yr_10419cfs' (p42) 'EX_UpRiverPk_0ft_TW' (p31)
Alternative 2	East Elm Street and Bridge Street Dam Demolition + Middle Falls Side Channel Modification • Removal of a 120 linear feet (LF) section of the East Elm Street Dam and the Denil-type fish passage structure located on the right descending bank of the Royal River. • Removal of Bridge Street Dam across the entire width of the river, which includes 275 LF structure and the Denil-type fish passage structure located on the right descending bank of the Royal River. • Modification of the Middle Falls side channel, which includes the placement of large boulders in the main river channel and chipping of rock ledges located in the side channel.	'TSP_7Q10-25cfs_0TW' (p27) 'TSP_MeanQ_120cfs_0ft_TW' (p28) 'TSP_2yr_3643cfs_0ft_TW' (p29) 'TSP_10yr_6480cfs_0ft_TW' (p19) 'TSP_10DEC_23DECC19' (p40) 'TSP_100yr_10419cfs' (p41) 'TSP_UpRiverPk_0ft_TW' (p30)
Alternative 3	East Elm Street and Bridge Street Dam Demolition • Removal of a 120 linear feet (LF) section of the East Elm Street Dam and the Denil-type fish passage structure located on the right descending bank of the Royal River. • Removal of Bridge Street Dam across the entire width of the river, which includes 275 LF structure and the Denil-type fish passage structure located on the right descending bank of the Royal River. • No action at the Middle Falls	[Model plans of this alternative were removed to avoid confusion and archived. May be made available upon request.]
Measure: Full Dam Removal	East Elm Street and Bridge Street Dam Full Demolition • Removal of the East Elm Street Dam across the entire width of the river including the Denil-type fish passage structure. • Removal full section of Bridge Street Dam across the entire width of the river, including the Denil-type fish passage structure and the penstock intake structure. • No action at the Middle Falls	[Model plans of this measure were removed to avoid confusion and archived. May be made available upon request.]
Measure: Partial Dam Removal	East Elm Street and Bridge Street Dam Partial Demolition • Removal of a 120 linear feet (LF) section of the	[Model plans of this measure were removed to avoid confusion and archived. May be made available upon request.]

Alternative	Description	Model Plans
	East Elm Street Dam and the Denil-type fish passage structure located on the right descending bank of the Royal River • Removal of ~150-ft spillway section of Bridge Street Dam, including the Denil-type fish passage structure. • No action at the Middle Falls	
Measures: Middle Falls	Various geometric configurations of Middle Falls rock diversion structures to promote flow in the bypass; modeled iteratively in conjunction with Alternative #2 geometry	[Model plans of this measure were removed to avoid confusion and archived. May be made available upon request.]
Sensitivity: Tailwater	Sensitivity of Alternative 2 (TSP) Conditions varying downstream boundary tailwater	'TSP_UpRiverPk_9_6ft_TW' (p49) 'TSP_UpRiverPk_-9ft_TW' (p50)
Sensitivity: Manning's n roughness	Sensitivity of Existing Conditions varying roughness coefficients	'EX_UpRiverPk_0ft_TW_Low_n_sens' (p02) 'EX_UpRiverPk_0ft_TW_High_n_sens' (p03)
Sensitivity: Manning's n roughness	Sensitivity of Alternative 2 (TSP) Conditions varying roughness coefficients	'TSP_UpRiverPk_0ft_TW_Low_n_sens' (p26)' 'TSP_UpRiverPk_0ft_TW_High_n_sens' (p01)
Sensitivity: "All Muck"	Sensitivity of Alternative 2 (TSP) Conditions varying bathymetry immediately upstream / under the East Elm Street Dam	[Model plans of this measure were removed to avoid confusion and archived. May be made available upon request.]

Flow diversion measures were also more generally evaluated at Middle Falls to improve aquatic organism passage, however lack of detailed topography/bathymetry and finalized design from USFWS at time of this appendix have limited its applicability. **Table 2** presents a USFWS summary of design guidelines for nature-like fish passage and related to swimming capabilities and safe, timely and efficient passage for Atlantic Coast diadromous fish species. Note: units are expressed in both metric (cm) and English units (feet or feet/sec). Refer to the source USFWS report "Fish Passage Engineering Design Criteria"(USFWS, 2019) for more information. This table establishes the hydraulic parameters and estimated metrics which can be used to design fish passage for the target species.

Table 2: USFWS Design Guidelines for Nature-Like Fish Passage (USFWS, 2019)



Species	Minimum TL (cm)	Maximum TL (cm)	Body Depth/ TL Ratio	Maximum Body Depth (cm)	Minimum Pool/Channel Width (ft)	Minimum Pool/Channel Depth (ft)	Minimum Pool/Channel Length (ft)	Minimum Weir Opening Width (ft)	Minimum Weir Opening Depth (ft)	Maximum Weir Opening Water Velocity (ft/sec)	Maximum Fishway Channel Slope
	TL_{min}	TL_{max}	BD/TL	BD_{max}	W_p	d_p	L_p	W_N	d_N	V_{max}	S_0
Sea Lamprey	60	86	0.072	6.2	10.0	2.00	20.0	0.75	0.75	6.00	1:30
Shortnose Sturgeon	52	143	0.148	21.2	30.0	4.00	30.0	2.75	2.25	5.00	1:50
Atlantic Sturgeon	88	300	0.150	45.0	50.0	7.00	75.0	5.50	4.50	8.50	1:50
American Eel ≤ 15 cm TL	**5**	**15**	**0.068**	**1.0**	**3.0**	**1.25**	**5.0**	**0.25**	**0.25**	**0.75**	**1:20**
American Eel >15 cm TL	15	116	0.068	7.9	6.0	2.00	10.0	0.75	1.00	1.00	1:20
Blueback Herring	**20**	**31**	**0.252**	**7.8**	**5.0**	**2.00**	**10.0**	**2.25**	**1.00**	**6.00**	**1:20**
Alewife	**22**	**38**	**0.233**	**8.9**	**5.0**	**2.25**	**10.0**	**2.50**	**1.00**	**6.00**	**1:20**
Hickory Shad	28	60	0.221	13.3	20.0	2.75	40.0	4.00	1.50	4.50	1:30
American Shad	**36**	**76**	**0.292**	**22.2**	**20.0**	**4.00**	**30.0**	**5.00**	**2.25**	**8.25**	**1:30**
Gizzard Shad	25	50	0.323	16.2	20.0	3.25	40.0	3.50	1.75	4.00	1:30
Rainbow Smelt	12	28	0.129	3.6	5.0	1.50	10.0	1.00	0.50	3.25	1:30
Atlantic Salmon	70	95	0.215	20.4	20.0	3.75	40.0	6.25	2.25	13.75	1:20
Sea Run Brook Trout	10	45	0.255	11.5	5.0	2.50	10.0	1.50	1.25	3.25	1:20
Juvenile Salmonid ≤ 20 cm TL	5	20	0.250	5.0	5.0	1.75	10.0	1.25	0.50	2.25	1:20
Atlantic Tomcod	15	30	0.202	6.1	5.0	2.00	10.0	2.00	0.75	0.75	1:30
Striped Bass	**40**	**140**	**0.225**	**31.5**	**20.0**	**5.25**	**30.0**	**9.25**	**3.25**	**5.25**	**1:30**

As described more fully in the main report, the estuary supports a broad range of fish species, including shellfish, anadromous and catadromous fish species such as blueback herring (Alosa aestivalis), alewife (A. pseudoharengus), American shad (A. sapidissima), and American eel (Anguilla rostrata), and a strong recreational fishery including bluefish (Pomatomus saltatrix) and striped bass (Morone saxatilis). For evaluation purposes, this report utilized Alewife as the target species for upriver migration design flow development.

5.0 MODELING

This section discusses the methods and assumptions used in the study of the removal of all or part of the Bridge Street Dam and the East Elm Street Dam. The existing dams and river were hydraulically modeled using multiple flows to determine peak water surface elevations and velocities for a range of events. Two removal alternatives for each dam were then modeled to determine corresponding water elevations and velocities. The results of each of the removal alternatives were compared to the results of the existing dam conditions to determine the effects that dam removals will have on the peak water surfaces and velocities along the river.

5.1 HYDROLOGY

Royal River flows generally north to south from Sabbathday Lake in New Gloucester, ME until it flows into Casco Bay and eventually the Atlantic Ocean. There are eight dams within the Royal River watershed that restrict aquatic organism passage. Royal River receives input from several natural springs such as in northern New Gloucester, bordering on Poland ME, partly regulated by Jordan Mill Dam, approximately 24 miles upstream of East Elm Street in Yarmouth; Meadow Brook, 19.7 miles upstream of East Elm Street in Yarmouth; Stevens Brook, approximately 19 miles upstream of East Elm Street (inflows from Stevens Brook are regulated at one unnamed dam); Bear Brook, 16.6 miles upstream of East Elm Street; Collyer Brook, 11.9 miles upstream of East Elm Street, partly regulated by the Pownal State School Dam, and by an unnamed dam on the Eddy Brook tributary; and Chandler River, 6.0 miles upstream of East Elm Street, partly regulated by Florida Lake on the Collins Brook tributary, and partly regulated by Runaround Pond Dam on the Alder Brook tributary. The Royal River tributaries and dam locations in the watershed are shown in **Figure 18**.

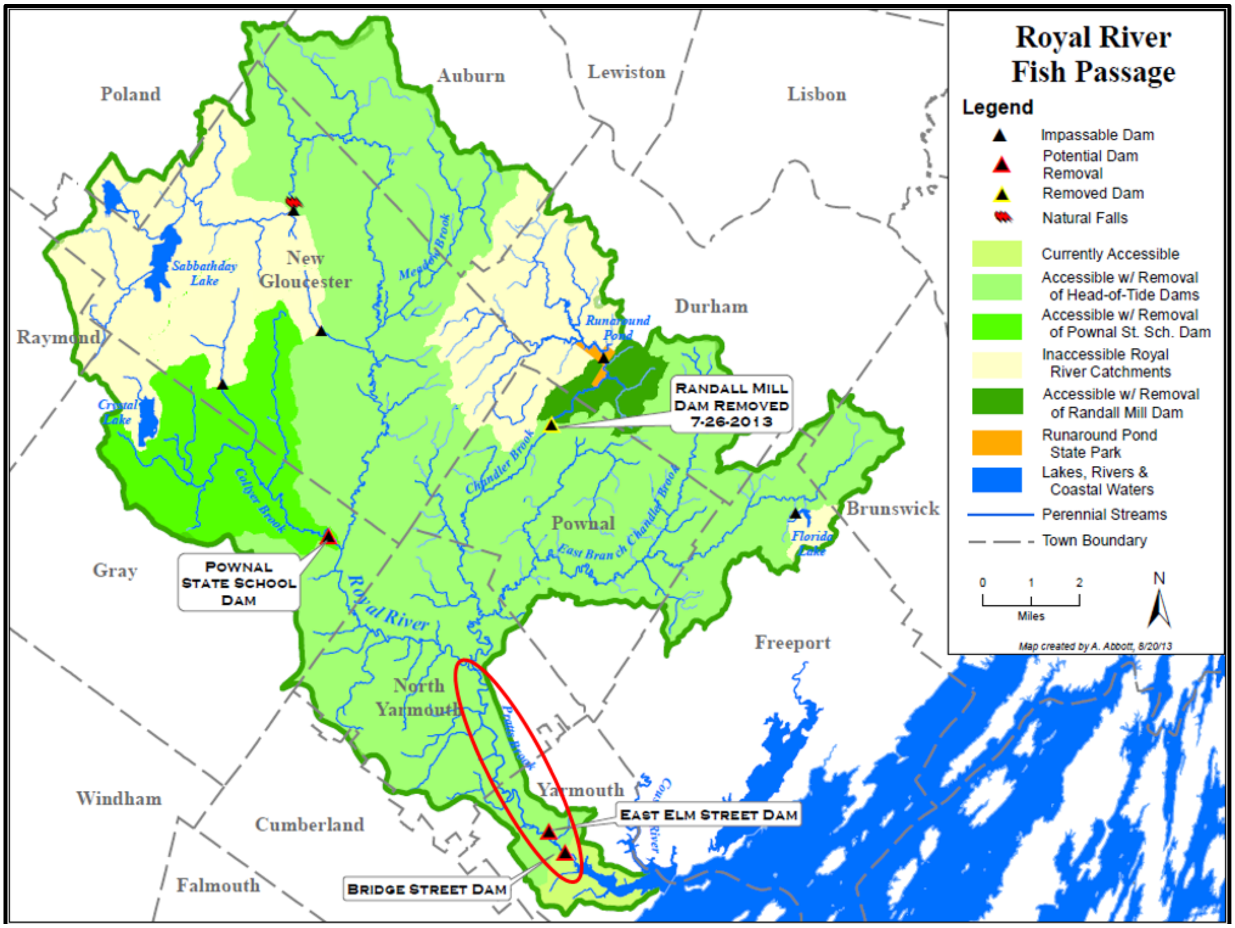


Figure 18: Royal River Aquatic organism Passage. Study area circled in red
(Source: Gulf of Maine Coastal Program, U.S. Fish and Wildlife Service, 2013)

For input to the hydraulic modeling described later in this report, it was necessary to determine stream flows over the range of natural variability for the Royal River through the reach of interest near Bridge Street Dam and the East Elm Street Dam. The U.S. Geological Survey (USGS) has recorded flows on the Royal River at a gage (gage #01060000) at Yarmouth, Maine, from 1949 to 2023, with a gap from 2004-2019. The gage has been located at, or near, the head-of-tide at First Falls for this period of record. Given the minimal decrease in contributory drainage area between the Yarmouth USGS gage and the estimated upstream limits of the study area near Route 9 (141 sq. mi. vs. 133 sq. mi., respectively, or less than 6 percent reduction), and lack of significant tributary inputs, flow data was used directly from the gage, without adjustment, for further analysis.

5.1.1 Daily Flows

Daily stream flow data for USGS gage 0106000 from the previous 59 years (October 1949-September 2004; October 2019-September 2023) (**Figure 19**) were assessed to determine flow-duration statistics for representative ‘normal’ (Annual Median Flow) conditions, monthly means and duration exceedances, and low flow conditions (7Q10).

The 7-day, 10-year (7Q10) annual low-flow statistics are based on an annual series of the smallest values of mean discharge computed over any 7-consecutive days during the annual period. A probability distribution is fit to the annual series of 7-day minimums, and the 7Q10 statistic is the annual 7-day minimum flow with a 10-year recurrence interval (nonexceedance probability of 10 percent).

Figure 20 below depicts the daily average flow duration curve for the entire year at the USGS gage, and **Figure 21** presents the daily average flow duration exceedance curve.

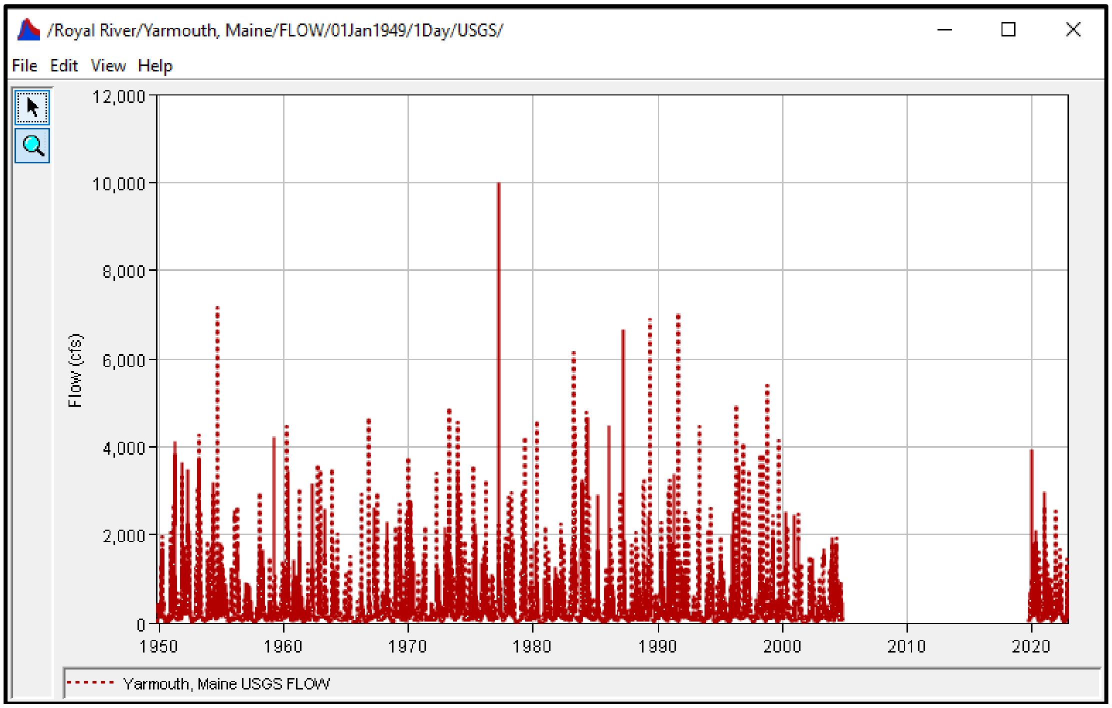


Figure 19: Royal River 1-Day Averaged Flows 1949-2023

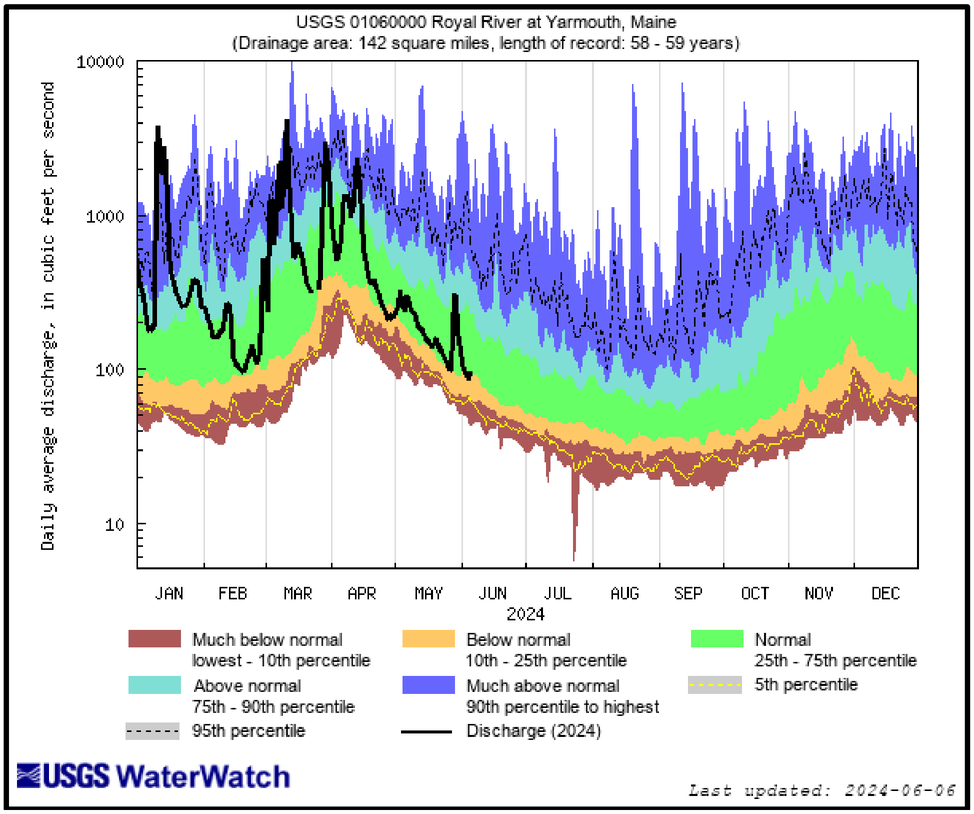


Figure 20: Annualized Daily Average Flow Statistics

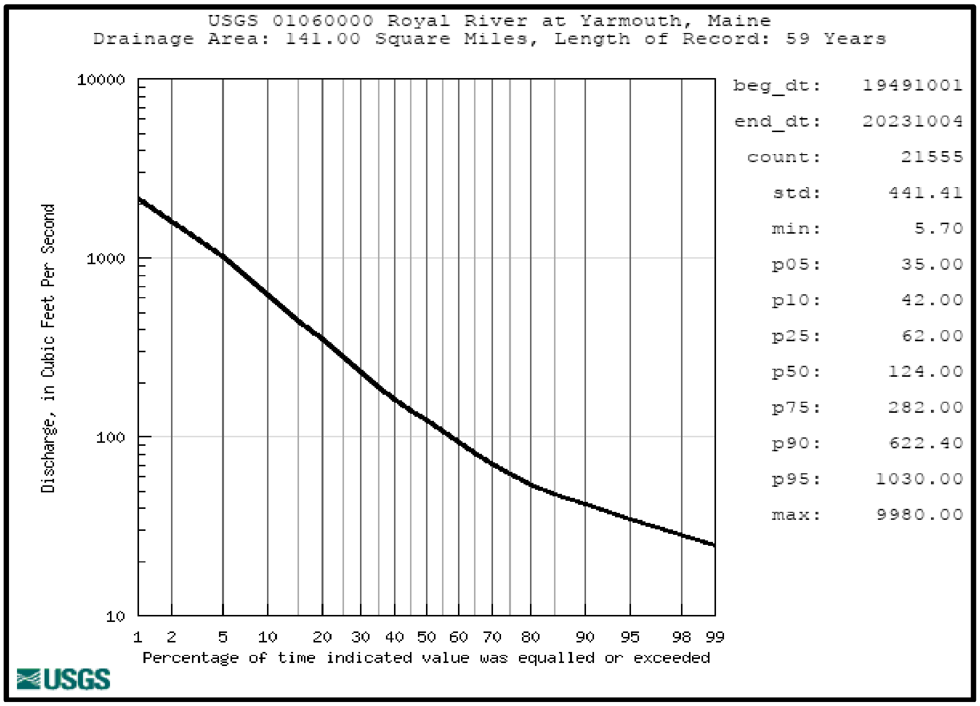


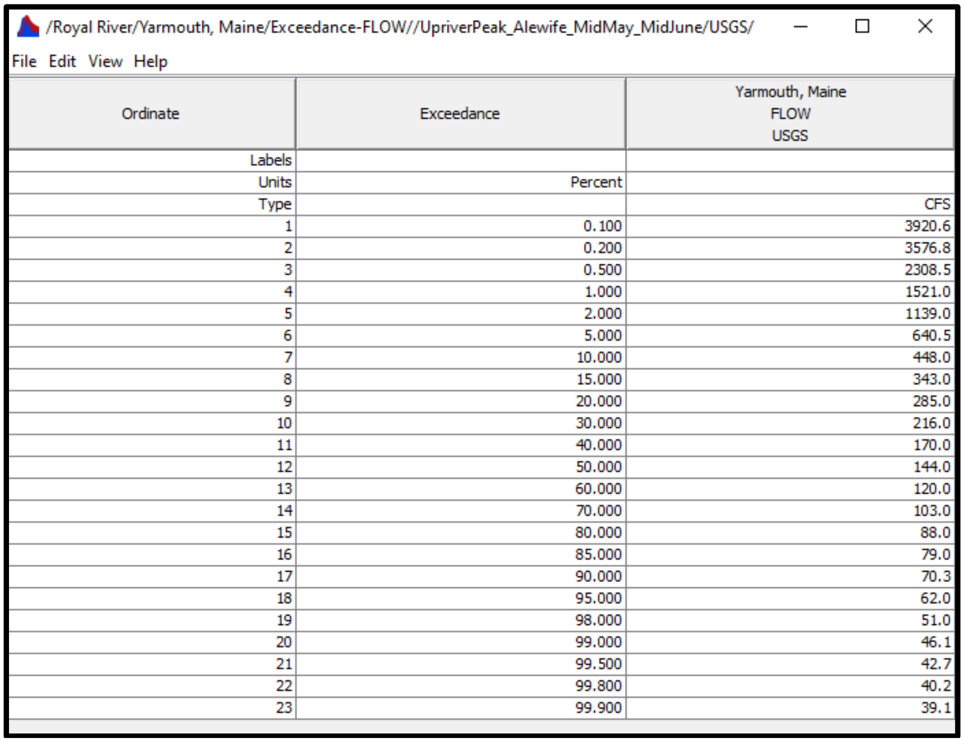
Figure 21: Flow Duration Curve Royal River

For the 7Q10, the project team utilized HEC-DSSVue version 3.3.29 with the full period of record daily flows from the Royal River stream gage, to determine the smallest values of mean discharge computed over any 7-consecutive days during each water year using a 7-day forward moving average. HEC-DSSVue was also used to fit an exceedance probability distribution to the annual series of 7-day minimums, resulting in a 7Q10 of 25 cfs. It was noted that this is similar to results published from the USGS of 24 cfs (Dudley, 2004), and the value reported in the Stantec 2013 report (23 cfs).

The Annual Median flow for the USGS gage is reported in the Stantec 2013 study to be 120 cfs. This value was adopted for this study after favorable comparison to the updated 50% exceedance statistics included in **Figure 21**.

Daily average flows for the period of record were imported into HEC-DSSVue (version 3.3.29) to derive migration season flow duration exceedance curves. For the Mid-May to Mid-June peak Alewife upriver passage, the Royal River flows for low (95% duration exceedance), average (50%), and high (5% duration exceedance) are 62 cfs, 144 cfs, and 641 cfs respectively, as shown in **Table 3**. The full May-June upriver migration period values are similar: 53 cfs, 149 cfs, and 706 cfs respectively. These discharges were compiled for use in the hydraulic model, specifically for evaluation of measures and conceptual designs, as described in later sections.

Table 3: Peak Upriver Migration Flow Duration Statistics — Mid-May to Mid-June



Ordinate	Exceedance	Yarmouth, Maine FLOW USGS
Labels		
Units	Percent	
Type		CFS
1	0.100	3920.6
2	0.200	3576.8
3	0.500	2308.5
4	1.000	1521.0
5	2.000	1139.0
6	5.000	640.5
7	10.000	448.0
8	15.000	343.0
9	20.000	285.0
10	30.000	216.0
11	40.000	170.0
12	50.000	144.0
13	60.000	120.0
14	70.000	103.0
15	80.000	88.0
16	85.000	79.0
17	90.000	70.3
18	95.000	62.0
19	98.000	51.0
20	99.000	46.1
21	99.500	42.7
22	99.800	40.2
23	99.900	39.1

5.1.2 Flood Flows

Flood flows were also necessary for use in the hydraulic model, to assess potential water surface impacts and the range of velocity/shear stress resulting from evaluated measures during the high flow events. Peak flow statistics for the Royal River were adopted from the recently updated Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Cumberland County, Maine (dated June 20, 2024).

Peak flows were available for the 10%, 2%, 1%, and 0.2% annual exceedance probability (AEP) (a.k.a. the 10-, 50-, 100-, and 500-yr annual recurrence interval (ARI)) storm events and it was noted that hydrologic calculations to support the FEMA FIS were completed in the 1980s. As such, an updated flood frequency analysis was completed using the USACE Hydrologic Engineering Center's Statistical Software Package (HEC-SSP), utilizing recommended Bulletin 17C procedures. The 15-year period from OCT2004-SEP2019 was censored because the gage was not operational. Flood frequency flows were determined for a range of standard frequency events. Results of the flood frequency analysis are shown in **Figure 22** and **Table 4** below.

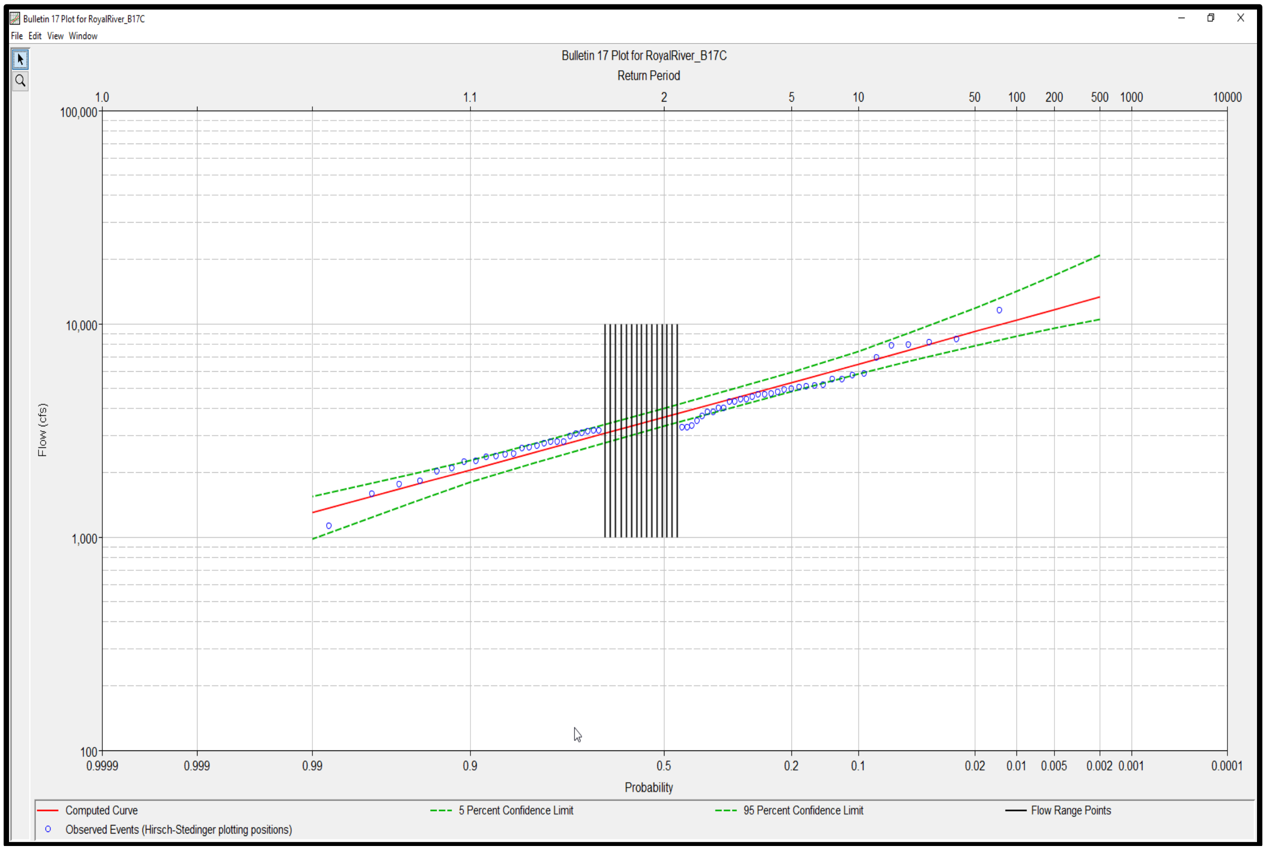


Figure 22: Flood Frequency Analysis Results

Table 4: Flood Frequency Analysis Results

Annual Chance Exceedance	Average Recurrence Interval (year)	Computed Curve (Flow, cfs)	Confidence Limits (Flow, cfs)		USGS StreamStats Flows (cfs)	FEMA FIS Flows (cfs)		Adopted Flows (cfs)
			0.05	0.95		At USGS gage 01060000	At Route 9 in North Yarmouth	
0.2	500	13,415	20,997	10,530	14,300	14,540	13,820	----
0.5	200	11,678	16,867	9,522	----	----	----	----
1	100	10,419	14,189	8,729	11,000	10,530	10,020	10,419
2	50	9,200	11,841	7,903	9,710	9,060	8,850	----
5	20	7,639	9,174	6,751	----	----	----	----
10	10	6,480	7,447	5,820	6,780	6,085	6,540	6,480
20	5	5,314	5,924	4,824	5,540	----	----	----
50	2	3,643	3,998	3,321	3,740	----	----	3,643
80	1.25	2,506	2,758	2,253	----	----	----	----
90	1.11	2,063	2,293	1,803	----	----	----	----
95	1.05	1,759	1,984	1,475	----	----	----	----
99	1.01	1,305	1,551	975	----	----	----	----

Updated frequency flows were similar to FEMA FIS flows available for comparison. All published FIS values are within the confidence limits of the flood frequency analysis. The FIS peak flows support the updated analysis flows which were then adopted for this study. As with the daily flows, USGS gage data was utilized directly without adjusting for slight increase in drainage area between the USGS gage and the upstream limits.

The final peak discharges for each modeled event are summarized in **Table 5**.

Table 5: Summary of Peak Discharges

Modeled Event	Peak Discharge (cfs)
7Q10	25
Annual Median	120
95% Exceedance MidMay-MidJune	62
5% Exceedance MidMay-MidJune	641
50% AEP	3,643
10% AEP	6,480
1%AEP	10,419
10-22DEC2019	4,300

For relative comparison, the flood of record on the Royal River occurred on March 13, 1977, and had a peak discharge of 11,500 cfs. Records from the 1977 event are not refined enough to develop a hydrograph, so the hydrograph of the 10-22 DEC 2019 storm event (peak discharge 4,300 cfs) was utilized for model validation and to inform the 1% AEP modeled event. Specifically, the 10-22 DEC 2019 storm event hydrograph was scaled by a factor of 2.42 to match historic hydrograph to the 1% AEP peak discharge.

5.2 HYDRAULICS

A hydraulic model for the reach of interest was necessary to simulate the range of anticipated water surface elevation and velocity resulting from each of the alternatives and was used to inform conceptual design of bank stabilization and in-stream structures.

5.2.1 Model Development

The USACE Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) model was utilized for this analysis, given the software capability for two-dimensional (2D) unsteady flow calculations. HEC-RAS version 6.1 was initially utilized for terrain and initial model development at the beginning of the study, with version 6.4.1 utilized for model finalization, computations, and alternative evaluation. The alternatives were simulated under a range of hydrologic loading conditions that include low-flow through extreme loading scenarios.

5.2.1.1 Domain

For the 2D model domain, a perimeter was established for the full study area extending from the downstream end of the estuary near Parker Point to approximately 750-feet upstream of Memorial Highway (State Route 9). The State Route 9/Baston Park vicinity was selected as the upper limit of the feasibility-level HEC-RAS hydraulic model domain based on previous studies (primarily Stantec 2013), their findings, and data availability. Specifically, the Stantec 2013 hydraulic model & report indicated that modeling up to State Route 9 / Baston Park vicinity should capture most of the impacts. Plus, State Route 9/Baston Park vicinity is the upstream limit of the available, detailed channel bathymetry. The model domain is shown in **Figure 23.**

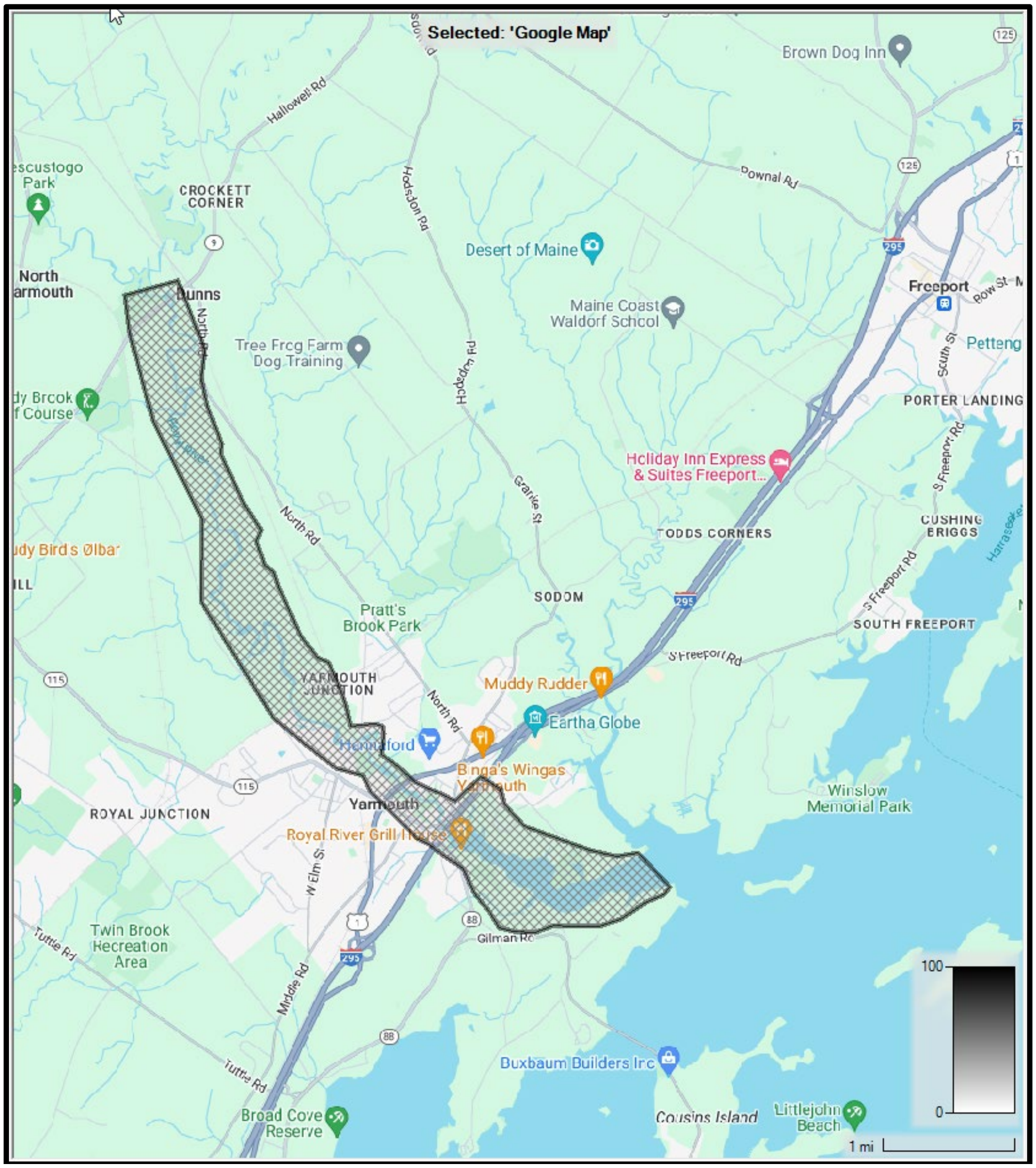


Figure 23: Royal River 2D Model Domain

5.2.1.2 Terrain

Model terrain was developed from the best available topographic and bathymetric data for the study area. This included: site surveys, bathymetric surveys, Digital Elevation Models (DEM), and LiDAR data. For assembly, all elevation sources (**Table 6**) were converted to the NAVD88 vertical datum, with units in feet, while the horizontal projection is NAD_1983_NSRS2007_StatePlane_Maine_West_FIPS_1802_Ft_US, with units in feet. Terrain processing was primarily performed in the HEC-RAS Ras Mapper utility, supplemented by ESRI ArcMap 10.6.1.

Table 6: Royal River Model Terrain Sources

Site Surveys	• Plan of Topographic Survey Bridge Street – Titcomb Associates (2013)
	• Plan of Topographic Survey East Elm Street– Titcomb Associates (2013)
	• Spot Elelvations Bridge Street & Elm Street Dams – Interfluve/University of Southern Maine (2016)
Bathymetry	• Elm Street Dam Impoundment - USACE (2022)
	• After Dredge Survey-ROY2769 - USACE (2015)
	• East Elm Street to Rt 9 – Stantec (2013)
	• Bridge Street Dam Impoundment - Stantec (2009/2010)
	• FEMA FIS XS Inverts and spot survey – FEMA (1979/1980)
LiDAR	• Lidar me_southcoastal_1_2020 las (USGS 3DEP)(2020) ○ for in-channel boulders & ledge
DEMs & DEM generated contours	• USGS 1 Meter - ME South Coastal - 1m resolution – 2020 (USGS 3DEP)
	• Geollibrary DEM 2013.08MAR22 - 1m resolution – Maine_Elevation_DEM_Aggregate - State of Maine (2013)
	• USGS 1/3 arc second - 10m resolution – 2021 (USGS 3DEP)

Approximate top of sediment bathymetry associated with the recent sediment probe data collected by USACE and Stantec were not explicitly incorporated into the terrain model, however the data was reviewed and found to generally match the terrain model.

A topographic work map displaying the terrain model is included in **Attachment B** of this appendix.

5.2.1.3 Structures

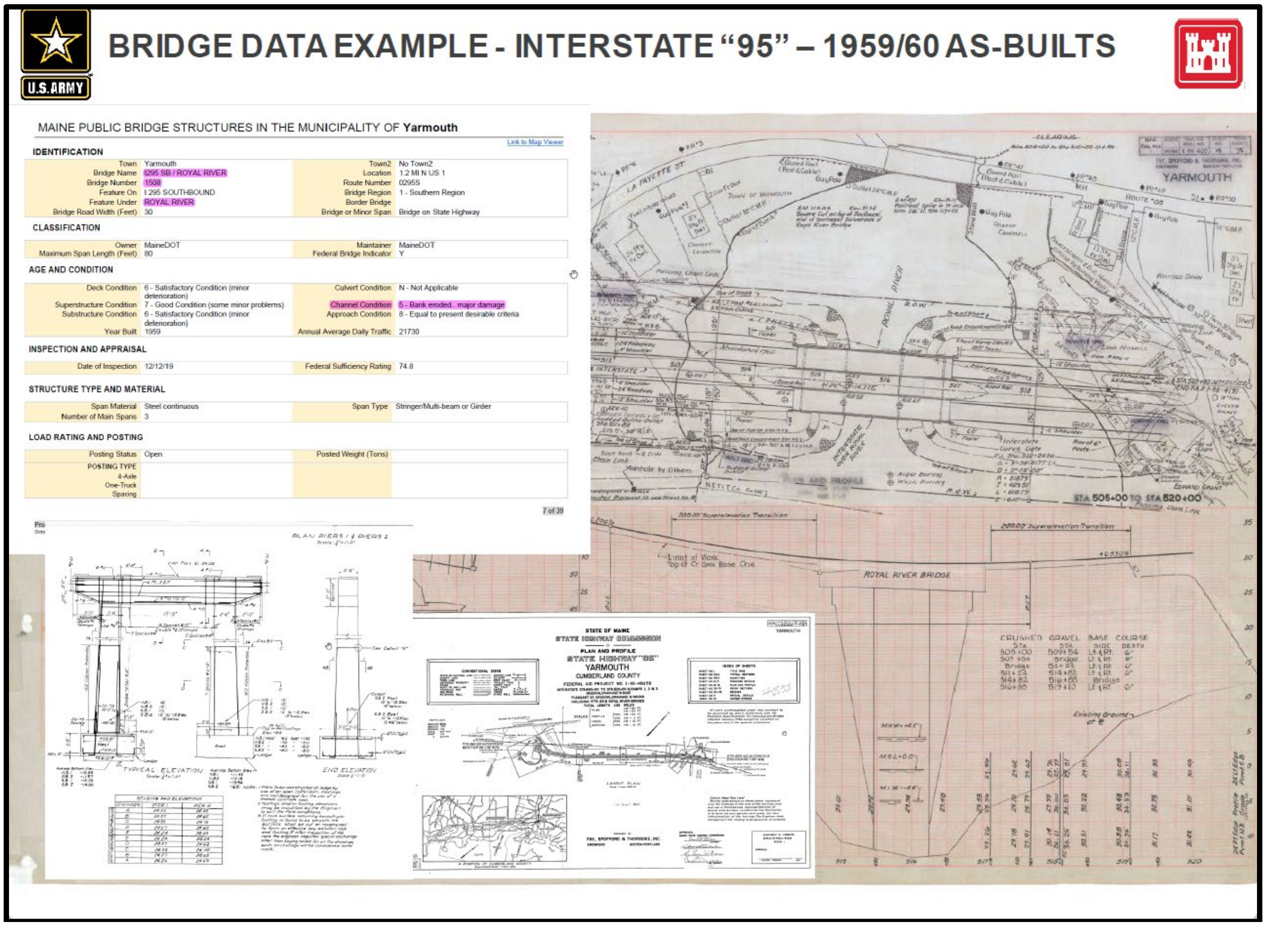
Existing hydraulic structures were incorporated into the HEC-RAS model domain as SA2D Connections. Correspondingly, modifications were added to the terrain model to represent substructure features. The primary difference between the Existing (without project) and TSP (with Project) hydraulic models are how the Bridge Street Dam and East Elm Street Dam are represented through SA2D Connections and terrain modifications, as well as the 2D computational mesh in the vicinity of the dams.

Dimensional information for the 2 dams (Bridge Street Dam, Elm Street Dam), 9 bridges that cross the Royal River, and 1 culvert at Foundry Channel are based on best available information as summarized in **Table 7**.

Table 7: Royal River Model Hydraulic Structure Information

Hydraulic Structure	Primary Reference
Bridge Street Dam	Titcomb Associates site survey (2013) / Interfluve/University of Southern Maine (2016)
East Elm Street Dam	
Interstate-295 Northbound & Southbound Bridges	MaineDOT MEPLANS As-Builts
MainStreet / Route 88 / Falls Bridge	
Bridge Street / Cotton Mill Bridge	
US Route 1 Bridge	
East Elm Street Bridge / Foundry Channel culvert	
Memorial Highway / State Route 9 / Dunns Bridge	
Beth Condon Memorial Footbridge	Town of Yarmouth As-Builts
Grand Trunk Railroad Bridge	Stantec 2013 HEC-RAS Geometry
Maine Central Railroad Bridge	

Note that all elevation data that was converted to NAVD88, if not natively in that vertical datum. Dam information was primarily derived from the Titcomb Associates site surveys and the Interfluve dataset. As-built plans were retrieved from the MaineDOT MEPLANS application in May 2022 for Interstate-295, Falls Bridge/MainStreet/Route 88, Cotton Mill/Bridge Street, US Route 1, Elm Street, and Memorial Highway/State Route 9/ Dunns bridges. As-built information for the Beth Condon Footbridge was provided by the Town of Yarmouth. As-built information for the Grand Trunk Railroad and Maine Central Railroad bridges was not readily available and thus the model geometry for these structures was based on the Stantec 2013 1-dimensonal hydraulic model. An excerpt of the Interstate-295 as-builts is provided in **Figure 24**. Available pertinent as-built plans are included in **Attachment B**.



BRIDGE DATA EXAMPLE - INTERSTATE “95” – 1959/60 AS-BUILTS

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	I295 SB / ROYAL RIVER	Location	1.2 MI N US 1
Bridge Number	1508	Route Number	0295S
Feature On	I 295 SOUTHBOUND	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	30	Bridge or Minor Span	Bridge on State Highway

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	80	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	7 - Good Condition (some minor problems)	Channel Condition	5 - Bank eroded.. major damage
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1959	Annual Average Daily Traffic	21730

INSPECTION AND APPRAISAL

Date of Inspection	12/12/19	Federal Sufficiency Rating	74.8

STRUCTURE TYPE AND MATERIAL

Span Material	Steel continuous	Span Type	Stringer/Multi-beam or Girder
Number of Main Spans	3		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE 4-Axle One-Truck Spacing			

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Figure 24: Royal River Bridge Data Example

Additionally, the Elm Street culvert on Foundry Channel was included in the model domain based on field measurements by USACE staff. The Elm Street culvert on Foundry Channel was measured at the downstream face and generalized to be 12-feet span and 8-feet rise, with an irregular bottom and 2-ft of cover between the crown and roadway surface. This information has been used to update the hydraulic model.

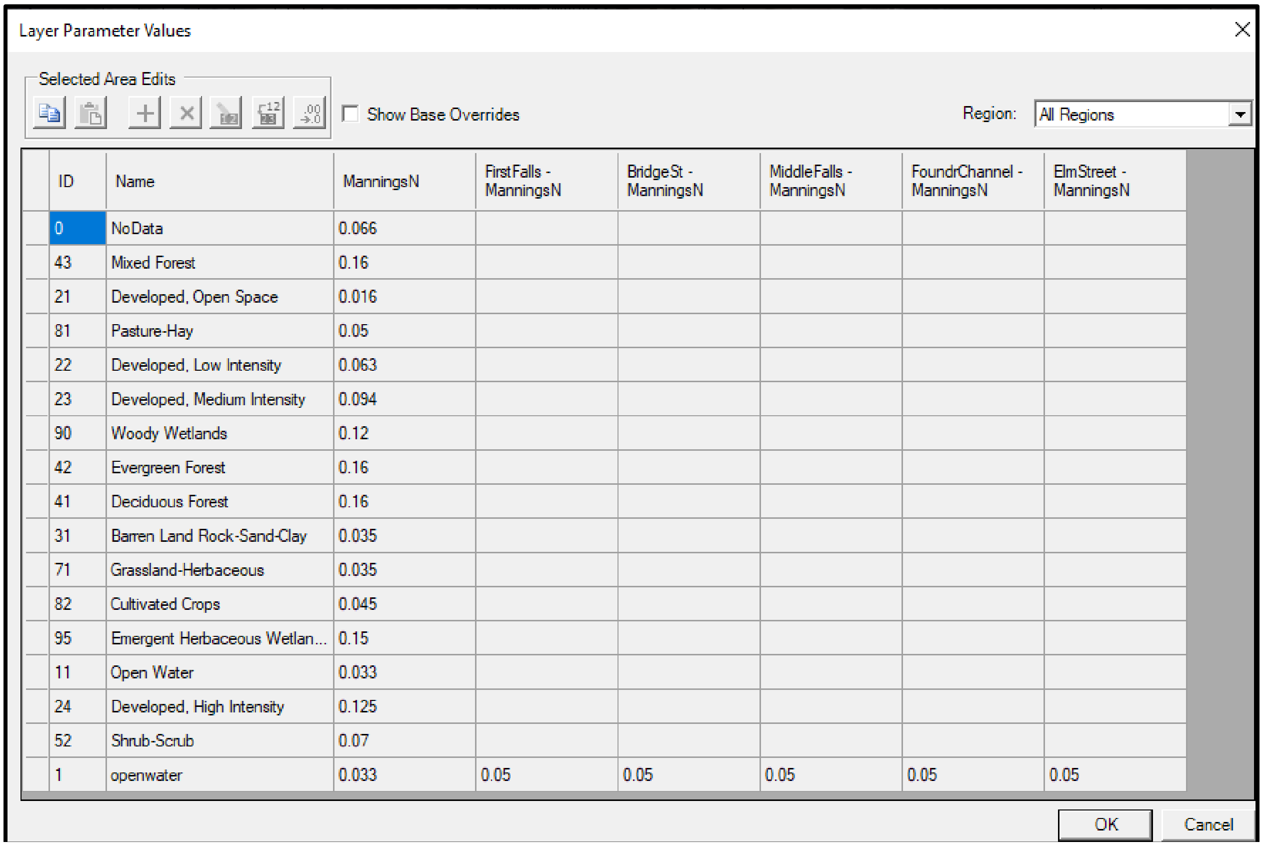
5.2.1.4 Roughness/Land Use

Roughness coefficients represent the resistance to flow in channels and floodplains. Roughness is usually presented in the form of a Manning's n value in HEC-RAS. The value of Manning’s n is highly variable and depends on a number of factors including: surface roughness; vegetation; channel irregularities; channel alignment; scour and deposition; obstructions; size and shape of the channel; stage and discharge; seasonal changes; temperature; and suspended material and bedload. Because Manning’s n depends on many factors, several options are available in HEC-RAS to vary n.

The process to assign roughness coefficients initially assigned Manning’s “n” values to the model domain based on land use classifications in the spatially varying National

Land Cover Database (NLCD) 2019. The georeferenced NLCD 2019 grid was imported into the HEC-RAS model domain and Manning's "n" values were assigned following a review of typical ranges presented in the HEC-RAS 2D User's Manual. The NLCD 2019/Manning's n association for Royal River is shown in **Table 8**.

Table 8: Royal River Roughness Coefficients Based on Land Cover



☐ Show Base Overrides

Region: All Regions

ID	Name	ManningsN	FirstFalls - ManningsN	BridgeSt - ManningsN	MiddleFalls - ManningsN	FoundrChannel - ManningsN	ElmStreet - ManningsN
0	NoData	0.066					
43	Mixed Forest	0.16					
21	Developed, Open Space	0.016					
81	Pasture-Hay	0.05					
22	Developed, Low Intensity	0.063					
23	Developed, Medium Intensity	0.094					
90	Woody Wetlands	0.12					
42	Evergreen Forest	0.16					
41	Deciduous Forest	0.16					
31	Barren Land Rock-Sand-Clay	0.035					
71	Grassland-Herbaceous	0.035					
82	Cultivated Crops	0.045					
95	Emergent Herbaceous Wetlan...	0.15					
11	Open Water	0.033					
24	Developed, High Intensity	0.125					
52	Shrub-Scrub	0.07					
1	openwater	0.033	0.05	0.05	0.05	0.05	0.05

The land use classification polygons were refined to establish the stream corridor as "openwater" through the study area based primarily upon boundaries in the Town of Yarmouth parcel database. It was noted that the referenced n values are for appreciable depths of flow and are not meant for shallow overland flow. Shallow, overland flow Manning's n values are generally much higher due to the relative roughness compared to the flow depth. Therefore, additional Manning's calibration regions were added for each of the four sets of falls, plus the Foundry Channel, and are discussed in more detail in the calibration section of this appendix. The spatial extents of the final Manning's values are shown in **Figure 25**.

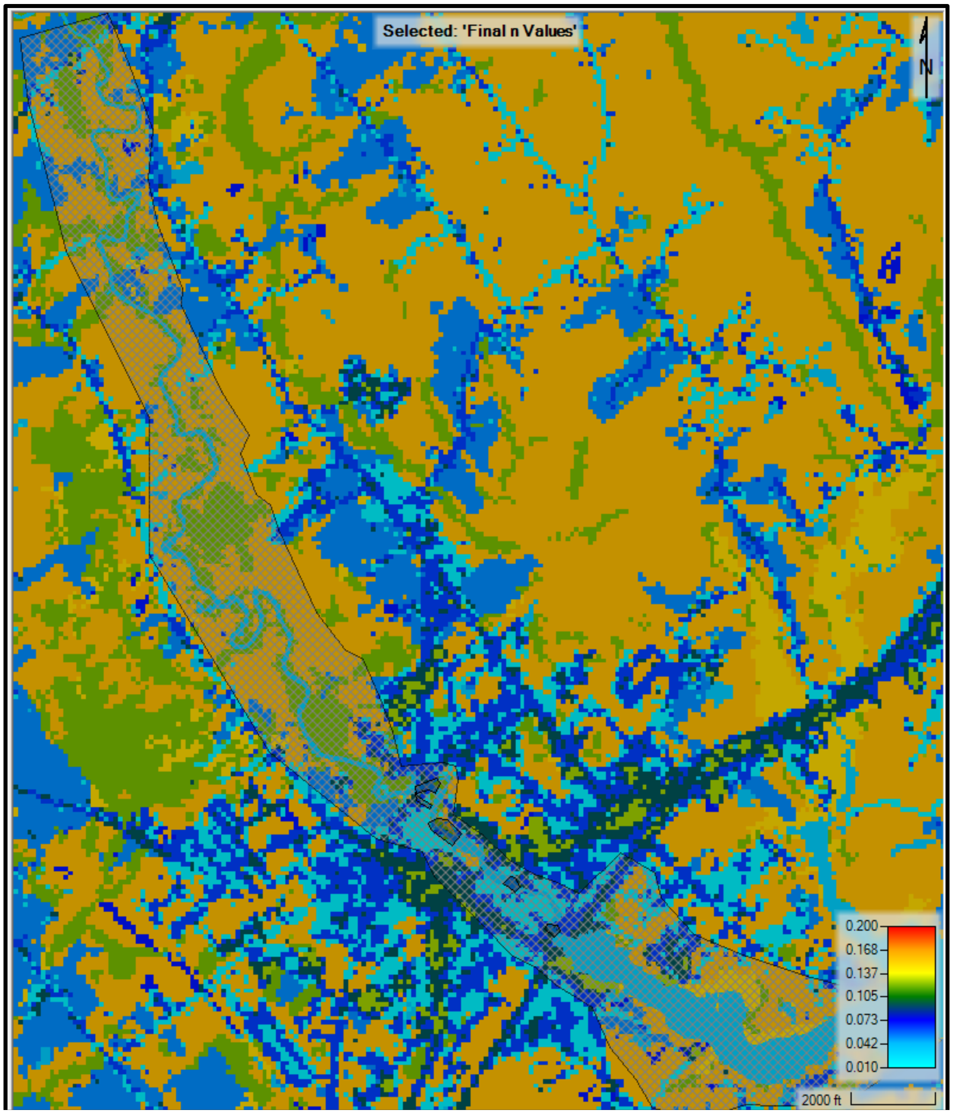


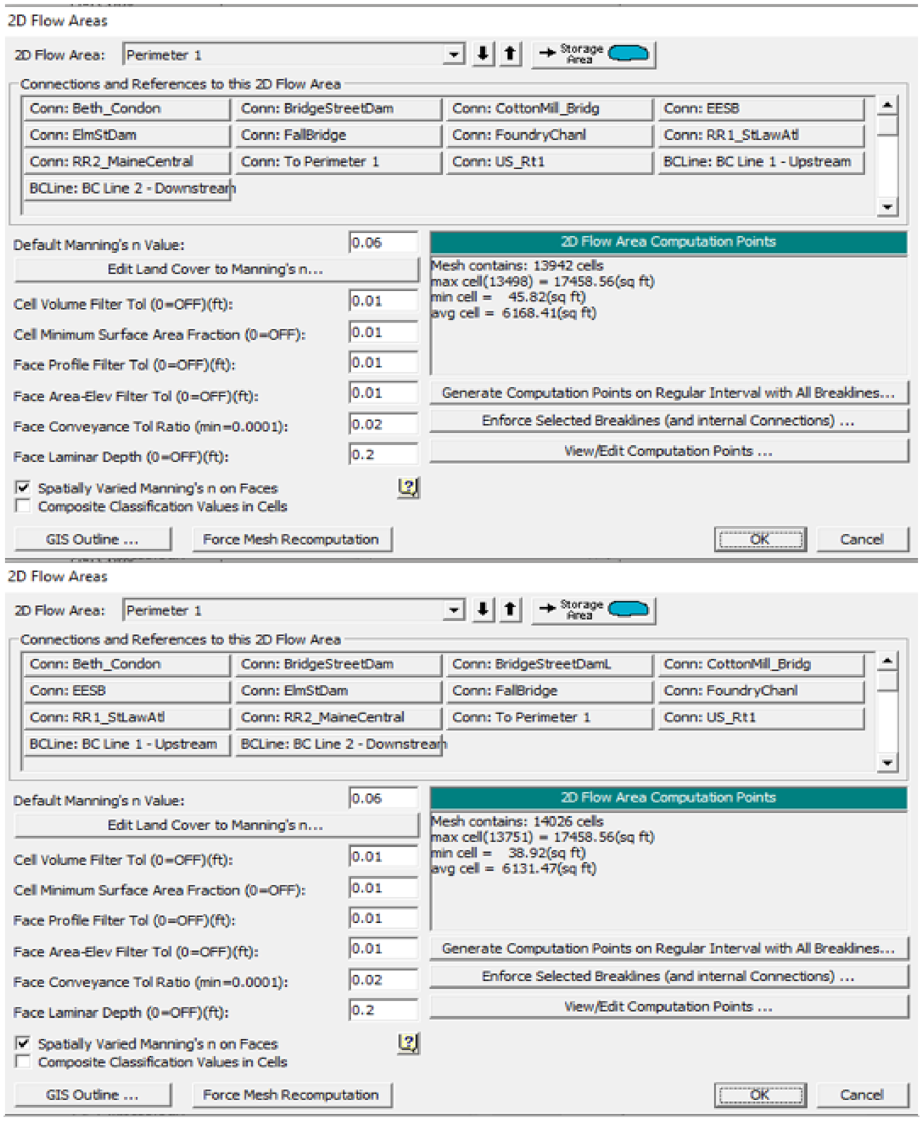
Figure 25: Royal River Final Roughness Coefficients

5.2.1.5 *Computational 2D Mesh/Breaklines*

The 2D computational grid was developed with Default point spacing of 80ft x 80 ft, and is summarized in **Table 9** while computational settings are shown in **Figure 26**.

Table 9: Royal River 2D Computational Mesh Properties

Geometry: Existing_2D_19JUL24	Geometry: TSP_2D_19JUL24
Number of Cells = 13942 Average Face Length = 79 ft. Average Cell Size = 6,168 sq.ft. Maximum Cell Size = 17,459 sq.ft. Minimum Cell Size = 46 sq.ft.	Number of Cells = 14026 Average Face Length = 78 ft Average Cell Size = 6,131 sq ft Maximum Cell Size = 17,459 sq ft Minimum Cell Size = 39 sq ft



2D Flow Area: Perimeter 1

Connections and References to this 2D Flow Area

Conn: Beth_Condon
Conn: BridgeStreetDam
Conn: CottonMill_Bridg
Conn: EESB
Conn: ElmStDam
Conn: FallBridge
Conn: FoundryChanl
Conn: RR1_StLawAtl
Conn: RR2_MaineCentral
Conn: To Perimeter 1
Conn: US_Rt1
BCLine: BC Line 1 - Upstream
BCLine: BC Line 2 - Downstream

Default Manning's n Value: 0.06
Cell Volume Filter Tol (0=OFF)(ft): 0.01
Cell Minimum Surface Area Fraction (0=OFF): 0.01
Face Profile Filter Tol (0=OFF)(ft): 0.01
Face Area-Elev Filter Tol (0=OFF)(ft): 0.01
Face Conveyance Tol Ratio (min=0.0001): 0.02
Face Laminar Depth (0=OFF)(ft): 0.2
☑ Spatially Varied Manning's n on Faces
☐ Composite Classification Values in Cells

Mesh contains: 13942 cells
max cell(13498) = 17458.56(sq ft)
min cell = 45.82(sq ft)
avg cell = 6168.41(sq ft)

2D Flow Area: Perimeter 1

Connections and References to this 2D Flow Area

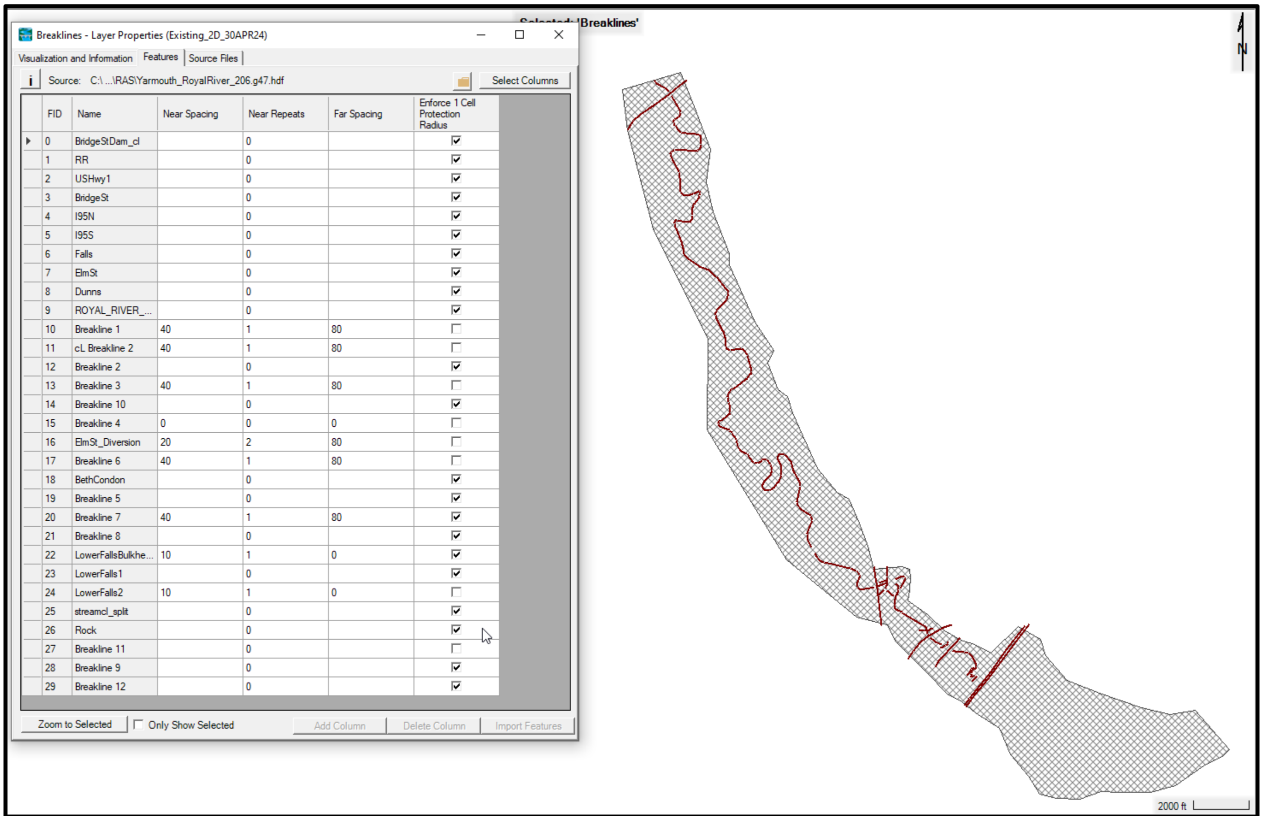
Conn: Beth_Condon
Conn: BridgeStreetDam
Conn: BridgeStreetDamL
Conn: CottonMill_Bridg
Conn: EESB
Conn: ElmStDam
Conn: FallBridge
Conn: FoundryChanl
Conn: RR1_StLawAtl
Conn: RR2_MaineCentral
Conn: To Perimeter 1
Conn: US_Rt1
BCLine: BC Line 1 - Upstream
BCLine: BC Line 2 - Downstream

Default Manning's n Value: 0.06
Cell Volume Filter Tol (0=OFF)(ft): 0.01
Cell Minimum Surface Area Fraction (0=OFF): 0.01
Face Profile Filter Tol (0=OFF)(ft): 0.01
Face Area-Elev Filter Tol (0=OFF)(ft): 0.01
Face Conveyance Tol Ratio (min=0.0001): 0.02
Face Laminar Depth (0=OFF)(ft): 0.2
☑ Spatially Varied Manning's n on Faces
☐ Composite Classification Values in Cells

Mesh contains: 14026 cells
max cell(13751) = 17458.56(sq ft)
min cell = 38.92(sq ft)
avg cell = 6131.47(sq ft)

Figure 26: Royal River 2D Computational Mesh Settings Geometry: Existing_2D_19JUL24 & TSP_2D_19JUL24

Breaklines were added to align the 2D computational grid with the Royal River, plus significant topographic features, and infrastructure. Specifically, twenty-nine (29) breaklines were defined as shown in **Figure 27**.



Breaklines - Layer Properties (Existing_2D_30APR24)

Source: C:\ ...\RAS\Yarmouth_RoyalRiver_206.g47.hdf

FID	Name	Near Spacing	Near Repeats	Far Spacing	Enforce 1 Cell Protection Radius
0	BridgeStDam_cl		0		☑
1	RR		0		☑
2	USHwy1		0		☑
3	BridgeSt		0		☑
4	I95N		0		☑
5	I95S		0		☑
6	Falls		0		☑
7	ElmSt		0		☑
8	Dunns		0		☑
9	ROYAL_RIVER_...		0		☑
10	Breakline 1	40	1	80	☐
11	cL Breakline 2	40	1	80	☐
12	Breakline 2		0		☑
13	Breakline 3	40	1	80	☐
14	Breakline 10		0		☑
15	Breakline 4	0	0	0	☐
16	ElmSt_Diversion	20	2	80	☐
17	Breakline 6	40	1	80	☐
18	BethCondon		0		☑
19	Breakline 5		0		☑
20	Breakline 7	40	1	80	☑
21	Breakline 8		0		☑
22	LowerFallsBulkhe...	10	1	0	☑
23	LowerFalls1		0		☑
24	LowerFalls2	10	1	0	☐
25	streamcl_split		0		☑
26	Rock		0		☑
27	Breakline 11		0		☐
28	Breakline 9		0		☑
29	Breakline 12		0		☑

Figure 27: Royal River Breaklines

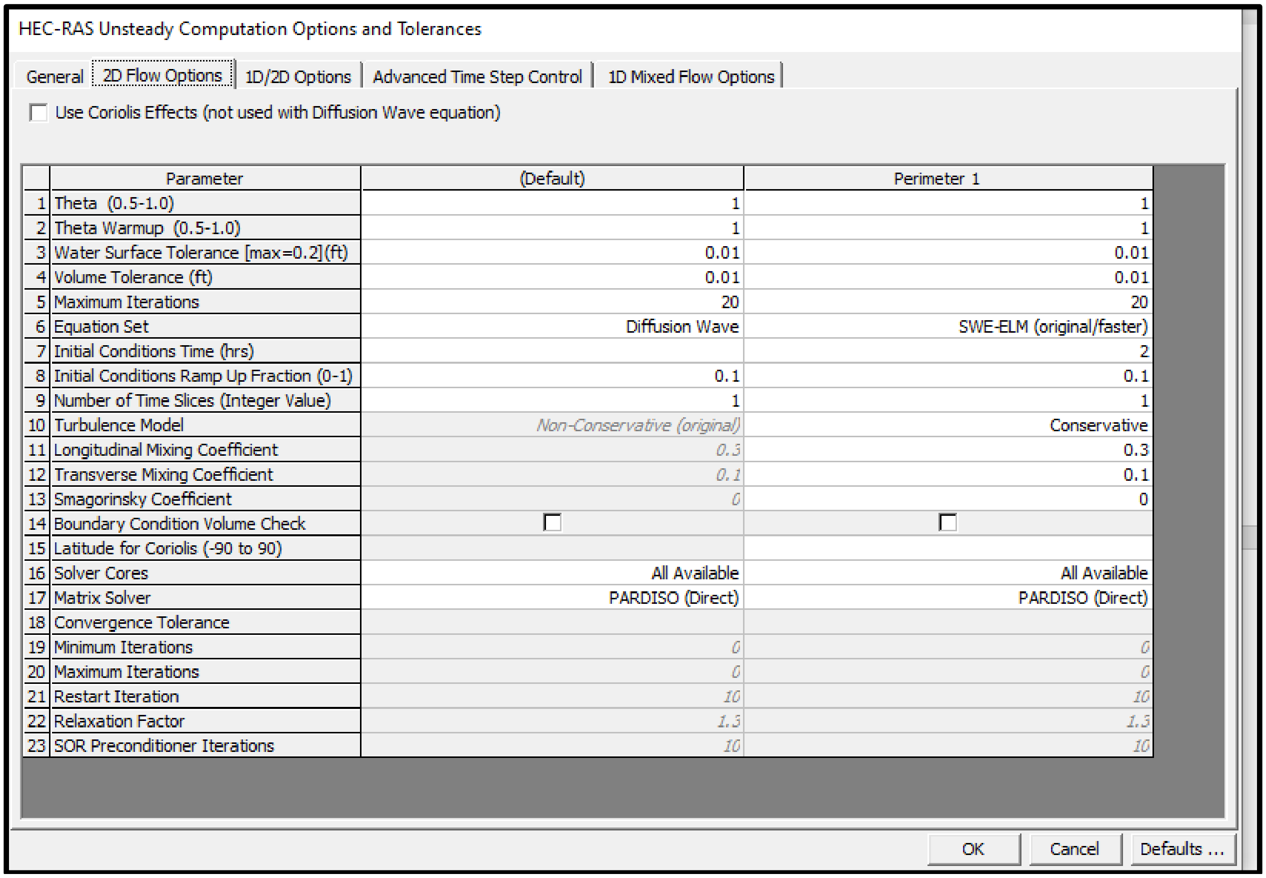
5.2.1.6 Boundary Conditions

<u>Flow</u>

- Normal Depth distribution at upstream boundary
- 7Q10, Annual Median Flow, 10%, 2%, 1%, and 0.2% AEP flood events as constant hydrograph flows. Each flow event has a constant flow hydrograph for the entire time series except the 1% AEP flow.
- Unsteady flow runs were performed for the 1% AEP modeled event, and the validation 10-22DEC2019 storm event.
- The hydrograph of the 10-22 DEC 2019 storm event (peak discharge 4,300 cfs) was utilized to inform the 1% AEP modeled event. Specifically, the 10-22 DEC 2019 storm event hydrograph was scaled by a factor of 2.42 to match the historic hydrograph to the 1% AEP peak discharge (10,419 cfs).
- For the Mid-May to Mid-June peak Alewife upriver passage, the Royal River flows for low (95% duration exceedance), average (50%), and high (5% duration exceedance) were also modeled with constant hydrograph flows.

Tide

- Assumed 0-ft NAVD88 for constant hydrograph run model plans, except the validation and 1% AEP model runs which are based on a storm (10-22DEC2019).
- Based on Portland, ME NOAA tide station for validation runs.
- Sensitivity to downstream boundary assumptions checked with constant tailwater runs alternately simulating the Portland NOAA tide station Upper 95% Confidence Interval, 1% AEP and the Lower 95% Confidence Interval, 1% AEP levels. More details in section 5.4 of this appendix.



HEC-RAS Unsteady Computation Options and Tolerances

☐ Use Coriolis Effects (not used with Diffusion Wave equation)

	Parameter	(Default)	Perimeter 1
1	Theta (0.5-1.0)	1	1
2	Theta Warmup (0.5-1.0)	1	1
3	Water Surface Tolerance [max=0.2](ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	SWE-ELM (original/faster)
7	Initial Conditions Time (hrs)		2
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	*Non-Conservative (original)*	Conservative
11	Longitudinal Mixing Coefficient	*0.3*	0.3
12	Transverse Mixing Coefficient	*0.1*	0.1
13	Smagorinsky Coefficient	*0*	0
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	All Available	All Available
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations	*0*	*0*
20	Maximum Iterations	*0*	*0*
21	Restart Iteration	*10*	*10*
22	Relaxation Factor	*1.3*	*1.3*
23	SOR Preconditioner Iterations	*10*	*10*

Figure 28: Royal River Computation Settings

5.2.1.6 Computational settings

- Equation Set: Shallow water (SWE-ELM)
- Turbulence - Conservative
- Timestep
  - Most model runs utilized 10 second timesteps
  - the 1% AEP and DEC19 validation runs used 3 second timesteps.
- Ramp-up & model time

- Initial Conditions time varied because runs with lower initial discharges needed more time to fill the stream (from upstream to downstream), while runs with higher discharges could do same in less time.

5.2.1.7 Profile Lines

A profile line representing the approximate Royal River stream centerline ("Royal River 1") was utilized for stream stationing and comparison purposes. In addition, profile lines were added along approximate fish passage routes through the dam sites and Middle Falls to evaluate fish passage parameters, and at intermediate locations across the channel to provide flow hydrographs and cross sections for comparison.

5.2.2 Existing Information

Existing hydraulic structures were incorporated into the HEC-RAS model domain as SA2D Connections. Correspondingly, modifications were added to the terrain model to represent substructure features. The primary difference between the Existing (without project) and TSP (with Project) hydraulic models are how the Bridge Street Dam and East Elm Street Dam are represented through SA2D Connections and terrain modifications, as well as the 2D computational mesh in the vicinity of the dams. Similarly, the two alternatives evaluated prior to TSP selection, full and partial dam removals, were also represented through SA2D Connections and terrain modifications, as well as the 2D computational mesh in the vicinity of the dams.

5.2.3 Calibration/Validation

Due to lack of quality High Water Marks that could be used for model calibration, Manning's n values in the Calibration Regions were initially adjusted to produce hydraulic results at the USGS Gage (01060000) that would generally match the published gaging station rating curve. Five model runs with Manning's n values ranging from 0.033 to 0.18, all assuming tailwater at a constant 0 ft, NAVD88, were compared to the station rating curve (**Figure 29**). Calibration Region n=0.05 was visually observed to match best and was adopted for this study. Model result sensitivity to Manning's n roughness coefficients was evaluated and is discussed in **Section 5.4**.

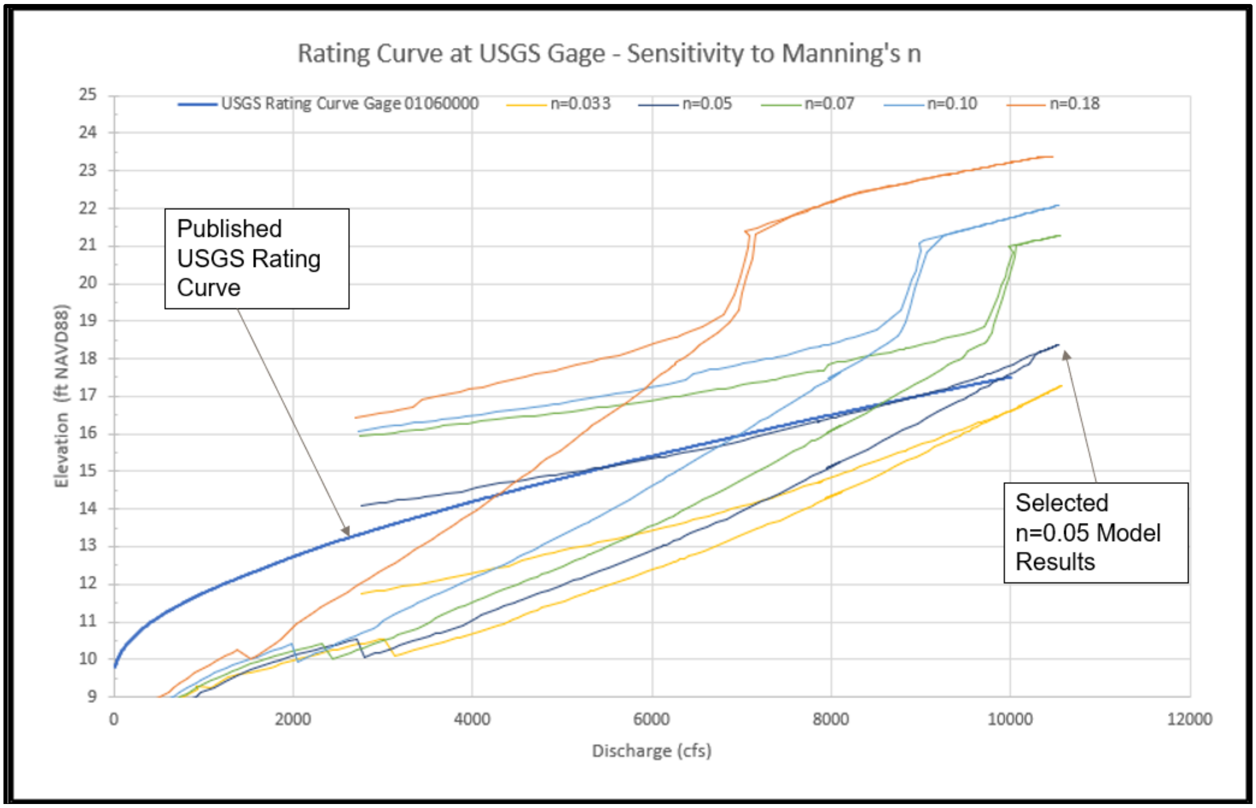
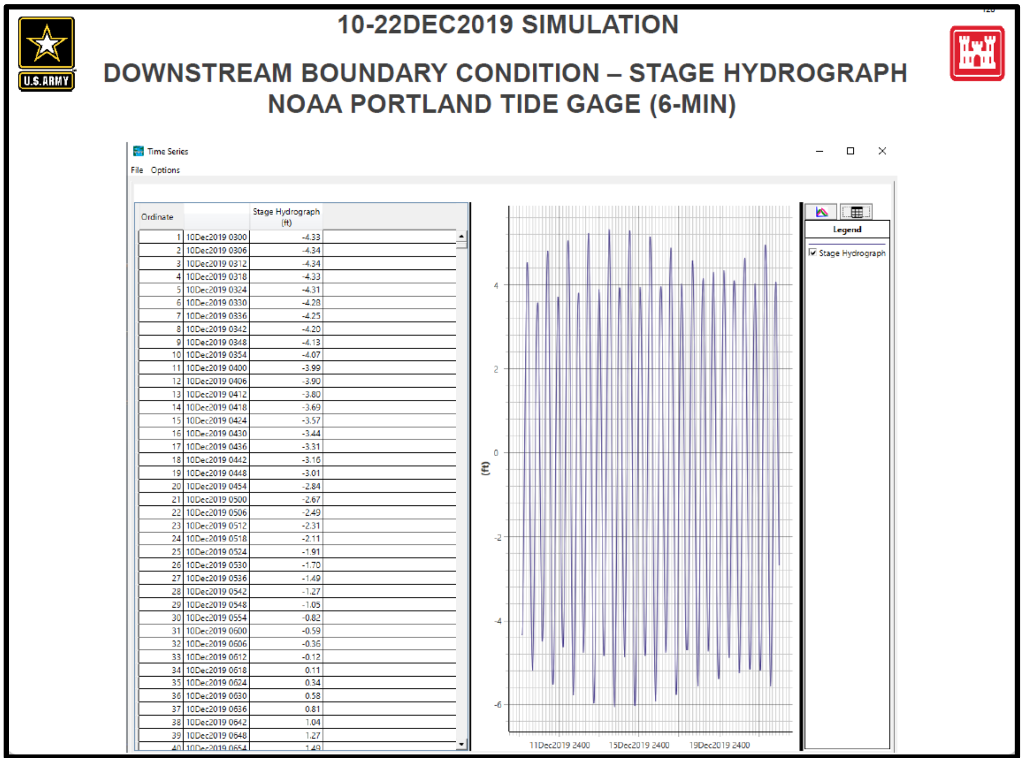


Figure 29: Royal River Rating Curve Comparison at USGS Gage

Additionally, a simulation of the 10-22 DEC 2019 storm event was performed as a validation of the model utilizing Without Project (Existing) conditions. A separate With Project (TSP) conditions model run was additionally performed to allow relative comparison.

A stage hydrograph of the tidal signal for the period, retrieved from the NOAA 8418150 Portland, ME tide gage, was utilized at the downstream boundary for the validation run. The tidal signal was utilized without adjustment because very little difference was noted in tidal amplitude and timing of high tide from Portland versus the subordinate tide stations nearest Yarmouth (South Freeport 8417801 and Prince Point 8417948) (**Figure 30** and **Figure 31**). The flow hydrograph observed at the USGS gage for the period was used as the upstream flow hydrograph for the model run (**Figure 32**).

Figure 30: NOAA Tide Stations Near Royal River

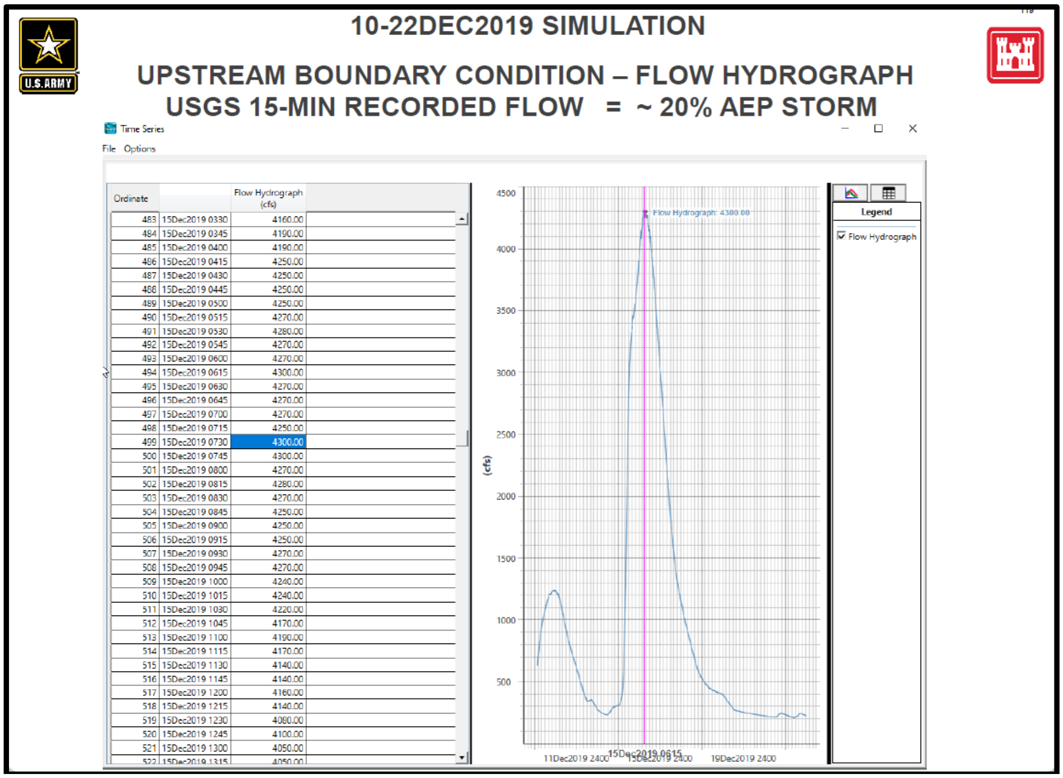


10-22DEC2019 SIMULATION

DOWNSTREAM BOUNDARY CONDITION – STAGE HYDROGRAPH
NOAA PORTLAND TIDE GAGE (6-MIN)

Ordinate		Stage Hydrograph (ft)
1	10Dec2019 0300	-4.33
2	10Dec2019 0306	-4.34
3	10Dec2019 0312	-4.34
4	10Dec2019 0318	-4.33
5	10Dec2019 0324	-4.31
6	10Dec2019 0330	-4.28
7	10Dec2019 0336	-4.25
8	10Dec2019 0342	-4.20
9	10Dec2019 0348	-4.13
10	10Dec2019 0354	-4.07
11	10Dec2019 0400	-3.99
12	10Dec2019 0406	-3.90
13	10Dec2019 0412	-3.80
14	10Dec2019 0418	-3.69
15	10Dec2019 0424	-3.57
16	10Dec2019 0430	-3.44
17	10Dec2019 0436	-3.31
18	10Dec2019 0442	-3.16
19	10Dec2019 0448	-3.01
20	10Dec2019 0454	-2.84
21	10Dec2019 0500	-2.67
22	10Dec2019 0506	-2.49
23	10Dec2019 0512	-2.31
24	10Dec2019 0518	-2.11
25	10Dec2019 0524	-1.91
26	10Dec2019 0530	-1.70
27	10Dec2019 0536	-1.49
28	10Dec2019 0542	-1.27
29	10Dec2019 0548	-1.05
30	10Dec2019 0554	-0.82
31	10Dec2019 0600	-0.59
32	10Dec2019 0606	-0.36
33	10Dec2019 0612	-0.12
34	10Dec2019 0618	0.11
35	10Dec2019 0624	0.34
36	10Dec2019 0630	0.58
37	10Dec2019 0636	0.81
38	10Dec2019 0642	1.04
39	10Dec2019 0648	1.27
40	10Dec2019 0654	1.49

Figure 31: Tide Stage for 10-22DEC2019 Storm Event Royal River



10-22DEC2019 SIMULATION

UPSTREAM BOUNDARY CONDITION – FLOW HYDROGRAPH
USGS 15-MIN RECORDED FLOW = ~ 20% AEP STORM

Ordinate		Flow Hydrograph (cfs)
483	15Dec2019 0330	4160.00
484	15Dec2019 0345	4190.00
485	15Dec2019 0400	4190.00
486	15Dec2019 0415	4250.00
487	15Dec2019 0430	4250.00
488	15Dec2019 0445	4250.00
489	15Dec2019 0500	4250.00
490	15Dec2019 0515	4270.00
491	15Dec2019 0530	4280.00
492	15Dec2019 0545	4270.00
493	15Dec2019 0600	4270.00
494	15Dec2019 0615	4300.00
495	15Dec2019 0630	4270.00
496	15Dec2019 0645	4270.00
497	15Dec2019 0700	4270.00
498	15Dec2019 0715	4250.00
499	15Dec2019 0730	4300.00
500	15Dec2019 0745	4300.00
501	15Dec2019 0800	4270.00
502	15Dec2019 0815	4280.00
503	15Dec2019 0830	4270.00
504	15Dec2019 0845	4250.00
505	15Dec2019 0900	4250.00
506	15Dec2019 0915	4250.00
507	15Dec2019 0930	4270.00
508	15Dec2019 0945	4270.00
509	15Dec2019 1000	4240.00
510	15Dec2019 1015	4240.00
511	15Dec2019 1030	4220.00
512	15Dec2019 1045	4170.00
513	15Dec2019 1100	4190.00
514	15Dec2019 1115	4170.00
515	15Dec2019 1130	4140.00
516	15Dec2019 1145	4140.00
517	15Dec2019 1200	4160.00
518	15Dec2019 1215	4140.00
519	15Dec2019 1230	4080.00
520	15Dec2019 1245	4100.00
521	15Dec2019 1300	4050.00
522	15Dec2019 1315	4050.00

Figure 32: Upstream Flow Hydrograph for 10-22DEC2019 Storm Event Royal River

The resulting hydraulic model discharge and water surface time series at the USGS gage location was then compared to the observed flow and stage for the 10-22 DEC 2019 storm event, as show in **Figure 33** and **Figure 34**.

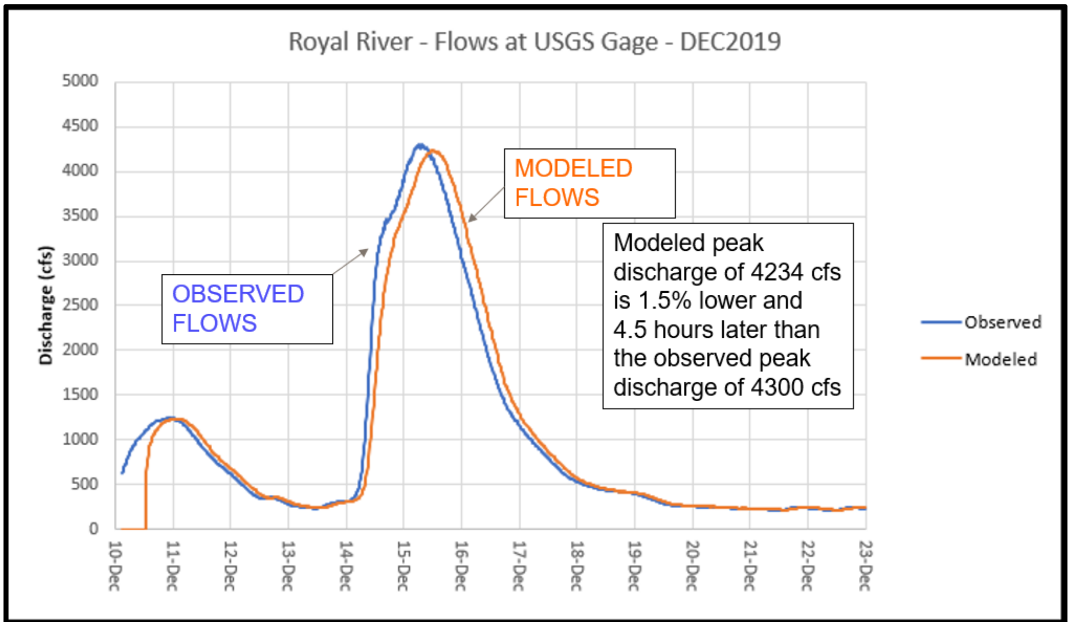


Figure 33: Modeled & Observed Flow Hydrograph at USGS Gage - 10-22DEC2019

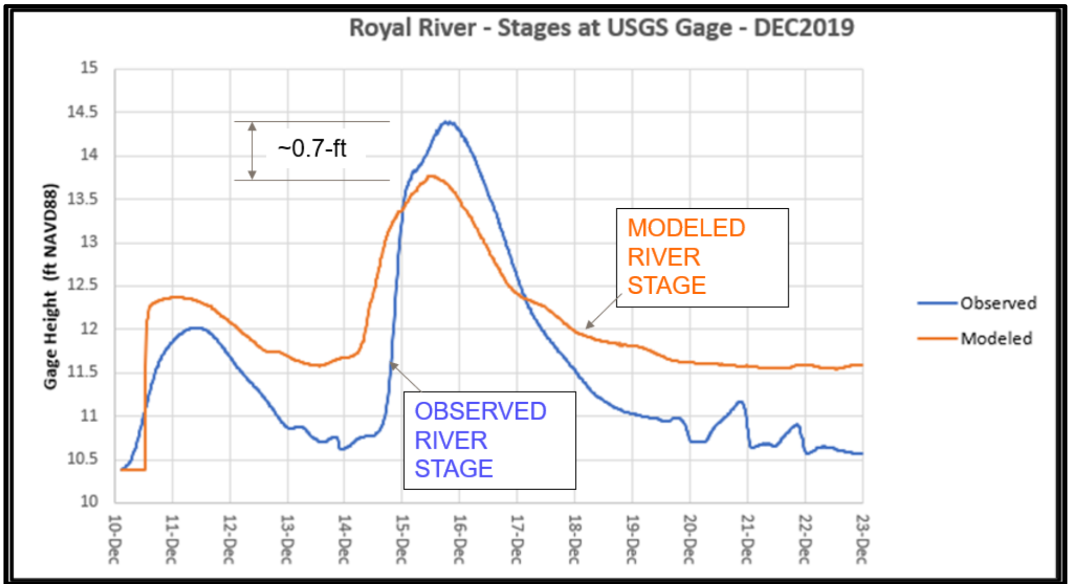


Figure 34: Modeled & Observed Stage Hydrograph at USGS Gage - 10-22DEC2019

The modeled peak discharge of 4234 cfs is 1.5% lower and 4.5 hours later than the observed peak discharge of 4300 cfs. The closely matching discharge response demonstrates that the inflow hydrograph magnitude is minimally affected by channel and storage routing between the upstream limit of study and the USGS gage location.

Additionally, the hydraulic model underpredicts observed peak water surface at the USGS gage by approximately 0.7-ft. This finding is in parity with the graphical representation in the rating curve comparison (**Figure 35**) indicating that the model is somewhat more efficient than measured observations at these flow and tidal conditions, but generally matches the trend.

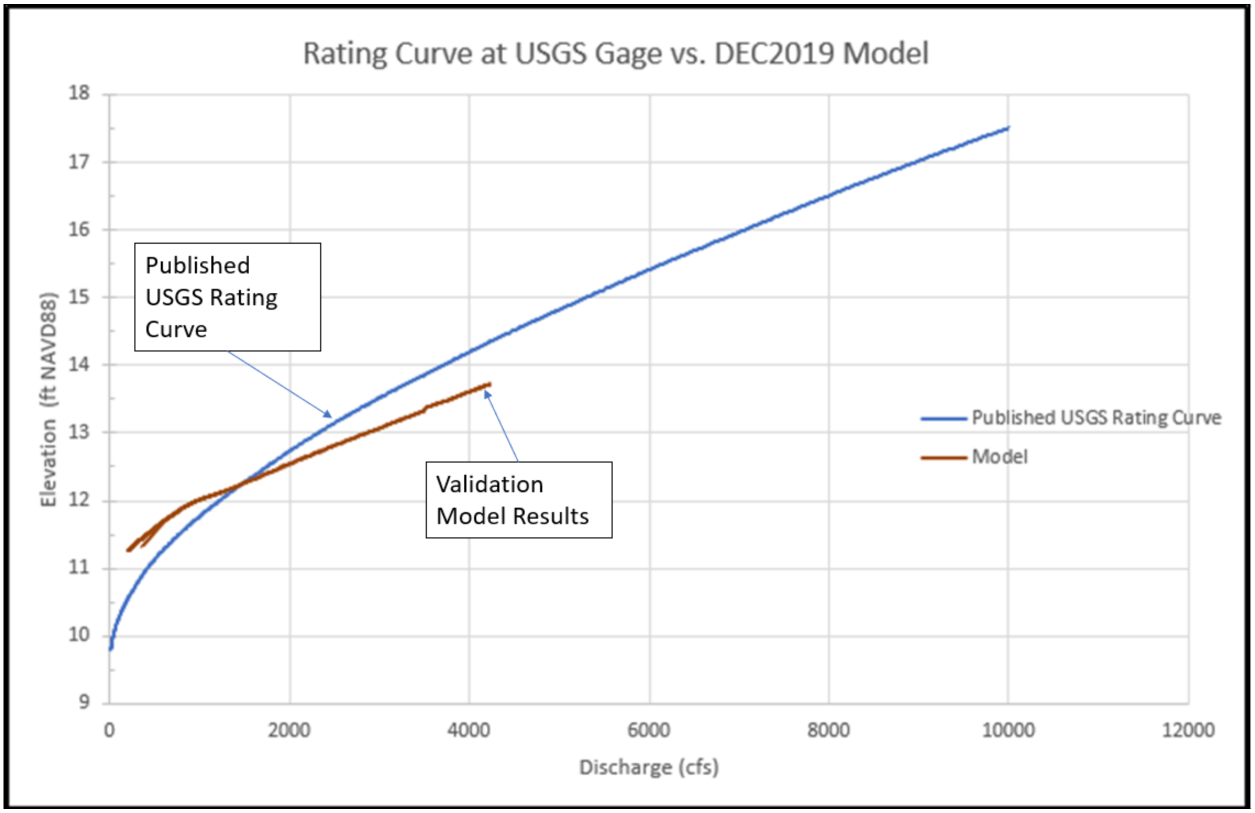


Figure 35: Modeled & Published Rating Curve at USGS Gage - 10-22DEC2019

5.2.4 Results

Without and With Project conditions were modeled for the 7Q10, Annual Median Flow, 50%, and 10% AEP flood events as constant hydrograph flows. The 1% AEP flood event was modeled utilizing a version of the 10-22DEC2019 historic storm hydrograph scaled to mimic 1% AEP peak flows. For the Mid-May to Mid-June peak Alewife upriver passage, the Royal River flows for design low (95% duration exceedance) and design high (5% duration exceedance) were also modeled with constant hydrograph flows.

5.2.4.1 Without Project Conditions

Without Project water surface, depth, and velocity results are presented in **Attachment C** “RoyalRiver_Appendix_C_HydraulicsResults_30AUG24”.

5.2.4.2 With Project Conditions

With Project water surface, depth, and velocity results are presented in **Attachment C** "RoyalRiver_Appendix_C_HydraulicsResults_30AUG24".

5.2.4.3 Fish Passage Summary of Results

Hydraulic parameters were evaluated at the Bridge Street Dam, Middle Falls, and East Elm Street Dam sites for Peak Alewife upriver passage conditions (Mid-May to Mid-June 95% and 5% duration exceedance). This task was complicated by ledge outcrops at each of these sites yielding cascades with complex and varied flow paths that change depending on flow quantity. Likewise, unknown bottom conditions and bathymetry immediately upstream and below the dams add uncertainty to this task. Localized depths, velocities, vertical accelerations, turbulence, and other hydraulic phenomena may affect target species behavior at a scale that is impractical or impossible for 2D hydraulic modeling to accurately predict. These factors combined make determination of fish passage routes tenuous, at best. But an important consideration is that Royal River historically sustained upriver migration prior to construction of the dams, and With Project conditions intend to generally restore Royal River to that state.

For purposes of this evaluation, profile lines "BridgeSt_LowFlow1", "Middle Falls Bypass", and "Elm_St_Low_Flow1" were added to the model based on initial 95% exceedance peak upriver migration inundation limits as the assumed migration pathways to evaluate of the hydraulic parameters. **Table 10** presents a summary of hydraulic parameters along these profile lines, as a natural system, as well as the values from **Table 2** USFWS design guidance values for engineered, nature-like fish passage of the target species as a reference.

Table 10: Royal River Summary of Site-Specific Fish Passage Parameters

USFWS Recommended Parameters for Fish Passage Design	Species	Minimum Pool/Channel Width (ft)	Minimum Pool/Channel Depth (ft)	Minimum Pool/Channel Length (ft)	Minimum Weir Opening Width (ft)	Minimum Weir Opening Depth (ft)	Maximum Weir Opening Water Velocity (ft/sec)	Maximum Fishway Channel Slope
	Alewife	5.0	2.25	10.0	2.50	1.00	6.00	1:20
	Location: Bridge Street Dam							
TSP Model Results: Bridge Street Dam	Upriver Migration 95% Exceedance	16	< 1 (natural)	15	N/A (natural)	< 1 (natural)	4.6 (natural)	1:10, local max 1:5 (natural)
	Upriver Migration 5% Exceedance	40	< 1 (natural)	30	N/A (natural)	< 1 (natural)	8.9 (natural)	1:10, local max 1:5 (natural)
	Location: Middle Falls							
TSP Model Results: Middle Falls	Upriver Migration 95% Exceedance	4	< 1 (natural)	14	N/A (natural)	< 1 (natural)	2.6 (natural)	1:15, local max 0.5:1 (natural)
	Upriver Migration 5% Exceedance	20	< 2 (natural)	60	N/A (natural)	< 1 (natural)	4.3 (natural)	1:15, local max 0.5:1 (natural)
	Location: East Elm Street Dam							
TSP Model Results: Elm Street Dam	Upriver Migration 95% Exceedance	2	< 1 (natural)	5	N/A (natural)	< 1 (natural)	4.5 (natural)	1:7, local max 1:5 (natural)
	Upriver Migration 5% Exceedance	5	< 2 (natural)	7	N/A (natural)	< 1 (natural)	11.6 (natural)	1:7, local max 1:5 (natural)

While some of the parameters in **Table 10** are outside the design guidelines for an engineered nature-like fishway, the proposed natural setting at each of these sites may yet allow upriver migration through yet-undefined flow pathways, whether currently visible or post-demolition. If further review by fish passage experts, USFWS, or other partners indicate grave concerns for target species passage based on these results, at any or all of these sites, additional site design could be addressed in the Design and Implementation Phase through the project's Adaptive Management Plan. Such designs would likely fine-tune localized hydraulics for effect by supplementing the natural stream bed with limited and strategically placed material such as sandbags, boulders, or remnant granite blocks from dam demolition.

5.2.4.4 Recreation Summary of Results

Changes to depth, width and velocity of the river were reviewed with regards to potential impacts to recreation from the Yarmouth History Center boat launch to the upstream limits of the study, near Route 9.

In general, With Project water levels during "normal" Annual Median flows are anticipated to be approximately 4-feet lower than Without Project conditions, from the Yarmouth History Center boat launch to a point approximately 4 miles upstream near the mouth of Toddy Brook. From the mouth of Toddy Brook to Route 9, at the upstream end of the study reach, the difference in water levels decreases from 4-feet to approximately 1-foot. Although not explicitly in the model, testing indicates that lower water levels are unlikely to extend beyond Wescustugo Park or the railroad tracks along Chandler Brook.

Despite the lower water levels, flow widths and depths at the canoe launch and heading upstream appear to continue to support recreation activities, as shown in the "paddle depth" plots contained in Attachment C "RoyalRiver_Appendix_C_HydraulicsResults_30AUG24". In the "paddle depth" review, With Project flow depths are displayed highlighting locations predicted to be less than 1-foot deep during "normal" Annual Median Flows. The flow depth plots have orange colors for depths less than 1-ft, and red below 6-inches, indicating potential recreational hazards.

Areas across from the Yarmouth History Center canoe launch and towards the Elm Street Bridge could be problematic for paddling, but depths in the upstream direction appear sufficient for recreation. Four locations of potential stream narrowing with relatively shallow depths (< 1.5-ft depth) are indicated in the plots, generally in the upper reaches near Toddy Brook, which may require limited portage. Although the flow velocity during "normal" Annual Median Flows is generally predicted to increase, it is predicted to remain low near the canoe launch (<2 feet/second).

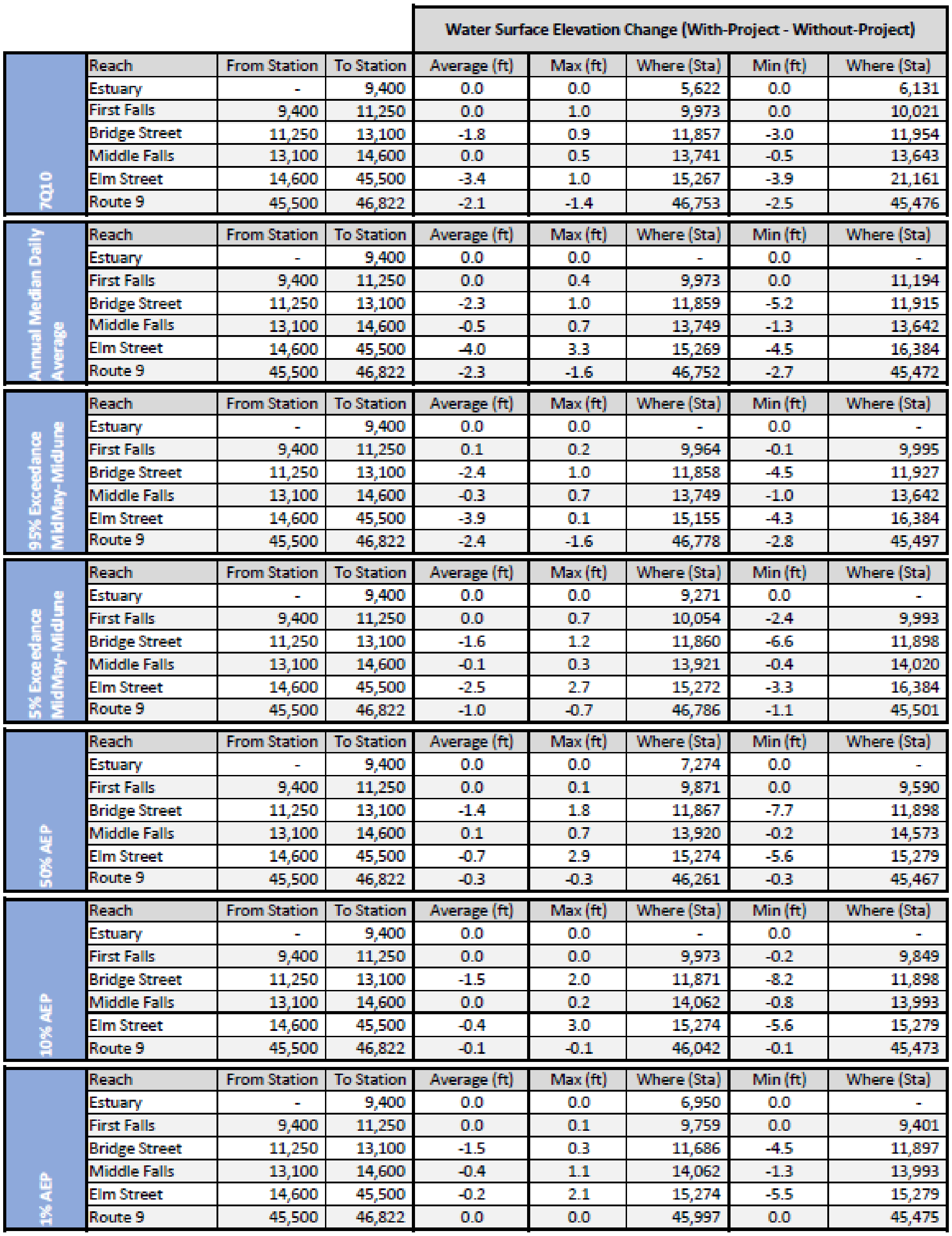
This review is intended to be representative but is not all inclusive. It is possible that shallower depths may sustain recreation, or deeper depths may pose recreational hazards based on individual circumstances. Similarly, thunderstorms and/or heavy rainfall in the Royal River watershed could lead to rapidly changing and dangerous conditions on the river, as is currently the case under Without Project conditions. USACE assumes no liability regarding these findings or future recreational uses on the Royal River.

5.2.4.5 Summary of Results

With- and Without Project conditions results were compared for the low- and normal-flow periods (7Q10 and Annual Median Flow), peak Alewife upriver passage conditions (Mid-May to Mid-June 95% and 5% duration exceedance), and flood events (50%, 10%, and 1% AEP).

Water surface elevation change (With-Project - Without-Project) was evaluated along the stream centerline "Royal River 1" for each of these modeled events and is presented in **Table 11**.

Table 11: Royal River Predicted Water Surface Elevation Changes



				Water Surface Elevation Change (With-Project - Without-Project)					
7Q10	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	5,622	0.0	6,131
	First Falls	9,400	11,250	0.0	1.0	9,973	0.0	10,021
	Bridge Street	11,250	13,100	-1.8	0.9	11,857	-3.0	11,954
	Middle Falls	13,100	14,600	0.0	0.5	13,741	-0.5	13,643
	Elm Street	14,600	45,500	-3.4	1.0	15,267	-3.9	21,161
	Route 9	45,500	46,822	-2.1	-1.4	46,753	-2.5	45,476
Annual Median Daily Average	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	-	0.0	-
	First Falls	9,400	11,250	0.0	0.4	9,973	0.0	11,194
	Bridge Street	11,250	13,100	-2.3	1.0	11,859	-5.2	11,915
	Middle Falls	13,100	14,600	-0.5	0.7	13,749	-1.3	13,642
	Elm Street	14,600	45,500	-4.0	3.3	15,269	-4.5	16,384
	Route 9	45,500	46,822	-2.3	-1.6	46,752	-2.7	45,472
95% Exceedance MidMay-MidJune	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	-	0.0	-
	First Falls	9,400	11,250	0.1	0.2	9,964	-0.1	9,995
	Bridge Street	11,250	13,100	-2.4	1.0	11,858	-4.5	11,927
	Middle Falls	13,100	14,600	-0.3	0.7	13,749	-1.0	13,642
	Elm Street	14,600	45,500	-3.9	0.1	15,155	-4.3	16,384
	Route 9	45,500	46,822	-2.4	-1.6	46,778	-2.8	45,497
5% Exceedance MidMay-MidJune	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	9,271	0.0	-
	First Falls	9,400	11,250	0.0	0.7	10,054	-2.4	9,993
	Bridge Street	11,250	13,100	-1.6	1.2	11,860	-6.6	11,898
	Middle Falls	13,100	14,600	-0.1	0.3	13,921	-0.4	14,020
	Elm Street	14,600	45,500	-2.5	2.7	15,272	-3.3	16,384
	Route 9	45,500	46,822	-1.0	-0.7	46,786	-1.1	45,501
50% AEP	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	7,274	0.0	-
	First Falls	9,400	11,250	0.0	0.1	9,871	0.0	9,590
	Bridge Street	11,250	13,100	-1.4	1.8	11,867	-7.7	11,898
	Middle Falls	13,100	14,600	0.1	0.7	13,920	-0.2	14,573
	Elm Street	14,600	45,500	-0.7	2.9	15,274	-5.6	15,279
	Route 9	45,500	46,822	-0.3	-0.3	46,261	-0.3	45,467
10% AEP	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	-	0.0	-
	First Falls	9,400	11,250	0.0	0.0	9,973	-0.2	9,849
	Bridge Street	11,250	13,100	-1.5	2.0	11,871	-8.2	11,898
	Middle Falls	13,100	14,600	0.0	0.2	14,062	-0.8	13,993
	Elm Street	14,600	45,500	-0.4	3.0	15,274	-5.6	15,279
	Route 9	45,500	46,822	-0.1	-0.1	46,042	-0.1	45,473
1% AEP	Reach	From Station	To Station	Average (ft)	Max (ft)	Where (Sta)	Min (ft)	Where (Sta)
	Estuary	-	9,400	0.0	0.0	6,950	0.0	-
	First Falls	9,400	11,250	0.0	0.1	9,759	0.0	9,401
	Bridge Street	11,250	13,100	-1.5	0.3	11,686	-4.5	11,897
	Middle Falls	13,100	14,600	-0.4	1.1	14,062	-1.3	13,993
	Elm Street	14,600	45,500	-0.2	2.1	15,274	-5.5	15,279
	Route 9	45,500	46,822	0.0	0.0	45,997	0.0	45,475

Below is a list of select observations made while comparing the With- and Without Project conditions and results for the low- and normal-flow periods (7Q10 and Annual Median), peak Alewife upriver passage conditions (Mid-May to Mid-June 95% and 5% duration exceedance), and flood events (50%, 10%, and 1% AEP).

- Comparison of the With- and Without Project conditions indicates Royal River will be lower during normal and low flow conditions in areas upstream of the dams - generally between Bridge Street and Middle Falls, and also between the East Elm Street Dam / Royal River Park and State Route 9 / Baston Park. Some areas may experience within bank flow depth increases, particularly areas downstream of the dams. As flows increase due to precipitation or snowmelt, the Royal River is expected to behave more similar to existing conditions.

- Comparison of Hydraulic fish passage parameters at the Bridge Street Dam, Middle Falls, and East Elm Street Dam sites for Peak Alewife upriver passage conditions (Mid-May to Mid-June 95% and 5% duration exceedance) were made to USFWS suggested guidelines for engineered nature-like fishway designs for the target species. Although multiple factors made this comparison tenuous, and some of the parameters in **Table 10** are outside the design guidelines, the proposed natural setting at each of these sites may yet allow upriver migration through yet-undefined flow pathways, whether currently visible or post-demolition.

- Aside from locations under the dams, two new areas of predicted streambed bedrock outcropping are predicted to become visible during normal flows. The first location is approximately 100-ft upstream of the Beth Condon pedestrian footbridge. This location was observed during a trial drawdown of Bridge Street Dam on 12NOV2014 and was also observed during a 2011 drawdown (Maine Rivers, 2013). The second location is between the Elm Street bridge and the Yarmouth Historical building.

- Flood conditions will be generally identical or have slight reduction based on 50%, 10%, and 1% (2-, 10-, and 100-yr) storm events. However, there are some locations of water level increase during the 1% AEP (100-yr) storm event, as shown in **Attachment C**. Specifically, water levels are predicted to increase on average 0.1-ft between the estuary and Bridge Street, average 0.2-ft between Bridge Street and the Bridge Street Dam site. A photograph provided by the Yarmouth Historical Society depicting Grist Mill during a flood in 1893 seems to indicate that the building would be resilient to such an increase (see **Attachment C**). Upstream of Bridge Street on the left side could experience a water level increase of 0.5-ft., possibly due to acceleration and increased flow in With Project conditions on that side of the stream interacting with the island upstream of the bridge, however it is still expected to crest multiple feet below the retaining wall. Comparison of results indicates areas of potential increase up to 1-foot located in the far left floodplain near US Route 1 and the Beth Condon footbridge. It is suspected, but not yet confirmed, that the results in this specific area are likely inaccurate due to how the SA2D connections are modeled for the two closely spaced bridges. Comparison at Middle Falls indicates that 1% AEP water surface levels could increase by up to 2.5-feet, however the extents are limited to largely difficult-to-access areas with no predicted adverse impacts. There is also an area immediately downstream of Elm Street Dam indicating an increase of 3.5 feet water level, due to the removal of the dam its associated plunge jet of water. Refined hydraulic modeling may be able to more accurately predict 1% AEP With Project conditions in the future, but at this time the results indicate that no existing structures would be adversely impacted in a significant manner under the With Project conditions

- Review of the 1% AEP (scaled 10-22DEC2019 storm hydrograph) model runs, roughly equivalent to the 1% AEP and based on an actual storm hydrograph and tailwater combination, also follows the trend of generally identical or slight reduction with some areas of slight increase. Similar to the 1% AEP constant hydrograph flow model run, water levels are predicted to increase on average 0.1-ft between the estuary and the Bridge Street Dam site, with an isolated area near Bridge Street that could experience up to a maximum water level increase of 0.2-ft. The area immediately downstream of Elm Street Dam is predicted to have a water level increase 2.1 feet, but is subject to the same localized, transient condition and also does not impact structures in the vicinity.

- Significant increase of within bank velocity through the Bridge Street Dam site during flood flows primarily due to the narrowing and the lowering of the floodplain through that area. Impacts are generally expected inside the channel between Bridge Street and Middle Falls. These effects are also reflected in the upriver migration results but to a lesser extent as the flows are lower, as summarized in **Table 10** and displayed in **Attachment C**.

- Significant increase of within bank velocity through the East Elm Street Dam site during flood flows primarily due to the narrowing and the lowering of the floodplain through that area. Impacts are generally expected inside the channel between Elm Street and Middle Falls, along the southern side of Gooch Island near the existing fish ladder. These effects are also reflected in the upriver migration results but to a lesser extent as the flows are lower, as summarized in **Table 10** and displayed in **Attachment C**.

- Foundry Channel is expected to become intermittent except during higher flow events. Flows in Foundry Channel will be largely controlled by the invert of the culvert under East Elm Street.

- Based on available bathymetry and hydraulic model results, a portion of the back channel of Gooch Island closest to the East Elm Street Dam is expected to become intermittent except during high flow events. The hydraulic modeling does not explicitly account for flow through the cracks between the granite blocks, however. Anecdotal evidence suggests an unquantified portion of the flow in the back channel flows through, not over, the dam. The hydraulic modeling does indicate that other portions of the back channel are expected to have water during normal conditions, fed from the downstream junction. Recent collections of bathymetry have not sampled in the back channel, so improved bathymetry could help enhance the definition of the hydraulic response in this area, as it is currently based on the FEMA study and some LiDAR spot elevations. Similarly, further studies could include a focused inspection and identification effort to quantify major cracks between granite blocks, estimate current flow through the dam, and estimate the amount of potential flow reduction due to With Project reduced water levels.

- The water levels at Baston Park and at the State Route 9 bridge are predicted to decrease by approximately 2-feet under normal conditions. It is currently unknown if this change could impact operation of the dry hydrant or planned improvements at Baston Park.

- Lower normal water levels may affect some recreational opportunities; however, the general lowering of water levels between Elm Street and State Route 9 by an average of 3.8 feet does not appear to necessarily exclude any current opportunity. The water depth at the canoe launch behind the Yarmouth Historical building would still have more than 3-ft flow depth without a significant increase in stream velocity. This is partially due to the predicted streambed bedrock outcropping between the Yarmouth Historical building and Elm Street. Some locations between the Yarmouth Historical building and the State Route 9 canoe launch may become relatively narrow and have normal flow depths of approximately 1.5-ft, based on current bathymetry.

5.3 ASSUMPTIONS & SIMPLIFICATIONS

For this feasibility-level CAP 206 aquatic ecosystem restoration study, several assumptions/simplifications were necessary:

- Hydraulic model results are assumed to be generally representative for feasibility-level aquatic organism passage considerations. At the falls and other locations within the model domain, localized depths, velocities, vertical accelerations, turbulence, and other hydraulic phenomena may affect target species behavior at a scale that is impractical or impossible for 2D hydraulic modeling to accurately predict.

- Due to unknowns regarding dam construction methods in this study area, there is uncertainty regarding the stream bed under the dams. While it is known that the dams were built upon bedrock formations, the extent to which the bedrock may have been modified is unknown. Additionally, bathymetric data immediately upstream of the dams was not collected due to safe access constraints. For purposes of this study, the underlying stream bed was assumed to have a smooth linear slope between nearest available bathymetric data points.

- Tailwater assumed constant 0-ft NAVD88 for majority of model runs, except the 1% AEP and DEC19 model validation runs. Due to the First Falls hydraulic control at the head-of -tide, the model is largely not sensitive to this assumption as discussed in section 5.4 of this appendix.

- As noted in the previous hydrology and boundary condition discussions of this appendix, flows were defined only at the upstream boundary. While most of the runs are constant hydrograph flow, the DEC19 model validation run demonstrates that the inflow hydrograph is minimally affected by channel and storage routing between the upstream limit of study and the USGS gage location. While there are some tributaries and directly contributing runoff areas within the study reach, they are minor compared to the upstream watershed.

- The bathymetric surface is assumed to be a fixed bed (non-erodible sediment) for model simplification. While there is significant uncertainty regarding depth to bedrock below the bathymetric surface in some areas, especially immediately upstream of the dams, available sediment probes indicate surficial deposits are relatively shallow. The following was noted by USACE staff performing sediment sampling in October 2023: “The majority of the riverbed is scoured hard bottom with some coarse sediment (cobble, gravel, and a little bit of sand). With the exception of the area immediately behind the East Elm Street Dam we had to really hunt for areas with sediment to sample. In most cases the samples had to be taken immediately adjacent to the shoreline in order to get anything at all. The material next to the shore line was typically a mix of sand, organic silt, and vegetative debris.” Sensitivity to this fixed bed assumption, focused on the area immediately upstream of East Elm Street Dam “All Muck”, is included in section 5.4 of this appendix.

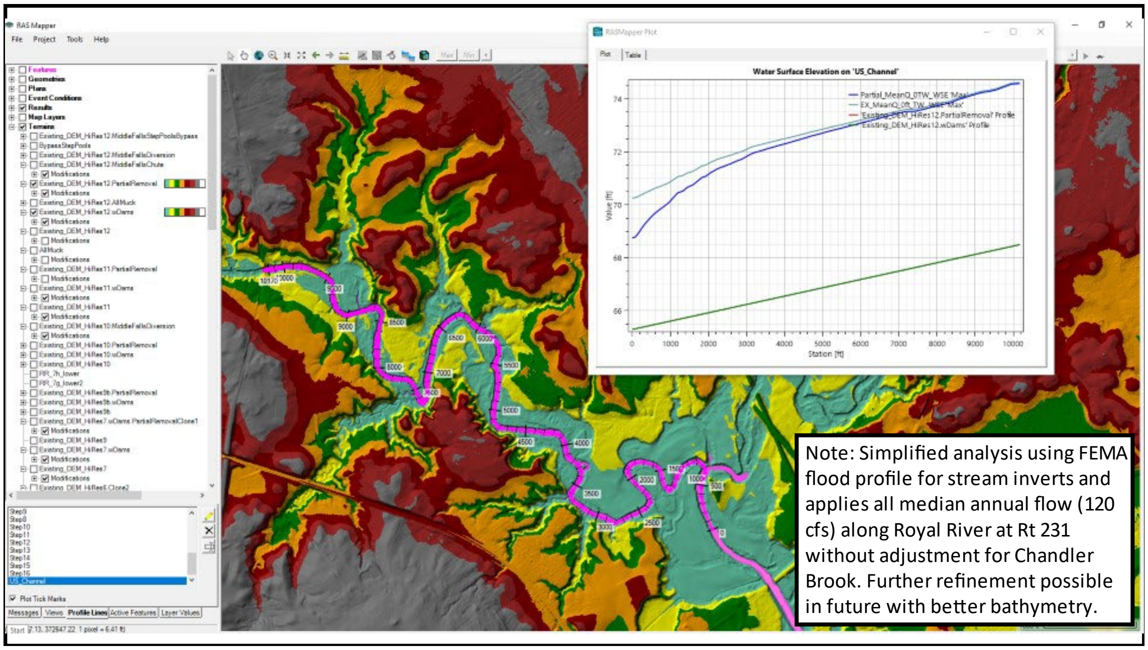
- Potential geomorphological and/or channel bank instability due to water level draw down, especially upstream of Elm Street, assumed to not generate a significant increase in sediment delivery or otherwise pose a significant threat to the feasibility of the project. The PDT has coordinated with the ERDC WOTS program to evaluate and address the likelihood of this concern, however at the time of this draft a final report is not available.

These concerns were also evaluated by FGS, for the Stantec 2013 report, concluding in full:

"Removal of the East Elm Street Dam is likely to increase bank erosion in the upstream impoundment but is less likely to increase sediment delivery to the harbor as large floods, given the confined nature of the channel, appear responsible for the bulk of sediment delivery to the harbor and have been essentially unaffected by the dam's presence. Sediment released by additional bank erosion is more likely to remain at the base of the bank or be reworked within the impoundment by smaller floods whose transport efficiency will increase with dam removal. The modification of channel form due to the greater effectiveness of small floods could have minor impacts to recreational uses within the impoundment area. The slight increase in flow velocity at low flow conditions and shallowing of flow depths as riffles develop may reduce the number of suitable days and river length where ice conditions are appropriate for skating in the winter. Canoeing and other boating may become more difficult in the shallowest areas, but the effectiveness of large floods may periodically reverse these trends and lead to deepening of the sandy channel substrate. Habitat complexity is likely to increase with dam removal as more frequent pools, riffles, and point bars develop over time. Further studies could be conducted to corroborate the findings of this assessment, but the distinct confined nature of the impoundment on the Royal River upstream of the East Elm Street Dam has likely limited sediment storage behind the dam and, as a consequence, will minimize the impact of dam removal within the impoundment area and the harbor downstream."

- Explicit sediment transport modeling was not performed for this study, however there is significant sediment transport capacity in the Royal River to the estuary during flood flows, based on hydraulic results. This is supported by the shallow bedrock of the Royal River streambed and the steep channel slope of 70 feet/mile for the stream mile upstream of the head-of-tide. In addition, hydraulic results indicate that the river is largely insensitive to measures and alternatives considered for this feasibility study during flood flows. Smaller flows may influence some sediment transport and deposition within the upstream impoundments, as described in the FGS conclusions above, however this would be transitory in nature and reset by intermittent larger floods. In simple terms, the river is assumed to continue to transport sediment downstream to the estuary, as it has done historically, and sediment transport modeling is therefore assumed to be not required for the purposes of this study or future design efforts.

- The upstream limits of the study area are assumed to be acceptable for purposes of this CAP 206 study. Specifically, hydraulic results show that during the normal flow scenario approximately 1-foot of water level reduction occurs at the limit when comparing With and Without project conditions. The study limit was defined (at least partially) based on limit of bathymetric data. An attempt was made to extend the model further upstream using DEM information with an assumed triangular shaped channel with an invert based on the FEMA FIS flood profile slope and inverts in order to approximate how far the effects could propagate upstream, as shown in **Figure 36**. The approximation indicates that effects are unlikely to propagate further than 10,000 feet above the current study limits (Wescustogo Park/Route 231). The model extension was corrupted/lost during a software crash.



Note: Simplified analysis using FEMA flood profile for stream inverts and applies all median annual flow (120 cfs) along Royal River at Rt 231 without adjustment for Chandler Brook. Further refinement possible in future with better bathymetry.

Figure 36: Approximated Upstream Model Extension

- Any portions of dams not removed in partial removal measures are assumed to remain in place and be properly maintained.

- During the process of selecting LiDAR point cloud data to define in-channel boulders and other topographic features, some erroneous 'noise' was introduced into the terrain model. Although efforts attempted to remove as many of the erroneous LiDAR data points from the terrain as practical, some remain and potentially affect hydraulic results. An example of such spurious spikes resulting from erroneous LiDAR points is shown in **Figure 37**. Any erroneous LiDAR data points remaining in the terrain are assumed to be negligible and not impact the overall CAP study results.

Figure 37: Exaggerated vertical scale terrain model showing some erroneous LiDAR points near Gooch Island (yellow circle)

- Ice effects are not considered in this study. Ice is assumed not to affect river hydraulics during the upriver migration period. The target species will migrate and lay in the spring when the water is between 41-50F, which is May through June. While ice and ice jams may affect the flooding stage-frequency relationship along the Royal River, its formation, passage, and effects are assumed to be equivalent in With- and Without- project conditions. The only Royal River entry in the USACE Ice Jam Database indicates that there was a Break-Up ice jam reported at the USGS gage on 16 FEB 1984 at 1650 hours. No gage height or flooding was reported, and the average daily discharge was estimated to be 1500 cfs.

- Groundwater was not explicitly modeled and any drawdown effects in the potentiometric groundwater surface related to dam removal surface water drawdowns are assumed to be localized. Review of the Maine Department of Environmental Protection's Environmental and Groundwater Analysis Database, via the Maine Geological Survey (https://www.maine.gov/dacf/mgs/pubs/digital/well.htm#mapsearch) (accessed on 01April24) indicates that well depth in the vicinity are typically 200 feet or more.

- Accumulation of floating debris and its effects on hydraulics were not considered in this feasibility study. It is anticipated that increased amounts of floating debris may become trapped behind remnants of the East Elm

Street Dam in the With Project scenario. This is because the remaining wall will be on the outside of a bend in the river’s path and the lower water levels will not pass logs over the remaining wall, as occurs in Without Project. Natural, woody debris accumulation in that location is not expected to significantly affect hydraulics because it is not within the direct flow path. Routine maintenance by project partners is assumed to prevent significant accumulation.

5.4 SENSITIVITY ANALYSIS

TSP sensitivity to downstream boundary assumptions was checked for the Upriver Peak Migration 95% exceedance and 5% exceedance flows with constant tailwater runs based on the Portland NOAA tide station Upper 95% Confidence Interval, 1% AEP and the Lower 95% Confidence Interval, 1% AEP levels. The Portland NOAA tide station Upper 95% Confidence Interval, 1% AEP and the Lower 95% Confidence Interval, 1% AEP levels are 9.6-ft NAVD88, and -9.0-ft NAVD88, respectively. The results of the sensitivity runs were compared to TSP Upriver Peak Migration 95% exceedance and 5% exceedance flow results along the stream centerline. Water surface centerline profiles and tabular results of the comparison are included in **Attachment C**, but only nominal changes were identified at the USGS Gage location and no changes upstream of First Falls. Thus, the TSP model is not sensitive to downstream boundary tailwater assumptions.

Existing and TSP sensitivity to Manning’s n roughness assumptions were checked for the Upriver Peak Migration 95% exceedance and 5% exceedance flows. As discussed in sections 5.2.1 and 5.2.3, Existing and TSP Manning’s n roughness values were based on NLCD land use values as well as calibration zones. The ranges of typical n-values presented in the HEC-RAS 2D User Manual for each NLCD value was utilized to develop two test scenarios: Low and High roughness. The Low roughness scenario assigned the lowest values in each NLCD category based on the HEC-RAS 2D User Manual reference, and also set the calibration zones to the lowest value for open water. The High roughness scenario assigned values equal to 1.5 times the highest values in each NLCD category based on the HEC-RAS 2D User Manual reference. The High roughness scenario also set the calibration zones to 1.5 times the highest value for open water. Water surface centerline profiles and tabular results of the comparison are included in **Attachment C**. Generally stated, High n and Low n scenarios produce TSP water levels up to 0.8-ft higher and 0.2-ft lower, respectively, for the 95% Upriver Peak Migration Flows. Comparing Existing and TSP plans we see there is generally less drawdown with High n values (max 0.6-ft less), and generally more drawdown with Low n values (max 0.3 ft. more). For the 5% Upriver Peak Migration Flows, there is more difference with the additional flow: High n and Low n scenarios produce TSP water levels up to 2-ft higher and 0.5-ft lower, respectively. Comparing Existing and TSP plans we see there is generally less drawdown with High n values (max 0.8-ft less), and generally more drawdown with Low n values (max 0.5 ft. more). Thus, the Existing and TSP models are moderately sensitive to Manning’s n roughness assumptions.

Per the assumptions listed above, whatever sediments upstream of the dams were assumed immobile for purposes of the hydraulic model analysis. Bedrock is also observed at the dam locations, and many of the sediment probes in the vicinity indicate shallow substrate or rock. However, it is also known that there is some muck and other soft sediments that can be potentially mobilized, particularly behind the East Elm Street Dam. To check the sensitivity of this bottom condition assumption at East Elm Street Dam, a sensitivity "All Muck" run was performed. The "All Muck" model run modified bathymetric surface at East Elm Street Dam to lower elevations to the minimum values observed in the vicinity upstream and downstream of the dam (elevation 60-ft NAVD88). The results of this analysis indicated that Annual Median Flow water surface elevations could decrease by 2-feet or more vertically, however the extents of that change would be limited by upstream bedrock outcropping located approximately 150-feet upstream of the East Elm Street bridge. The upstream bedrock has been identified as rock and is predicted to act as a hydraulic control for upstream water surface elevations. In this "All Muck" Annual Median Flow scenario, flows would be expected to be generally shallow cascades starting at the upstream bedrock and running downstream through the East Elm Street dam location. If this scenario manifests, the increased drawdown may adversely impact minimum depths required for fish passage, as well as other parameters evaluated in **Table 10**, potentially requiring that the site is included in the Adaptive Management Plan.

6.0 CONCLUSIONS

Multiple flow conditions of the Royal River were modeled using HEC-RAS 2D hydraulics routines for evaluation of aquatic ecosystem restoration measures across the natural range of hydrologic variability. The results were used to inform planning, feasibility level design calculations, and cost estimates. Model results indicate that the Royal River will be lower during normal and low flow conditions in areas upstream of the dams - generally between Bridge Street and Middle Falls, and also between the East Elm Street Dam / Royal River Park and State Route 9 / Baston Park. Some areas may experience within bank flow depth increases, particularly areas downstream of the dams. As flows increase due to precipitation or snowmelt, the Royal River is expected to behave more similar to existing conditions.

Comparison of Hydraulic fish passage parameters at the Bridge Street Dam, Middle Falls, and East Elm Street Dam sites for Peak Alewife upriver passage conditions (Mid-May to Mid-June 95% and 5% duration exceedance) were made to USFWS suggested guidelines for engineered nature-like fishway designs for the target species. Although multiple factors made this comparison tenuous, and some of the parameters in **Table 10** are outside the design guidelines, the proposed natural setting at each of these sites may yet allow upriver migration through yet-undefined flow pathways, whether currently visible or post-demolition. If further review by fish passage experts, USFWS, or other partners indicate grave concerns for target species passage based on these results, at any or all of these sites, additional site design could be addressed in the Design and Implementation Phase through the project's Adaptive Management Plan. Such designs would likely fine-tune localized hydraulics for effect by supplementing the natural stream bed with limited and strategically placed material such as sandbags, boulders, or remnant granite blocks from dam demolition.

Changes to depth, width and velocity of the river were reviewed with regards to potential impacts to recreation from the Yarmouth History Center boat launch to the upstream limits of the study, near Route 9. Areas across from the Yarmouth History Center canoe launch and towards the Elm Street Bridge could be problematic for paddling, but depths in the upstream direction and typical flow velocities appear sufficient for continued recreational uses.

Flood conditions will be generally identical or have slight reduction based on 50%, 10%, and 1% (2-, 10-, and 100-yr) storm events. However, there are some locations of water level increase during the 1% AEP (100-yr) storm event. Specifically, water levels are predicted to increase on average 0.1-ft between the estuary and the Bridge Street Dam site, with an isolated area near Bridge Street that could experience up to a maximum water level increase of 0.5-ft.

Significant increase of within bank velocity through both the East Elm Street Bridge site and the Bridge Street Dam site are predicted during flood events due to the narrowing and the lowering of the floodplain through those areas. Impacts are generally expected to be limited to inside the channel with resistant bedrock streambed. These effects are also reflected in the upriver migration results but to a lesser extent as the flows are lower. Review of fish passage velocity parameters in **Table 10** are outside the design guidelines at Bridge Street Dam and at the East Elm Street Dam. The proposed natural setting at each of these sites may yet allow upriver migration through yet-undefined flow pathways, whether currently visible or post-demolition. If further review by fish passage experts, USFWS, or other partners indicate grave concerns for target species passage based on velocity, at any or all of these sites, additional site design could be addressed in the Design and Implementation Phase through the project's Adaptive Management Plan.

7.0 FUTURE EFFORTS

At the time of this draft, Middle Falls aquatic organism passage design is in progress and is pending input from USFWS. The results reported here do not reflect modifications to Middle Falls, but they should be included in the overall analysis in the future. It should be noted though that preliminary modeling has indicated that such efforts likely will have only localized within bank effects on streamflow.

If warranted by feasibility or design needs, the hydraulic model could be enhanced in the future:

- Evaluate/refine Middle Falls project elements for aquatic organism passage criteria, including acquisition of survey if required;

- Extend Royal River model upstream to Westcutugo Park and along Chandler Brook to the first railroad crossing, or further upstream, as relevant to evaluate the full upstream limits of potential effects;
- Rebuild the terrain model using updated Federal Navigation Project survey if relevant for estuary concerns;
- Further refine collective understanding of bathymetric surface at immediate vicinity of dams, remove erroneous lidar points, and remove likely mobilized, surficial sediments from the terrain model, as relevant;
- Collect additional bathymetry in the Gooch Island back channel to enhance the definition of the hydraulic response in this area, if appropriate;
- Enhance 2D computation mesh at areas of enhanced interest especially around dam removals and aquatic organism passage projects. In addition, review the dam and bridge hydraulics throughout the model and especially near the Beth Condon Footbridge, Route 1, and Falls Bridges as some results in these areas appear inconsistent at different flow values;
- Establishment of a stream gage, or similar instrumentation at the State Route 9 bridge could help provide a more complete understanding of channel hydraulics when used with the current USGS stream gage. This would allow model calibration for normal, and any flood flows experienced during its operation, and could improve understanding of both With and Without Project conditions.
- Develop a plan for post-construction validation of aquatic organism passage. Hydraulic modeling can only predict fish behavior to a certain extent and there might be a need to evaluate and modify site conditions after construction. For example, should there be an as-built survey and an as-built modeling update? Or is it sufficient to rely on actual fish passage data collected by partners? This can be integrated into the Adaptive Management Plan if appropriate.

The pending ERDC WOTS draft trip report identified potential items for further study:

- Sediment located on the margins of the pool upstream of the dam modification should be targeted for revegetation as the modifications are completed. Specifically, native species should be identified and used to re-establish nature conditions.

- Utilities, bridges, and other infrastructure should be further investigated to determine if any issues will arise from the dam modifications.

- Development of fish passage designs should include working with existing restoration groups and engineering designs previously implemented to ensure there is a “Systems Approach” to restoration for the entire reach.

- Although this project appears to be one of the best situations for dam removal, some additional tributary and bank erosion assessments should be completed upstream of the dam modification site during Design and Implementation.

- The nature of the Stream Alluvium on the Royal River channel margins and the interaction with the Presumpscot Formation (fine-grained clays) should be further investigated. The fine-grained clays may provide erosion protection both in the channel bed (tributaries) and in the lower banks of the Royal River.

  The nature of the bedrock is known locally around the dam locations and will need to be further investigated upstream of each structure so there are no significant impacts to the landowners immediately adjacent and upstream of the dam removal/modification sites.

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9.0 LIST OF ACRONYMS AND ABBREVIATIONS

AEP	Annual Exceedance Probability
ARI	Average Return Interval
cfs	Cubic feet / second
DPR	Detailed Project Report
DoD	Department of Defense
EO	Executive Order
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FID	Federal Interest Determination
FNP	Federal Navigation Project
MHW	Mean High Water
MHHW	Mean Higher High Water
MLW	Mean Low Water
MLLW	Mean Lower Low Water
NACCS	North Atlantic Coast Comprehensive Study
NAD	North Atlantic Division
NAVD 88	North American Vertical Datum of 1988
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Association
NTDE	National Tidal Datum Epoch
O&M	Operations & Maintenance
PDT	Project Delivery Team
sq. ft.	Square feet
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

Attachment A

Selections from the Effective FEMA HEC-2 Hydraulic Study

30AUG24 - SECTION 206
ROYAL RIVER FISH PASSAGE

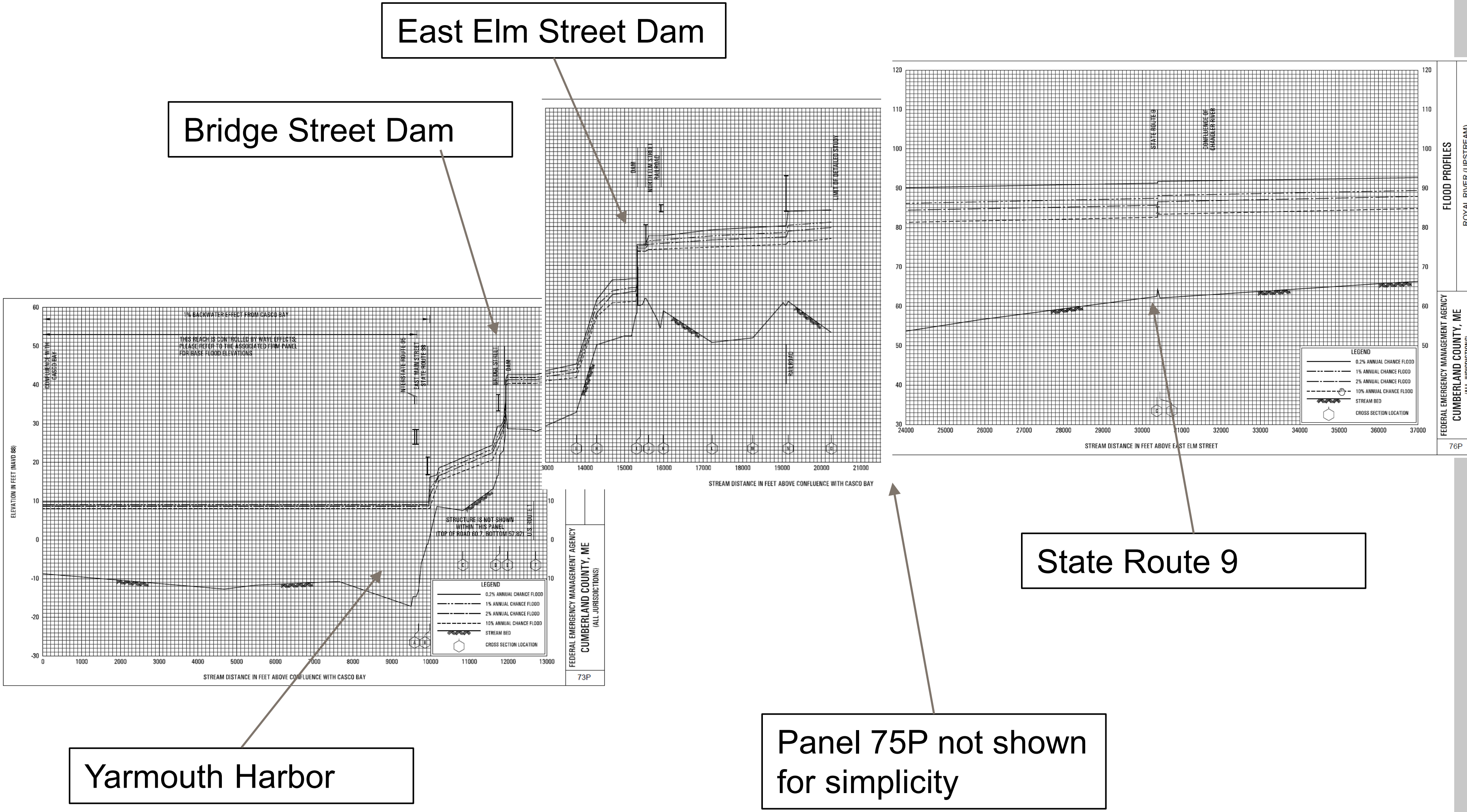
YARMOUTH, MAINE

ATTACHMENT A
SELECTIONS FROM THE EFFECTIVE FEMA HEC-2 HYDRAULIC STUDY

U.S.ARMY

US Army Corps of Engineers®

SECTION 206 ROYAL RIVER FISH PASSAGE – YARMOUTH, ME
FEMA FLOOD PROFILES FOR STUDY REACH



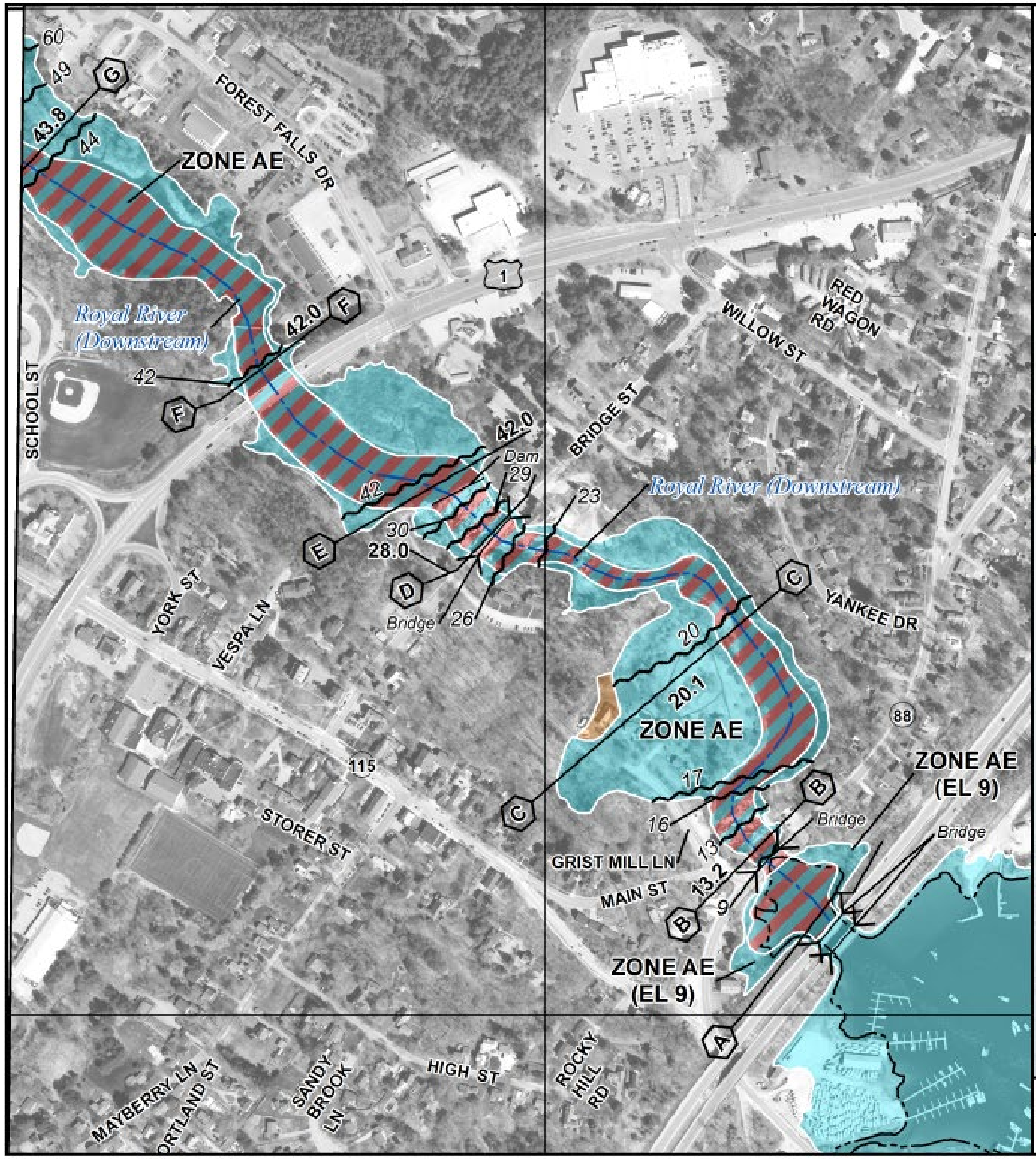
East Elm Street Dam

Bridge Street Dam

State Route 9

Yarmouth Harbor

Panel 75P not shown for simplicity



N

Map Projection:
NAD 1983 UTM Zone 19N;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet

0 500 1,000

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

CUMBERLAND COUNTY, MAINE
All Jurisdictions

PANEL **0541** OF **0837**

FEMA

Panel Contains:

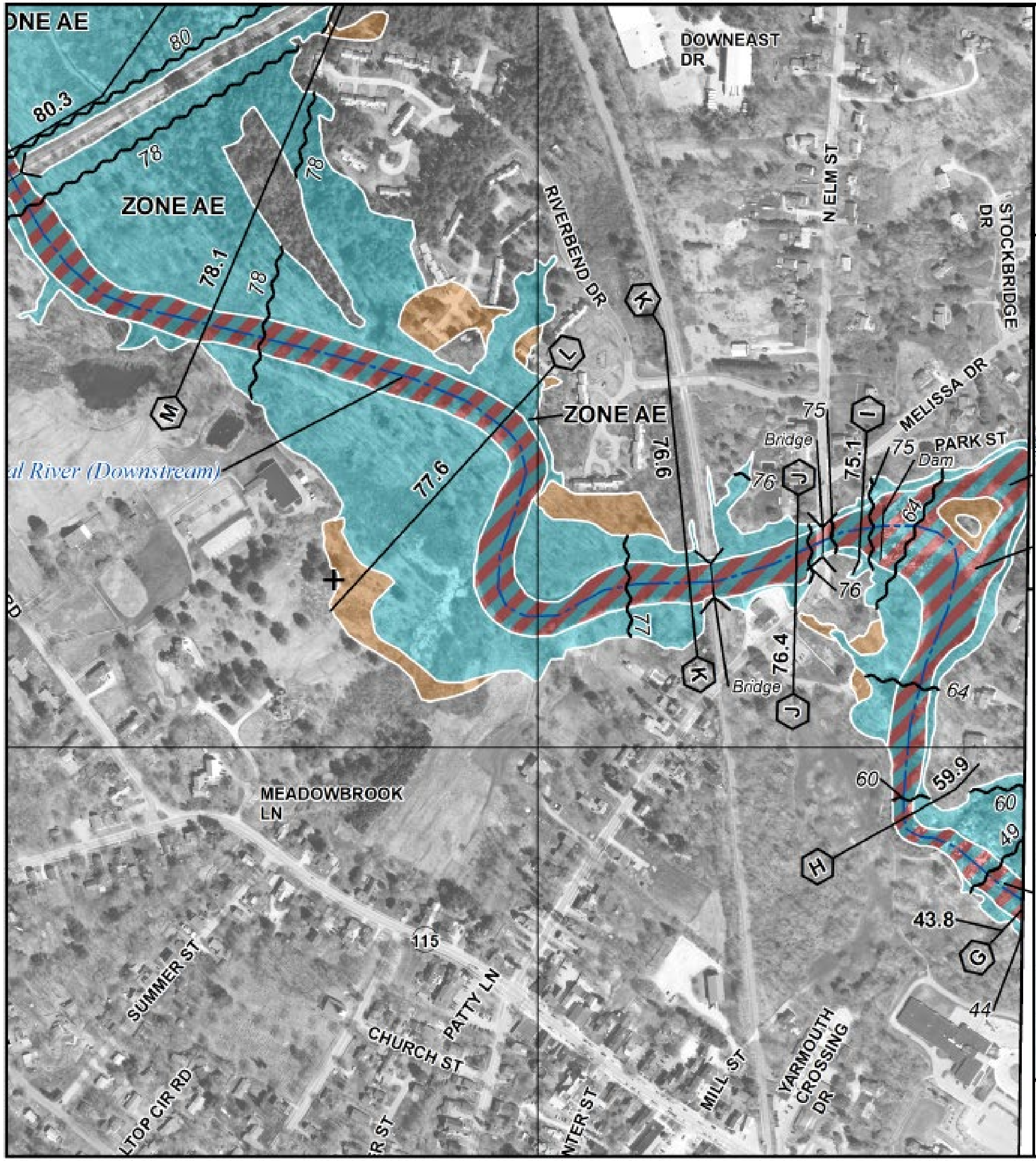
COMMUNITY	NUMBER	PANEL	SUFFIX
YARMOUTH, TOWN OF	230055	0541	F

VERSION NUMBER
2.3.2.1

MAP NUMBER
23005C0541F

EFFECTIVE DATE
June 20, 2024

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at https://msc.fema.gov.



Map Projection:
NAD 1983 UTM Zone 19N;
Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 500 feet

0 500 1,000

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

CUMBERLAND COUNTY, MAINE
All Jurisdictions

PANEL **0537** OF **0837**

FEMA

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
CUMBERLAND, TOWN OF	230162	0537	F
NORTH YARMOUTH, TOWN OF	230202	0537	F
YARMOUTH, TOWN OF	230055	0537	F

VERSION NUMBER
2.3.2.1

MAP NUMBER
23005C0537F

EFFECTIVE DATE
June 20, 2024

Table 2: Flooding Sources Included in this FIS Report - continued

Flooding Source	Community	Downstream Limit	Upstream Limit	HUC-8 Sub-Basin(s)	Length (mi) (streams or coastlines)	Area (mi^2) (estuaries or ponding)	Floodway (Y/N)	Zone shown on FIRM	Date of Analysis
Quaker Brook	Baldwin, Town of	Confluence with Saco River	Approximately 455 feet upstream of State Route 113 in the Town of East Baldwin	01060002	1.0		Y	AE	1978 (redelineated 2013)
Red Brook	South Portland, City of	Within the corporate limits of South Portland from confluence with Jackson Brook	Corporate limits with the Town of Scarborough	01060001	1.6		Y	AE	1980 (redelineated 2013)
Royal River Downstream	Yarmouth, Town of	Confluence with Casco Bay	Approximately 0.83 miles upstream of North Elm Street Railroad	01060001	2.0		Y	AE	1980 (redelineated 2013)
Royal River Upstream	Gloucester, Town of	Town of North Yarmouth corporate limits	Town of New Gloucester corporate limits	01060001	10.6		Y	AE	1980 (redelineated 2013)
Royal River Upstream	Gray, Town of	Within the Town of Gray	Within the Town of Gray	01060001	2.7		Y	AE	1980 (redelineated 2013)
Royal River Upstream	North Yarmouth, Town of	Town of North Yarmouth corporate limits	Town of New Gloucester corporate limits	01060001	7.9		Y	AE	1980 (redelineated 2013)
Saco River	Standish, Town of	York-Cumberland County Boundary	Town of Baldwin corporate limits	01060002	10.8		Y	AE	1979 (redelineated 2013)
Saco River	Baldwin, Town of	York-Cumberland County Boundary	Cumberland-Oxford County Boundary lines	01060002	12.9		Y	AE	1978 (redelineated 2013)
Saco River Left Channel	Standish, Town of	Cataract Dam	Confluence with the Saco River in the Town of Standish	01060001	0.4		Y	AE	1979 (redelineated 2013)

Table 13: Summary of Hydrologic and Hydraulic Analyses - continued

Flooding Source	Study Limits Downstream Limit	Study Limits Upstream Limit	Hydrologic Model or Method Used	Hydraulic Model or Method Used	Date Analyses Completed	Flood Zone on FIRM	Special Considerations
Red Brook	Within the corporate limits of South Portland from confluence with Jackson Brook	Corporate limits with the Town of Scarborough	regional equation prepared by USGS	USACE HEC-2 step-backwater	1980 (redelineated 2013)	AE w/ Floodway	
Royal River Downstream	Confluence with Casco Bay	Approximately 0.83 miles upstream of North Elm Street Railroad	USGS Maine Regional Equation	divided flow analysis	1980 (redelineated 2013)	AE w/ Floodway	Correlated with statistical analyses of USGS stream gage no. 0106000
Royal River Upstream	Town of North Yarmouth corporate limits	Town of New Gloucester corporate limits	USDA NRCS TR-20	USDA NRCS WSP-2	1980 (redelineated 2013)	AE w/ Floodway	
Royal River Upstream	Within the Town of Gray	Within the Town of Gray	USDA NRCS TR-20	USDA NRCS WSP-2	1980 (redelineated 2013)	AE w/ Floodway	
Royal River Upstream	Town of North Yarmouth corporate limits	Town of New Gloucester corporate limits	USDA NRCS TR-20	USDA NRCS WSP-2	1980 (redelineated 2013)	AE w/ Floodway	
Saco River	York-Cumberland County Boundary	Town of Baldwin corporate limits	log-Pearson Type III distribution	USGS E431 step-backwater	1979 (redelineated 2013)	AE w/ Floodway	
Saco River	York-Cumberland County Boundary	Cumberland-Oxford County Boundary lines	log-Pearson Type III, U.S. Water Resources Council Bulletin No. 17	USACE HEC-2 step-backwater	1978 (redelineated 2013)	AE w/ Floodway	USGS gage (no. 01066000) located at Cornish, Maine, on the Saco River, was used to establish the peak discharge-frequency relationships

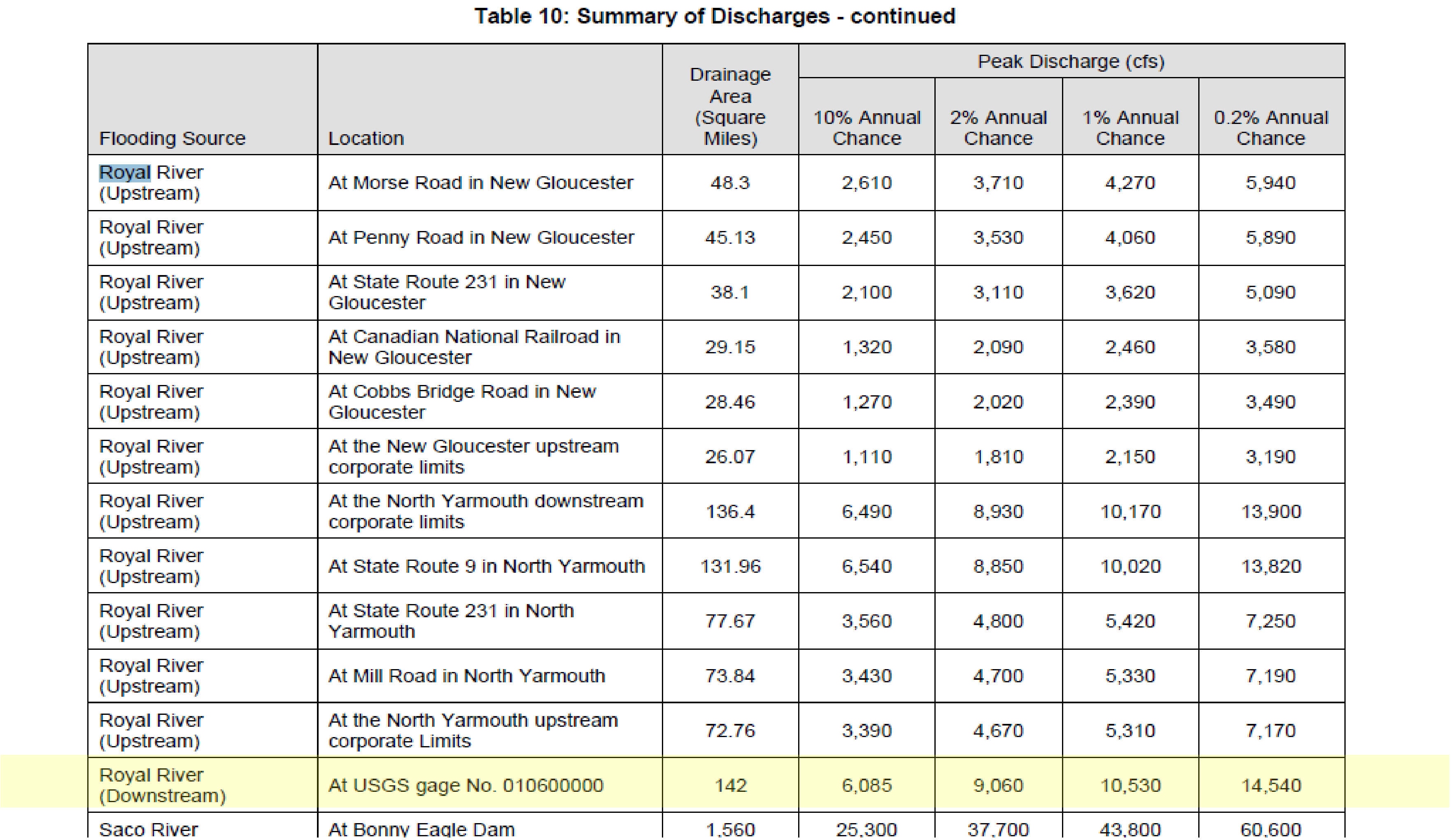


Table 10: Summary of Discharges - continued

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)			
			10% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Royal River (Upstream)	At Morse Road in New Gloucester	48.3	2,610	3,710	4,270	5,940
Royal River (Upstream)	At Penny Road in New Gloucester	45.13	2,450	3,530	4,060	5,890
Royal River (Upstream)	At State Route 231 in New Gloucester	38.1	2,100	3,110	3,620	5,090
Royal River (Upstream)	At Canadian National Railroad in New Gloucester	29.15	1,320	2,090	2,460	3,580
Royal River (Upstream)	At Cobbs Bridge Road in New Gloucester	28.46	1,270	2,020	2,390	3,490
Royal River (Upstream)	At the New Gloucester upstream corporate limits	26.07	1,110	1,810	2,150	3,190
Royal River (Upstream)	At the North Yarmouth downstream corporate limits	136.4	6,490	8,930	10,170	13,900
Royal River (Upstream)	At State Route 9 in North Yarmouth	131.96	6,540	8,850	10,020	13,820
Royal River (Upstream)	At State Route 231 in North Yarmouth	77.67	3,560	4,800	5,420	7,250
Royal River (Upstream)	At Mill Road in North Yarmouth	73.84	3,430	4,700	5,330	7,190
Royal River (Upstream)	At the North Yarmouth upstream corporate Limits	72.76	3,390	4,670	5,310	7,170
Royal River (Downstream)	At USGS gage No. 010600000	142	6,085	9,060	10,530	14,540
Saco River	At Bonny Eagle Dam	1,560	25,300	37,700	43,800	60,600

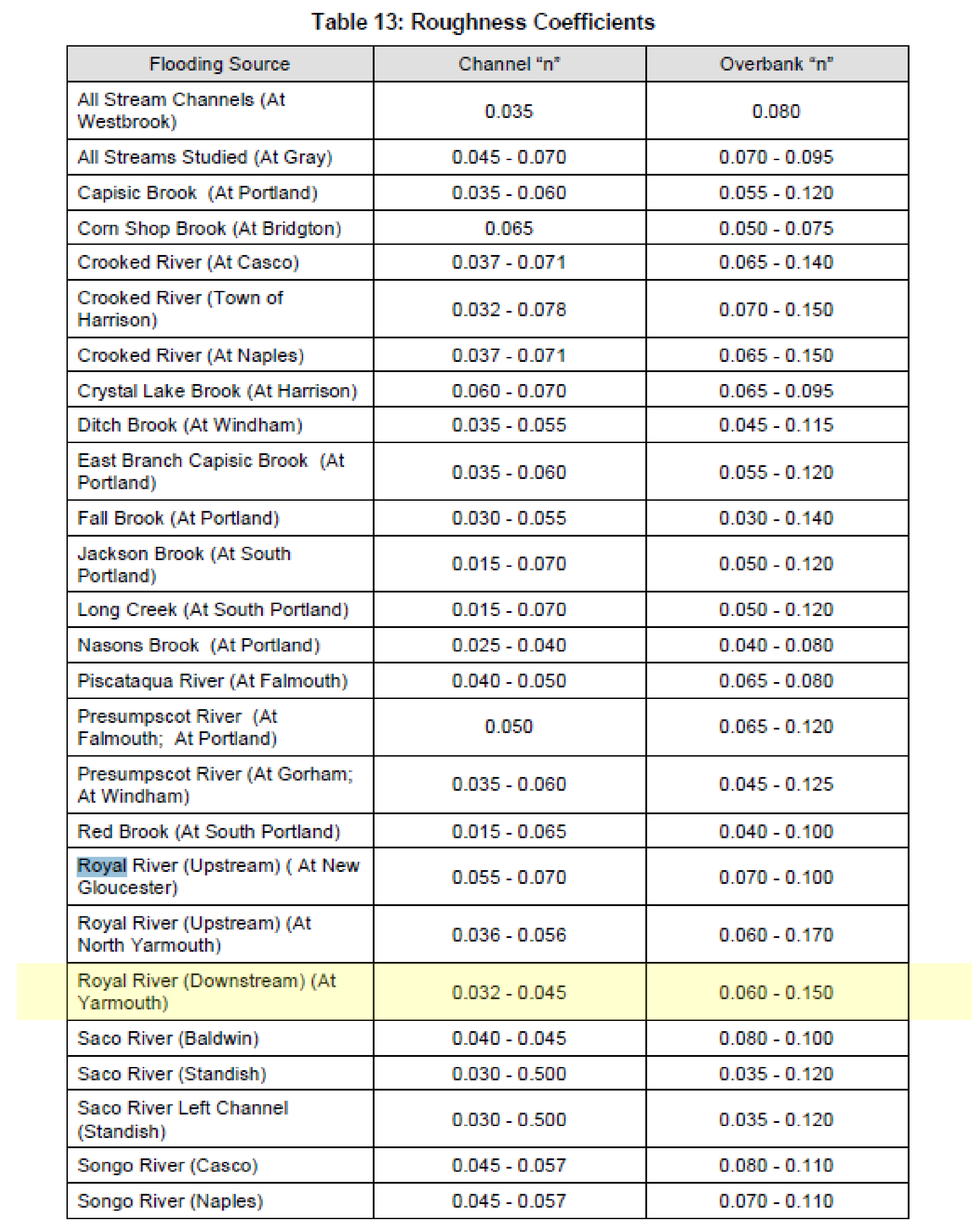


Table 13: Roughness Coefficients

Flooding Source	Channel “n”	Overbank “n”
All Stream Channels (At Westbrook)	0.035	0.080
All Streams Studied (At Gray)	0.045 - 0.070	0.070 - 0.095
Capisic Brook (At Portland)	0.035 - 0.060	0.055 - 0.120
Corn Shop Brook (At Bridgton)	0.065	0.050 - 0.075
Crooked River (At Casco)	0.037 - 0.071	0.065 - 0.140
Crooked River (Town of Harrison)	0.032 - 0.078	0.070 - 0.150
Crooked River (At Naples)	0.037 - 0.071	0.065 - 0.150
Crystal Lake Brook (At Harrison)	0.060 - 0.070	0.065 - 0.095
Ditch Brook (At Windham)	0.035 - 0.055	0.045 - 0.115
East Branch Capisic Brook (At Portland)	0.035 - 0.060	0.055 - 0.120
Fall Brook (At Portland)	0.030 - 0.055	0.030 - 0.140
Jackson Brook (At South Portland)	0.015 - 0.070	0.050 - 0.120
Long Creek (At South Portland)	0.015 - 0.070	0.050 - 0.120
Nasons Brook (At Portland)	0.025 - 0.040	0.040 - 0.080
Piscataqua River (At Falmouth)	0.040 - 0.050	0.065 - 0.080
Presumpscot River (At Falmouth; At Portland)	0.050	0.065 - 0.120
Presumpscot River (At Gorham; At Windham)	0.035 - 0.060	0.045 - 0.125
Red Brook (At South Portland)	0.015 - 0.065	0.040 - 0.100
Royal River (Upstream) (At New Gloucester)	0.055 - 0.070	0.070 - 0.100
Royal River (Upstream) (At North Yarmouth)	0.036 - 0.056	0.060 - 0.170
Royal River (Downstream) (At Yarmouth)	0.032 - 0.045	0.060 - 0.150
Saco River (Baldwin)	0.040 - 0.045	0.080 - 0.100
Saco River (Standish)	0.030 - 0.500	0.035 - 0.120
Saco River Left Channel (Standish)	0.030 - 0.500	0.035 - 0.120
Songo River (Casco)	0.045 - 0.057	0.080 - 0.110
Songo River (Naples)	0.045 - 0.057	0.070 - 0.110

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	9,689	*	2,912	3.6	9.1 [2]	6.1 [3]	6.6	0.5
B	9,979	*	1,510	7.0	13.2	13.2	13.6	0.4
C	10,835	*	1,103	9.5	20.1	20.1	20.3	0.2
D	11,785	*	879	12.0	28.0	28.0	28.1	0.1
E	11,986	*	2,987	3.5	42.0	42.0	42.0	0.0
F	12,714	*	1,436	7.3	42.0	42.0	42.0	0.0
G	13,781	*	1,192	8.8	43.8	43.8	44.1	0.3
H	14,298	*	693	15.2	59.9	59.9	59.9	0.0
I	15,407	*	1,532	6.9	75.1	75.1	75.1	0.0
J	15,618	*	2,326	4.5	76.4	76.4	76.6	0.2
K	15,988	*	1,849	5.7	76.6	76.6	76.8	0.2
L	17,223	*	2,191	4.8	77.6	77.6	77.8	0.2
M	18,258	*	2,245	4.7	78.1	78.1	78.3	0.2
N	19,156	*	1,555	6.8	80.3	80.3	80.3	0.0
O	20,254	*	2,435	4.3	81.1	81.1	81.5	0.4

[1] FEET ABOVE CONFLUENCE WITH CASCO BAY

[2] ELEVATION COMPUTED WITHOUT CONSIDERATION OF WAVE EFFECTS, PLEASE REFER TO ASSOCIATED DFIRM PANEL FOR BASE FLOOD ELEVATIONS

[3] ELEVATION COMPUTED WITHOUT BACKWATER EFFECTS FROM CASCO BAY

* FLOODWAY COINCIDENT WITH CHANNEL BANKS

TABLE 23

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

FLOODWAY DATA

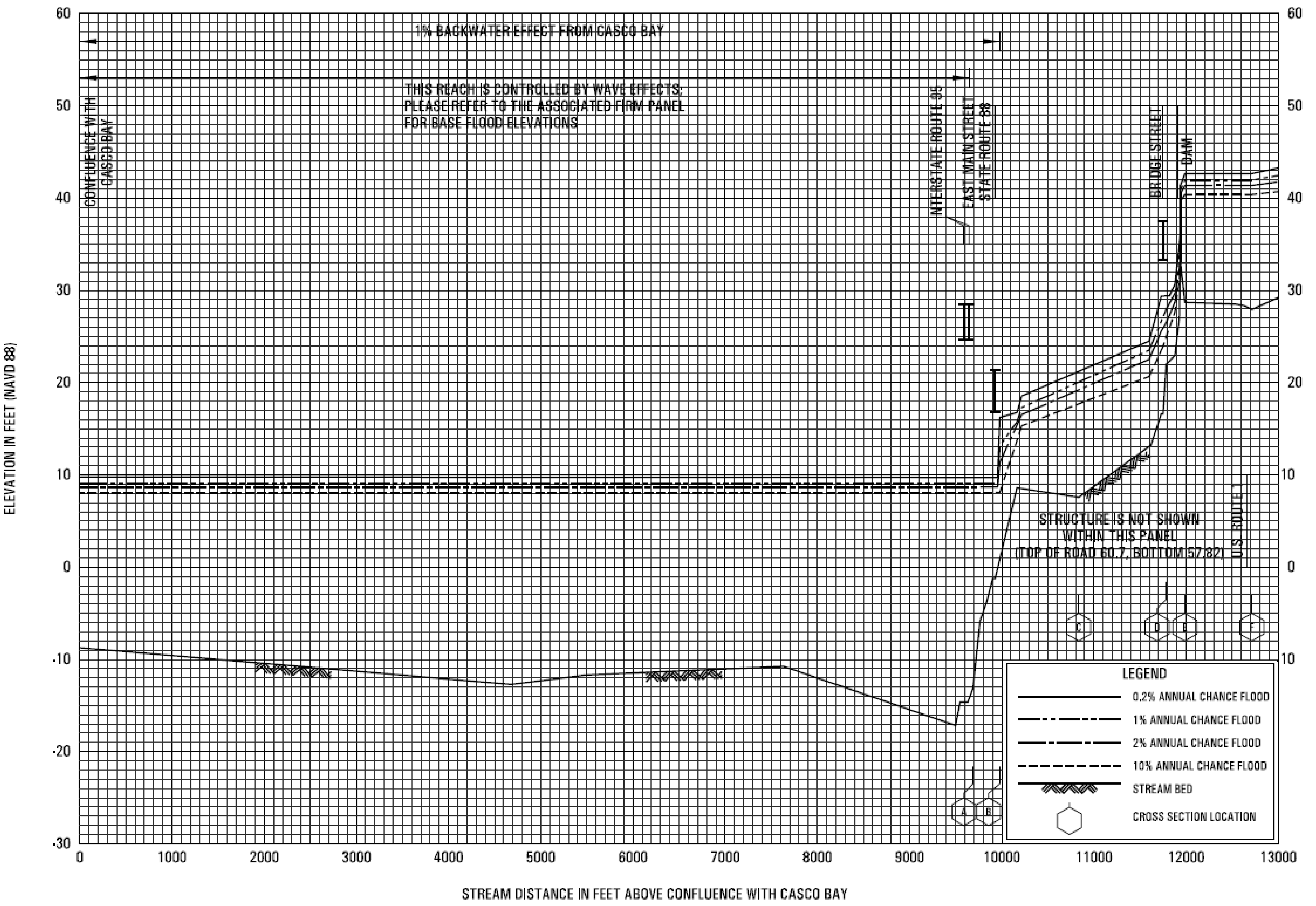
ROYAL RIVER (DOWNSTREAM)

Table 28: Summary of Contracted Studies Included in this FIS Report (continued)

Flooding Source	FIS Report Dated	Contractor	Number	Work Completed Date	Affected Communities
Piscataqua River	10/16/1984	Anderson-Nichols & Company, Inc., CDM/Resource Analysis, and New England Coastal Engineers for FEMA	H-4771	1980	Falmouth, Town of
Pleasant River	1/6/1982	USDA NRCS	IAA-H-17-78, Project Order No. 5	1980	Gray, Town of
Presumpscot River	10/15/1981 9/2/1981	U.S. Geological Survey	IAA-H-9-77, Project Order No. 7	1979	Gorham, Town of; Windham, Town of
Presumpscot River	7/17/1986 10/16/1984 1/2/1981	New England Division, USACE	IAA-H-7-76, Project Order No. 25, and IAA-H-10-77, Project Order No. 1	1978	Falmouth, Town of; Portland, City of; Westbrook, City of
Quahog Bay	6/20/2024	STARR	HSFEHQ-09-D-0370, Task Order 8 and Task Order 15	2013, 2016	Harpswell, Town of
Quaker Brook	7/2/1980	Edward C. Jordan Company	H-4578	1978	Baldwin, Town of
Red Brook	8/17/1981	Anderson-Nichols & Company, Inc., CDM/Resource Analysis, and New England Coastal Engineers for FEMA	H-4771	1980	South Portland, City of
Royal River (Downstream)	11/15/1984	Anderson-Nichols & Company, Inc., CDM/Resource Analysis, and New England Coastal Engineers for FEMA	H-4771	1980	Yarmouth, Town of

Table 28: Summary of Contracted Studies Included in this FIS Report (continued)

Flooding Source	FIS Report Dated	Contractor	Number	Work Completed Date	Affected Communities
Royal River (Upstream)	4/1/1982 1/6/1982 7/16/1981	USDA NRCS	IAA-H-17-78, Project Order No. 5	1980	Gray, Town of; New Gloucester, Town of; North Yarmouth, Town of
Saco River	5/19/1981	U.S. Geological Survey	IAA-H-14-78	1979	Standish, Town of
Saco River	7/2/1980	Edward C. Jordan Company	Contract No. H-4578	1978	Baldwin, Town of
Saco River Left Channel	5/19/1981	U.S. Geological Survey	IAA-H-14-78	1979	Standish, Town of
Sebago Lake	10/1/1981 9/2/1981 5/19/1981 5/5/1981 4/1/1981 3/2/1981	USDA NRCS & U.S. Geological Survey	IAA-H-17-78, Project Order No. 5 & IAA-H-9-77, Project Order No. 7	1979/1980	Casco, Town of; Frye Island, Town of; Naples, Town of; Raymond, Town of; Sebago, Town of; Standish, Town of; Windham, Town of
Songo River	5/5/1981	USDA NRCS	Interagency Agreement No. IAA-H-17-78, Project Order No. 5	1979	Casco, Town of
Songo River	10/1/1981	USDA NRCS	IAA-H-17-78, Project Order No. 5	1979	Naples, Town of
Stevens Brook	5/3/1982	USDA NRCS	Interagency Agreement No. IAA-H-17-78, Project Order No. 5	1980	Bridgton, Town of
Stroudwater River	7/17/1986	Anderson-Nichols & Company, Inc., CDM/Resource Analysis, and New England Coastal Engineers for FEMA	H-4771	1979	Portland, City of



FLOOD PROFILES

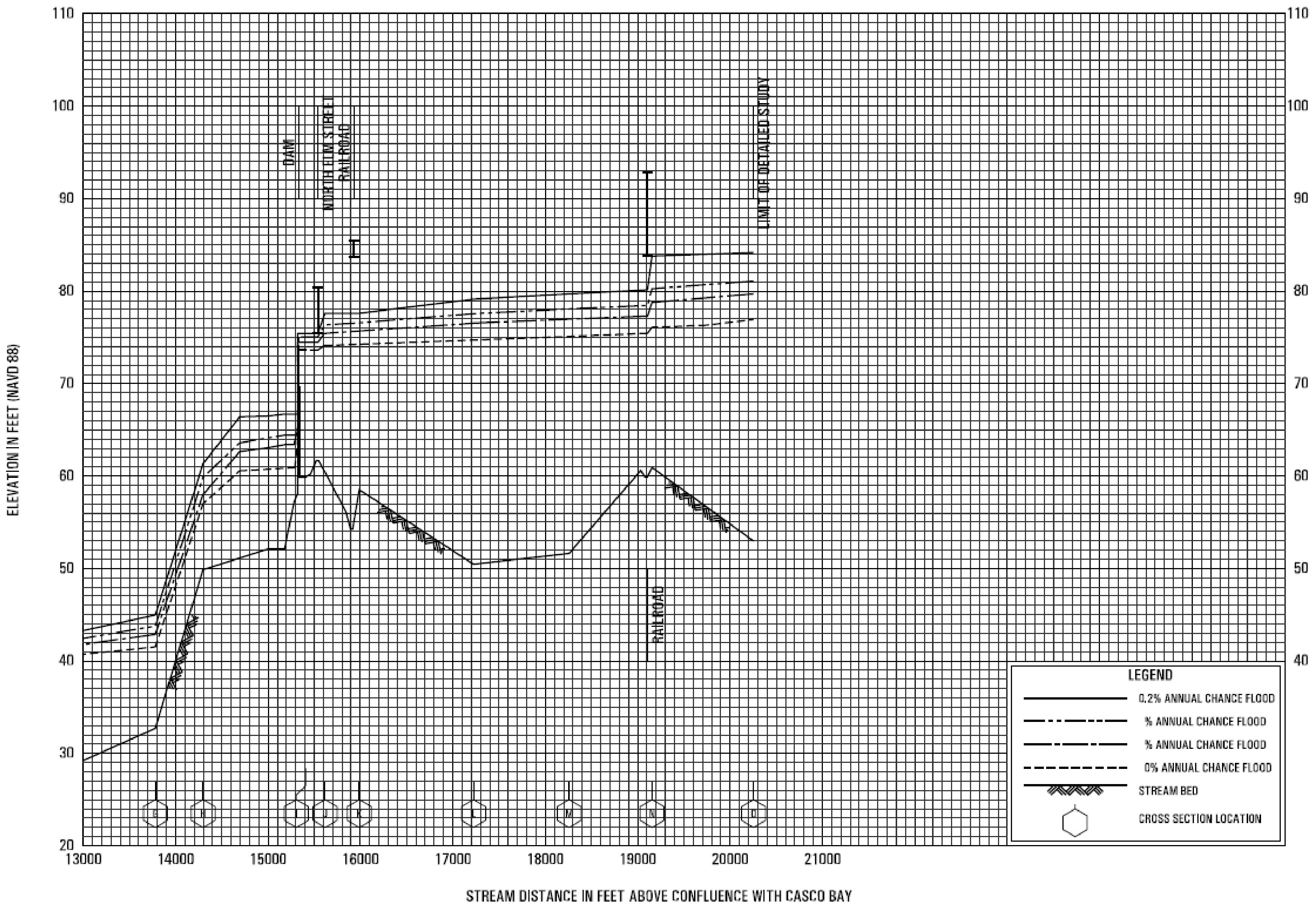
ROYAL RIVER (DOWNSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

73P



FLOOD PROFILES

ROYAL RIVER (DOWNSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

74P

FLOOD PROFILES

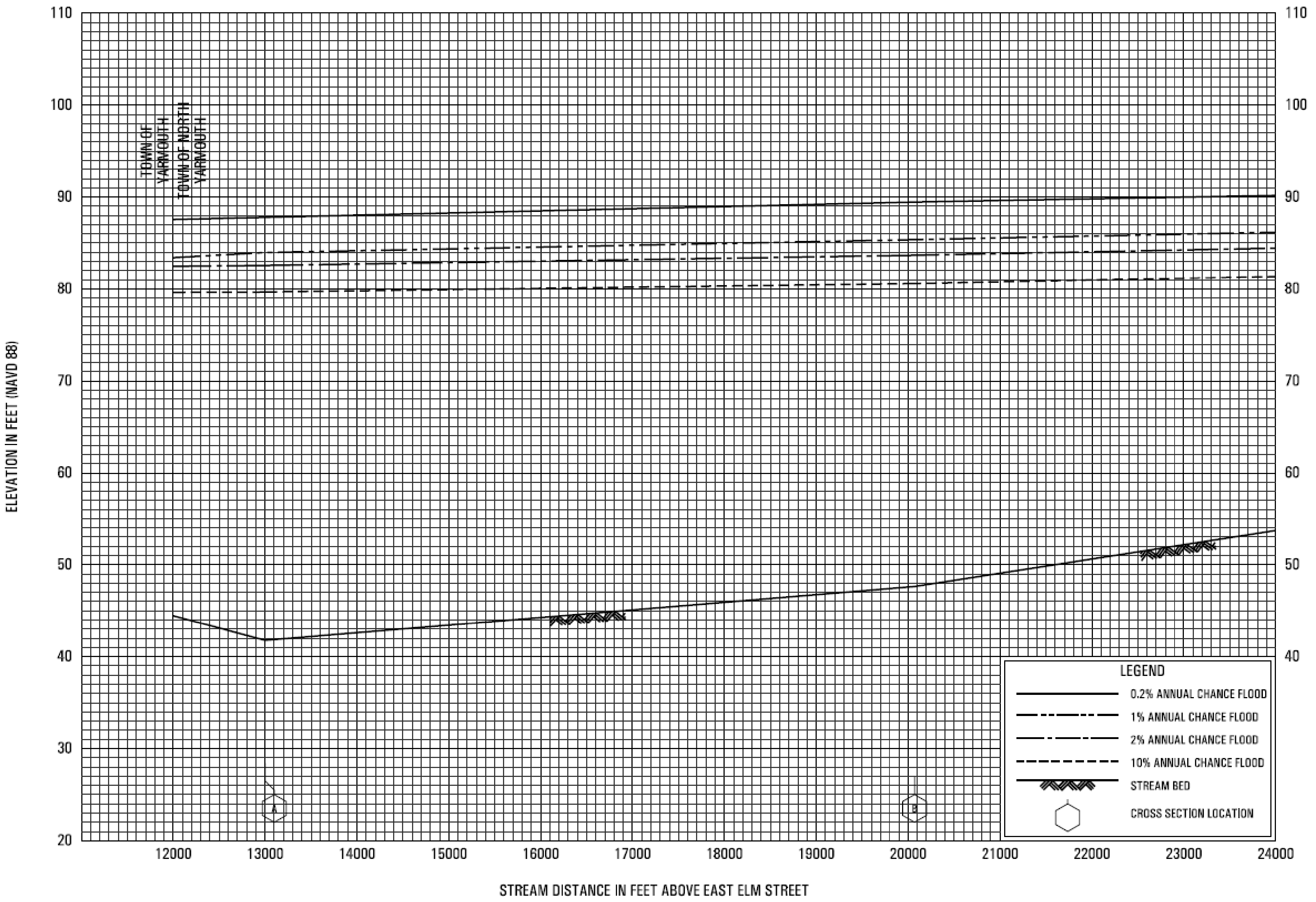
ROYAL RIVER (DOWNSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

74P



FLOOD PROFILES

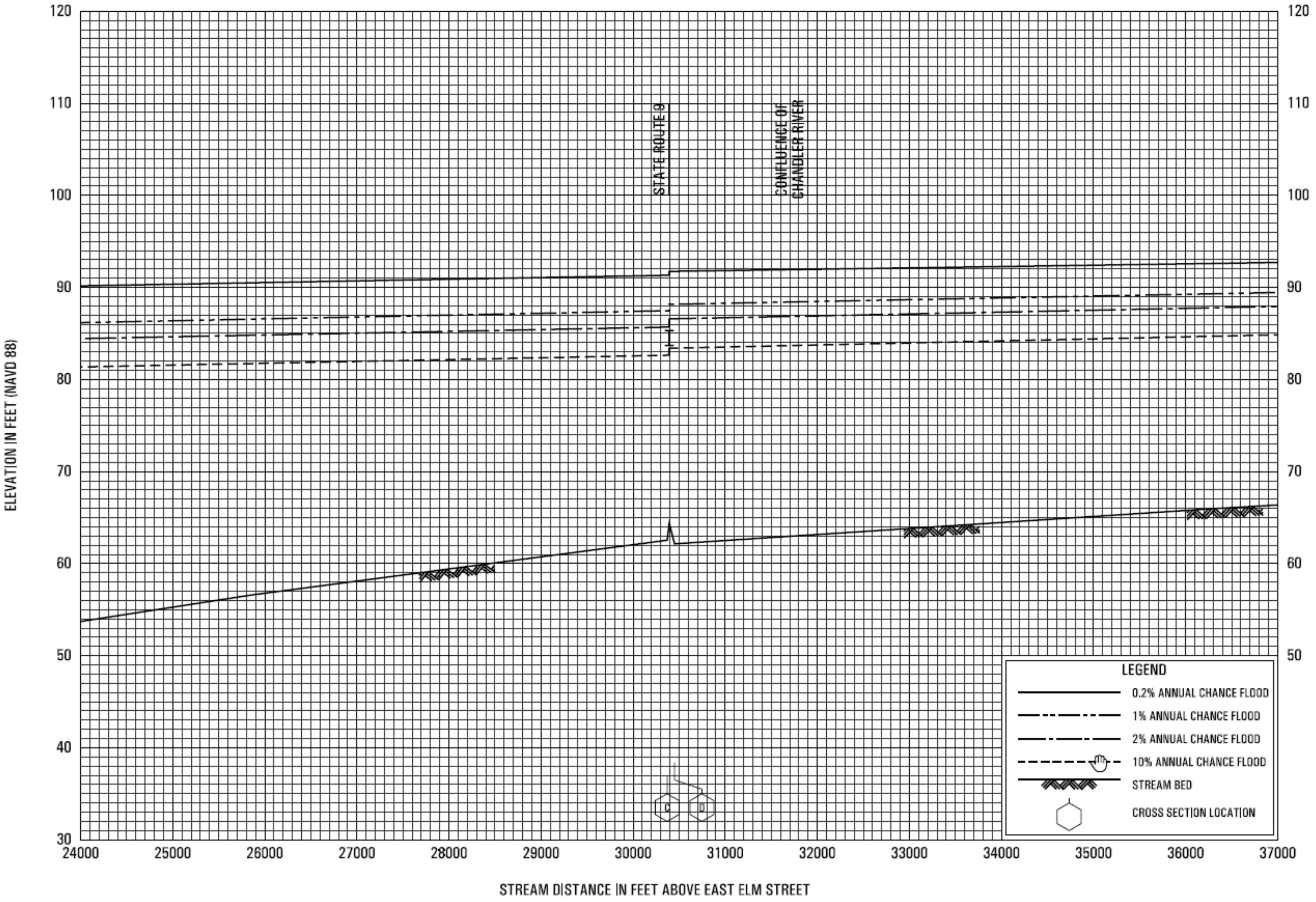
ROYAL RIVER (UPSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

75P



FLOOD PROFILES

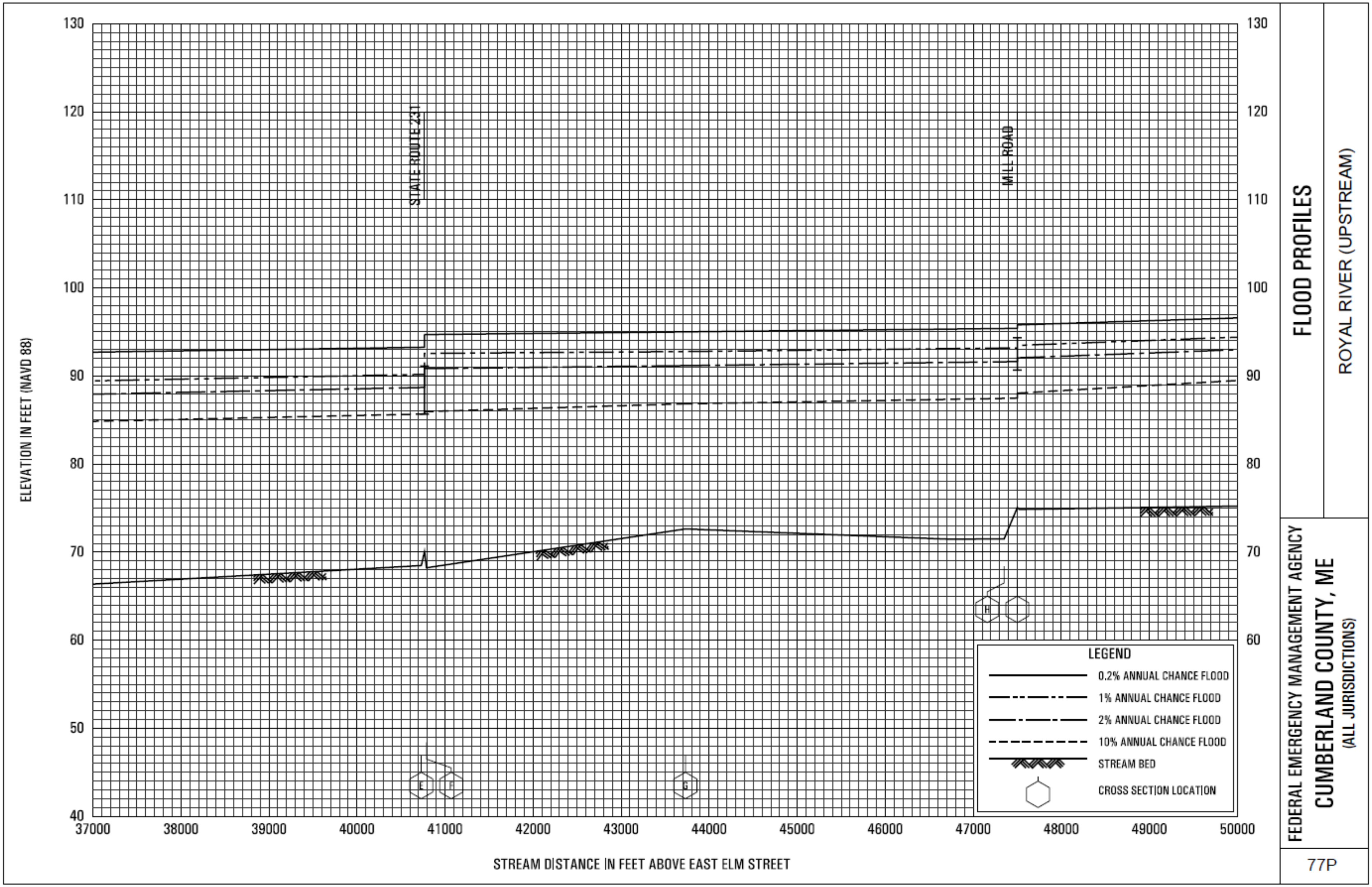
ROYAL RIVER (UPSTREAM)

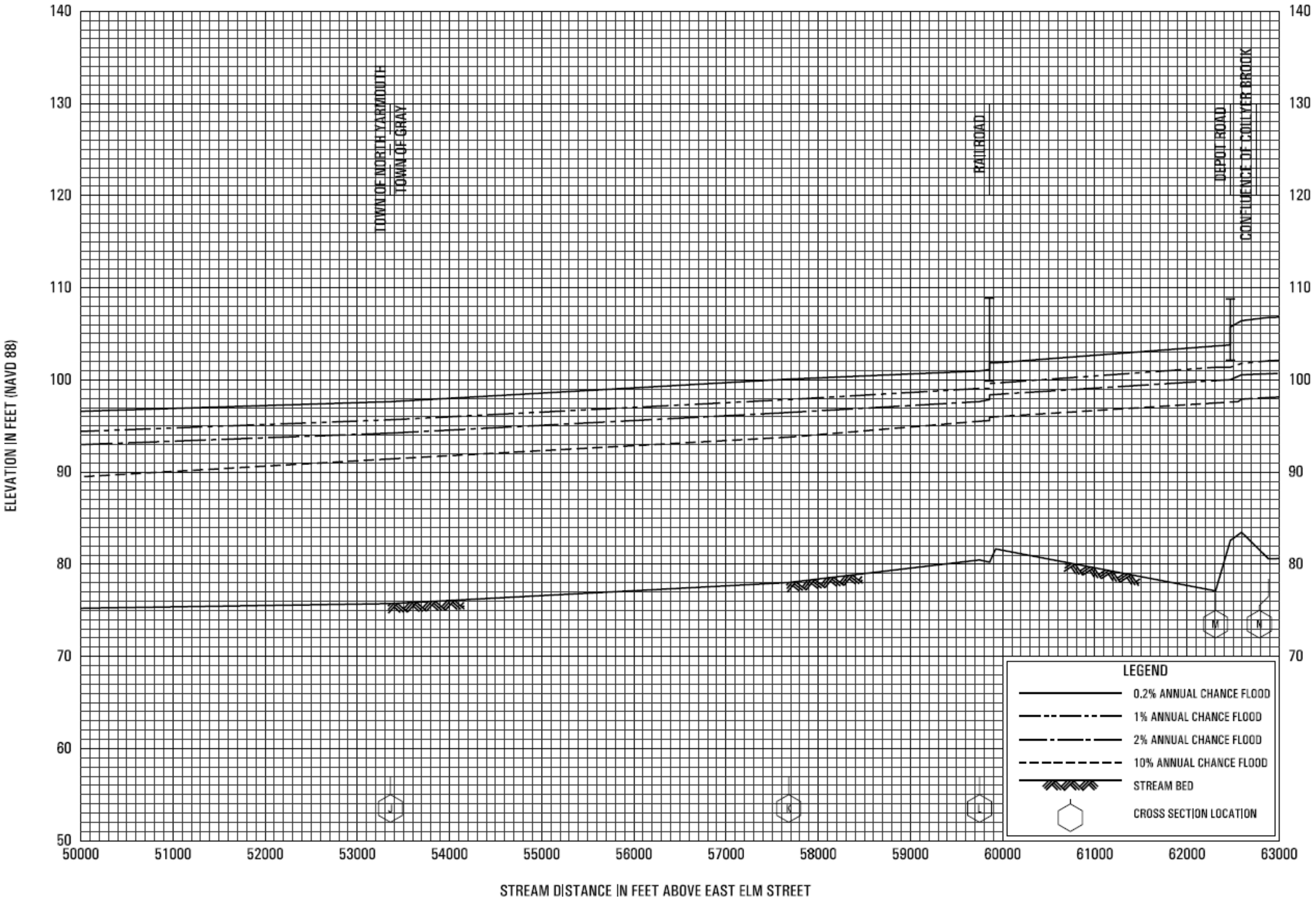
FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

76P


130
120
110
100
90
80
70
60
50
40
ELEVATION IN FEET (NAVD 88)
STATE ROUTE 231
MILL ROAD
E
F
G
H
37000
38000
39000
40000
41000
42000
43000
44000
45000
46000
47000
48000
49000
50000
STREAM DISTANCE IN FEET ABOVE EAST ELM STREET
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
ROYAL RIVER (UPSTREAM)
FEDERAL EMERGENCY MANAGEMENT AGENCY
CUMBERLAND COUNTY, ME
(ALL JURISDICTIONS)
77P



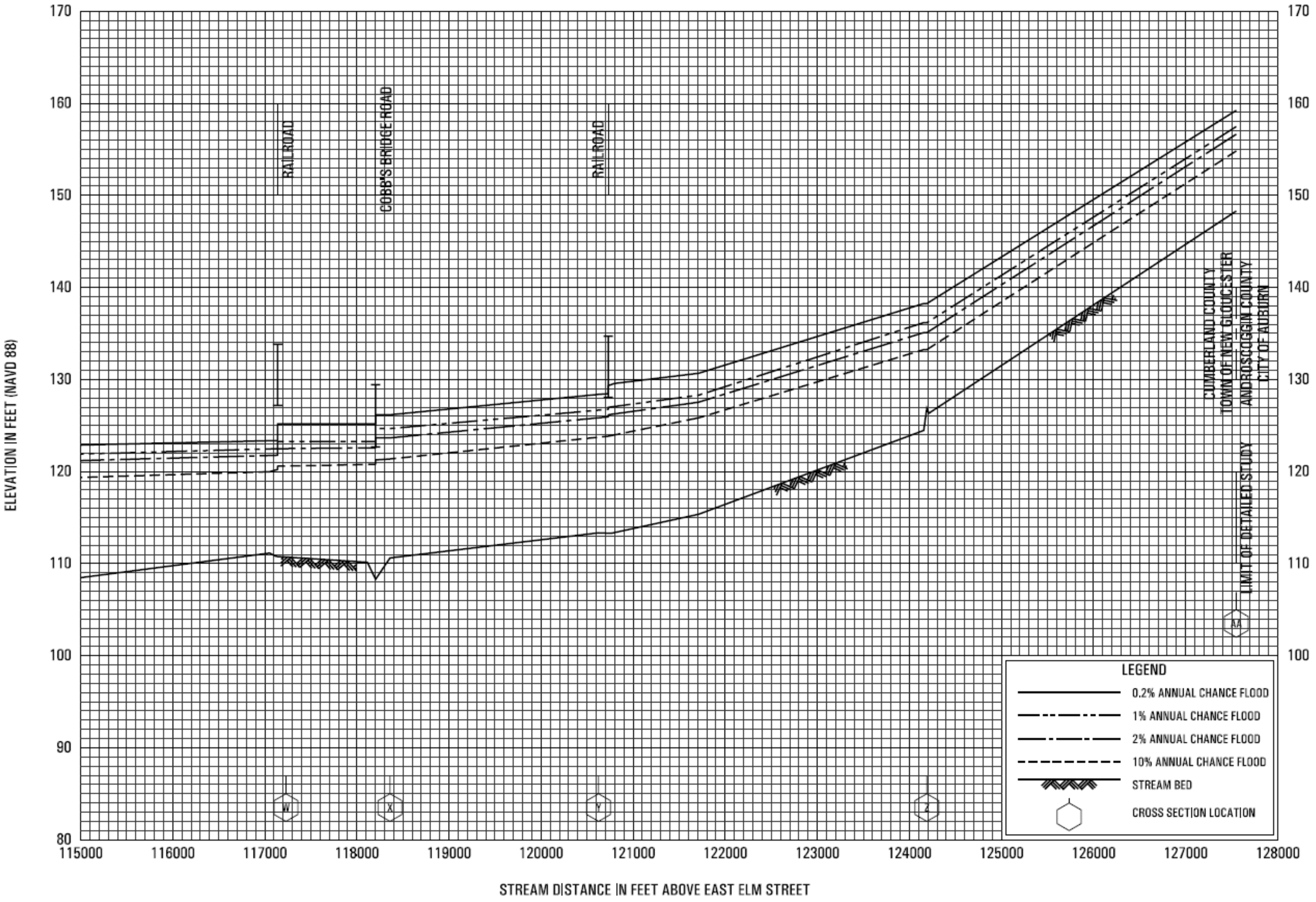
FLOOD PROFILES

ROYAL RIVER (UPSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)



FLOOD PROFILES

ROYAL RIVER (UPSTREAM)

FEDERAL EMERGENCY MANAGEMENT AGENCY

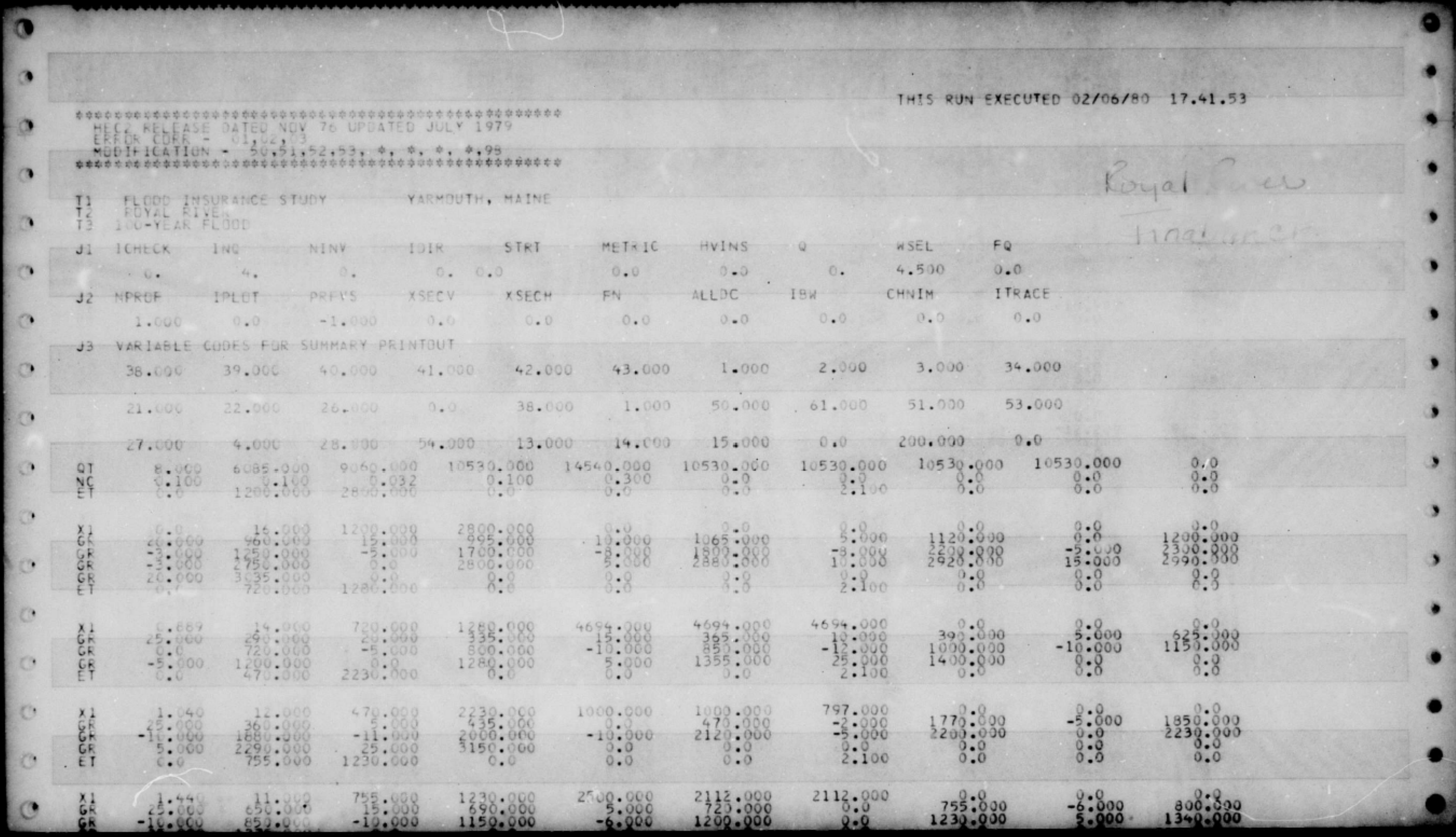
CUMBERLAND COUNTY, ME

(ALL JURISDICTIONS)

83P

E ~~N.~~ YARMOUTH, ME. 1"=400' 23704 E-FRAME 0005

ROYAL RIVER HEC-2 HYDRAULIC MODEL



Royal River

Final [illegible]

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  HEC2 RELEASE DATED NOV 76 UPDATED JULY 1979
  ERROR CORR -  01,02,03
  MODIFICATION -  50,51,52,53, *, *, *, *,98
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T1    FLOOD INSURANCE STUDY          YARMOUTH, MAINE
T2    ROYAL RIVER
T3   100-YEAR FLOOD

J1   ICHECK      INQ       NINV      IDIR      STRT     METRIC    HVINS       Q        WSEL        FQ
         0.        4.        0.        0.  0.0           0.0       0.0        0.     4.500       0.0
J2   NPROF     IPLOT     PRFVS     XSECV     XSECH        FN     ALLDC       IBW     CHNIM    ITRACE
      1.000       0.0    -1.000       0.0       0.0       0.0       0.0       0.0       0.0       0.0
J3   VARIABLE CODES FOR SUMMARY PRINTOUT
     38.000    39.000    40.000    41.000    42.000    43.000     1.000     2.000     3.000    34.000

     21.000    22.000    26.000       0.0    38.000     1.000    50.000    61.000    51.000    53.000

     27.000     4.000    28.000    54.000    13.000    14.000    15.000       0.0   200.000       0.0
QT      8.000  6085.000  9060.000 10530.000 14540.000 10530.000 10530.000 10530.000 10530.000       0.0
NC      0.100     0.100     0.032     0.100     0.300       0.0       0.0       0.0       0.0       0.0
ET        0.0  1200.000  2800.000       0.0       0.0       0.0     2.100       0.0       0.0       0.0

X1        0.0    16.000  1200.000  2800.000       0.0       0.0       0.0       0.0       0.0       0.0
GR     20.000   960.000    15.000   995.000    10.000  1065.000     5.000  1120.000       0.0  1200.000
GR     -3.000  1250.000    -5.000  1700.000    -8.000  1800.000    -8.000  2200.000    -5.000  2300.000
GR     -3.000  2750.000       0.0  2800.000     5.000  2880.000    10.000  2920.000    15.000  2990.000
GR     20.000  3035.000       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET        0.0   720.000  1280.000       0.0       0.0       0.0     2.100       0.0       0.0       0.0

X1      0.889    14.000   720.000  1280.000  4694.000  4694.000  4694.000       0.0       0.0       0.0
GR     25.000   290.000    20.000   335.000    15.000   365.000    10.000   390.000     5.000   625.000
GR        0.0   720.000    -5.000   800.000   -10.000   850.000   -12.000  1000.000   -10.000  1150.000
GR     -5.000  1200.000       0.0  1280.000     5.000  1355.000    25.000  1400.000       0.0       0.0
ET        0.0   470.000  2230.000       0.0       0.0       0.0     2.100       0.0       0.0       0.0

X1      1.040    12.000   470.000  2230.000  1000.000  1000.000   797.000       0.0       0.0       0.0
GR     25.000   360.000     5.000   435.000       0.0   470.000    -2.000  1770.000    -5.000  1850.000
GR    -10.000  1880.000   -11.000  2000.000   -10.000  2120.000    -5.000  2200.000       0.0  2230.000
GR      5.000  2290.000    25.000  3150.000       0.0       0.0       0.0       0.0       0.0       0.0
ET        0.0   755.000  1230.000       0.0       0.0       0.0     2.100       0.0       0.0       0.0

X1      1.440    11.000   755.000  1230.000  2500.000  2112.000  2112.000       0.0       0.0       0.0
GR     25.000   650.000    15.000   690.000     5.000   720.000       0.0   755.000    -6.000   800.000
GR    -10.000   850.000   -10.000  1150.000    -6.000  1200.000       0.0  1230.000     5.000  1340.000
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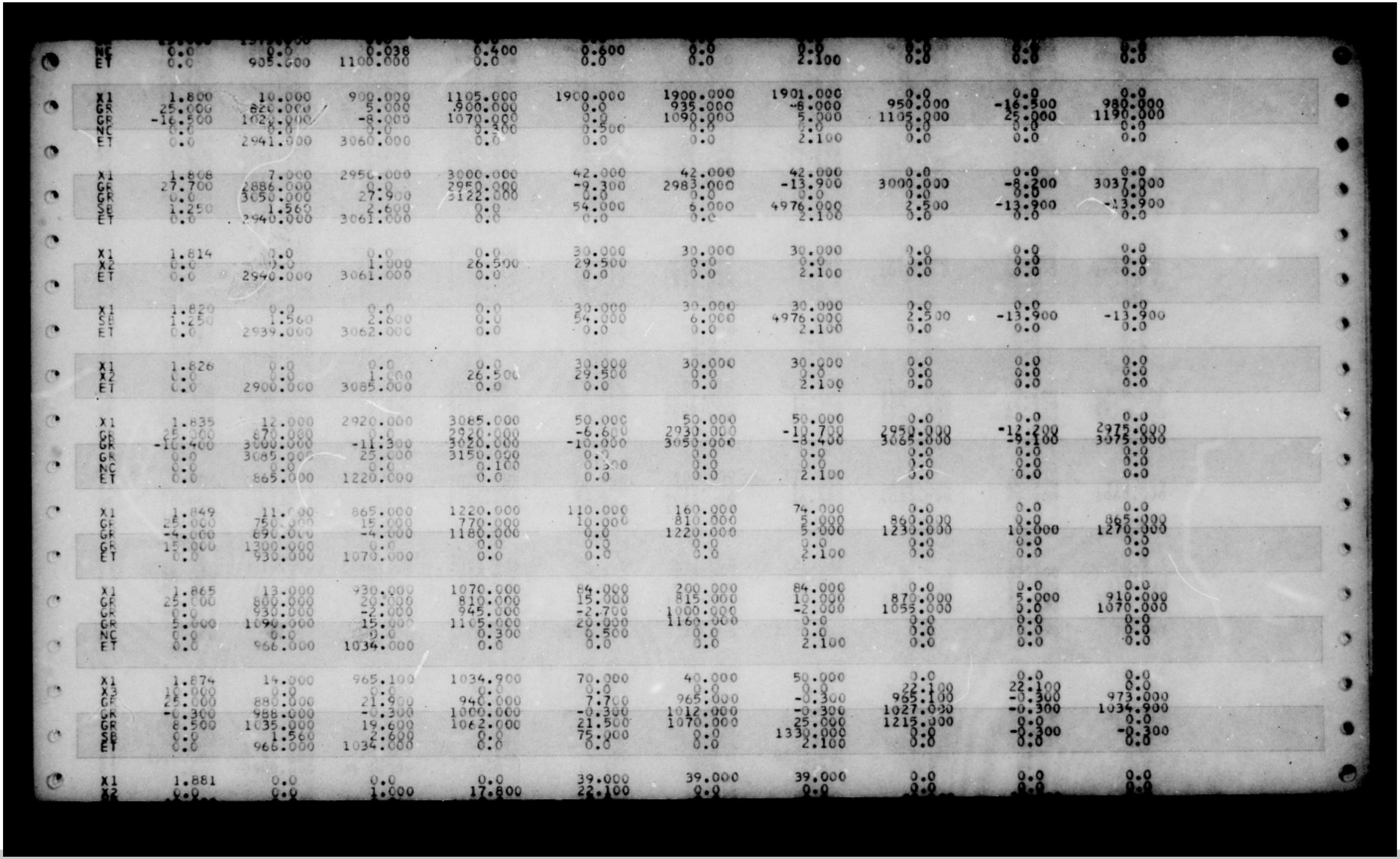
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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NC      0.0      0.0      0.038     0.400     0.600     0.0       0.0       0.0       0.0       0.0
ET      0.0    905.000  1100.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.800   10.000   900.000  1105.000  1900.000  1900.000  1901.000    0.0       0.0       0.0
GR     25.000  820.000     5.000   900.000     0.0     935.000    -8.000   950.000   -16.500   980.000
GR    -16.500 1020.000    -8.000  1070.000     0.0    1090.000     5.000  1105.000    25.000  1190.000
NC      0.0      0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0
ET      0.0   2941.000  3060.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.808    7.000  2950.000  3000.000    42.000    42.000    42.000     0.0       0.0       0.0
GR     27.700 2886.000     0.0    2950.000    -9.300  2983.000   -13.900  3000.000    -8.200  3037.000
GR      0.0   3050.000    27.900  3122.000     0.0       0.0       0.0       0.0       0.0       0.0
SB      1.250    1.560     2.600     0.0      54.000     6.000  4976.000     2.500   -13.900   -13.900
ET      0.0   2940.000  3061.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.814    0.0       0.0       0.0      30.000    30.000    30.000     0.0       0.0       0.0
X2      0.0      0.0       1.000    26.500    29.500     0.0       0.0       0.0       0.0       0.0
ET      0.0   2940.000  3061.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.820    0.0       0.0       0.0      30.000    30.000    30.000     0.0       0.0       0.0
SB      1.250    1.560     2.600     0.0      54.000     6.000  4976.000     2.500   -13.900   -13.900
ET      0.0   2939.000  3062.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.826    0.0       0.0       0.0      30.000    30.000    30.000     0.0       0.0       0.0
X2      0.0      0.0       1.000    26.500    29.500     0.0       0.0       0.0       0.0       0.0
ET      0.0   2900.000  3085.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.835   12.000  2920.000  3085.000    50.000    50.000    50.000     0.0       0.0       0.0
GR     25.000  670.000     0.0    2920.000    -6.600  2930.000   -10.700  2950.000   -12.200  2975.000
GR    -10.400 3000.000   -11.300  3020.000   -10.000  3050.000    -8.400  3065.000    -9.100  3075.000
GR      0.0   3085.000    25.000  3150.000     0.0       0.0       0.0       0.0       0.0       0.0
NC      0.0      0.0       0.0       0.100     0.300     0.0       0.0       0.0       0.0       0.0
ET      0.0    865.000  1220.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.849   11.000   865.000  1220.000   110.000   160.000    74.000     0.0       0.0       0.0
GR     25.000  750.000    15.000   770.000    10.000   810.000     5.000   860.000     0.0     865.000
GR     -4.000  690.000    -4.000  1180.000     0.0    1220.000     5.000  1230.000    10.000  1270.000
GR     15.000 1300.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET      0.0    930.000  1070.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.865   13.000   930.000  1070.000    84.000   200.000    84.000     0.0       0.0       0.0
GR     25.000  800.000    20.000   810.000    15.000   815.000    10.000   870.000     5.000   910.000
GR      0.0    930.000    -2.000   945.000    -2.700  1000.000    -2.000  1055.000     0.0    1070.000
GR      5.000 1090.000    15.000  1105.000    20.000  1160.000     0.0       0.0       0.0       0.0
NC      0.0      0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0
ET      0.0    966.000  1034.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.874   14.000   965.100  1034.900    70.000    40.000    50.000     0.0       0.0       0.0
X3     10.000    0.0       0.0       0.0       0.0       0.0       0.0      22.100    22.100     0.0
GR     25.000  880.000    21.900   940.000     7.700   965.000    -0.300   965.100    -0.300   973.000
GR     -0.300  988.000    -0.300  1000.000    -0.300  1012.000    -0.300  1027.000    -0.300  1034.900
GR      8.500 1035.000    19.600  1062.000    21.500  1070.000    25.000  1215.000     0.0       0.0
SB      0.0      1.560     2.600     0.0      75.000     0.0    1330.000     0.0      -0.300    -0.300
ET      0.0    966.000  1034.000    0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1      1.881    0.0       0.0       0.0      39.000    39.000    39.000     0.0       0.0       0.0
X2      0.0      0.0       1.000    17.800    22.100     0.0       0.0       0.0       0.0       0.0
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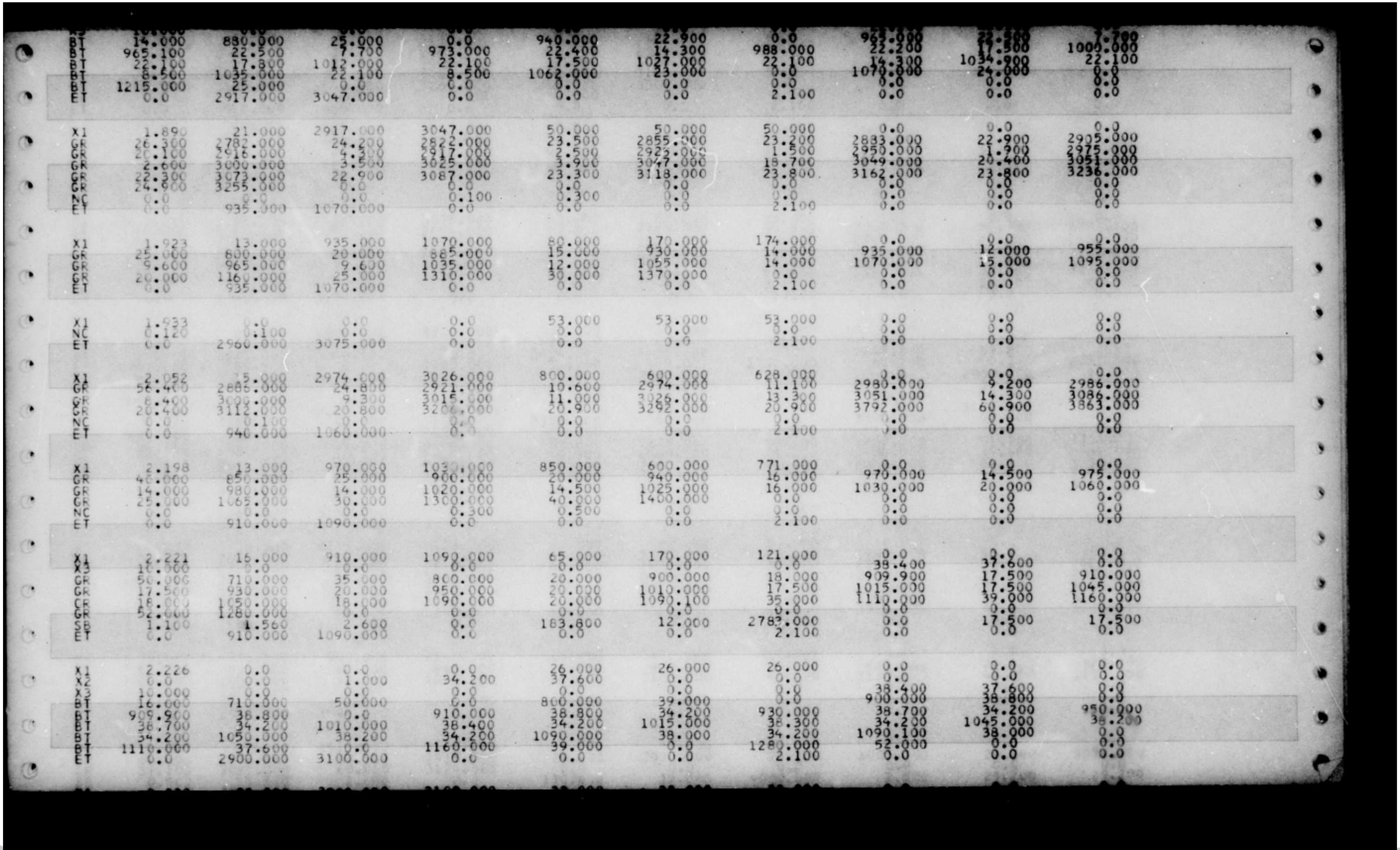
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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BT    14.000   880.000    25.000     0.0     940.000    22.900     0.0     965.000    22.500     7.700
BT   965.100    22.500     7.700   973.000    22.400    14.300   988.000    22.200    17.500  1000.000
BT    22.100    17.800  1012.000    22.100    17.500  1027.000    22.100    14.300  1034.900    22.100
BT     8.500  1035.000    22.100     8.500  1062.000    23.000     0.0    1070.000    24.000     0.0
BT  1215.000    25.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET     0.0    2917.000  3047.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     1.890    21.000  2917.000  3047.000    50.000    50.000    50.000     0.0       0.0       0.0
GR    26.300  2782.000    24.200  2822.000    23.500  2855.000    23.200  2883.000    22.900  2905.000
GR    20.100  2916.000     4.300  2917.000     2.500  2923.000     1.500  2950.000     1.900  2975.000
GR     2.600  3000.000     3.500  3025.000     3.900  3047.000    18.700  3049.000    20.400  3051.000
GR    22.300  3073.000    22.900  3087.000    23.300  3118.000    23.800  3162.000    23.800  3236.000
GR    24.900  3255.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
NC     0.0       0.0       0.0       0.100     0.300     0.0       0.0       0.0       0.0       0.0
ET     0.0     935.000  1070.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     1.923    13.000   935.000  1070.000    80.000   170.000   174.000     0.0       0.0       0.0
GR    25.000   800.000    20.000   885.000    15.000   930.000    14.000   935.000    12.000   955.000
GR     9.600   965.000     9.600  1035.000    12.000  1055.000    14.000  1070.000    15.000  1095.000
GR    20.000  1160.000    25.000  1310.000    30.000  1370.000     0.0       0.0       0.0       0.0
ET     0.0     935.000  1070.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     1.933     0.0       0.0       0.0      53.000    53.000    53.000     0.0       0.0       0.0
NC     0.120     0.100     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET     0.0    2960.000  3075.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.052    25.000  2974.000  3026.000   800.000   600.000   628.000     0.0       0.0       0.0
GR    56.400  2885.000    24.800  2921.000    10.600  2974.000    11.100  2980.000     9.200  2986.000
GR     8.400  3000.000     9.300  3015.000    11.000  3026.000    13.300  3051.000    14.300  3086.000
GR    20.400  3112.000    20.800  3206.000    20.900  3292.000    20.900  3792.000    60.900  3863.000
NC     0.0       0.100     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET     0.0     940.000  1060.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.198    13.000   970.000  1030.000   850.000   600.000   771.000     0.0       0.0       0.0
GR    46.000   850.000    25.000   900.000    20.000   940.000    16.000   970.000    14.500   975.000
GR    14.000   980.000    14.000  1020.000    14.500  1025.000    16.000  1030.000    20.000  1060.000
GR    25.000  1065.000    30.000  1300.000    40.000  1400.000     0.0       0.0       0.0       0.0
NC     0.0       0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0
ET     0.0     910.000  1090.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.221    16.000   910.000  1090.000    65.000   170.000   121.000     0.0       0.0       0.0
X3    10.000     0.0       0.0       0.0       0.0       0.0       0.0      38.400    37.600     0.0
GR    50.000   710.000    35.000   800.000    20.000   900.000    18.000   909.900    17.500   910.000
GR    17.500   930.000    20.000   950.000    20.000  1010.000    17.500  1015.000    17.500  1045.000
GR    18.000  1050.000    18.000  1090.000    20.000  1090.100    35.000  1110.000    39.000  1160.000
GR    52.000  1280.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
SB     1.100     1.560     2.600     0.0     183.800    12.000  2783.000     0.0      17.500    17.500
ET     0.0     910.000  1090.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.226     0.0       0.0       0.0      26.000    26.000    26.000     0.0       0.0       0.0
X2     0.0       0.0       1.000    34.200    37.600     0.0       0.0       0.0       0.0       0.0
X3    10.000     0.0       0.0       0.0       0.0       0.0       0.0      38.400    37.600     0.0
BT    16.000   710.000    50.000     0.0     800.000    39.000     0.0     900.000    38.800     0.0
BT   909.900    38.800     0.0     910.000    38.800    34.200   930.000    38.700    34.200   950.000
BT    38.700    34.200  1010.000    38.400    34.200  1015.000    38.300    34.200  1045.000    38.200
BT    34.200  1050.000    38.200    34.200  1090.000    38.000    34.200  1090.100    38.000     0.0
BT  1110.000    37.600     0.0    1160.000    39.000     0.0    1280.000    52.000     0.0       0.0
ET     0.0    2900.000  3100.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0
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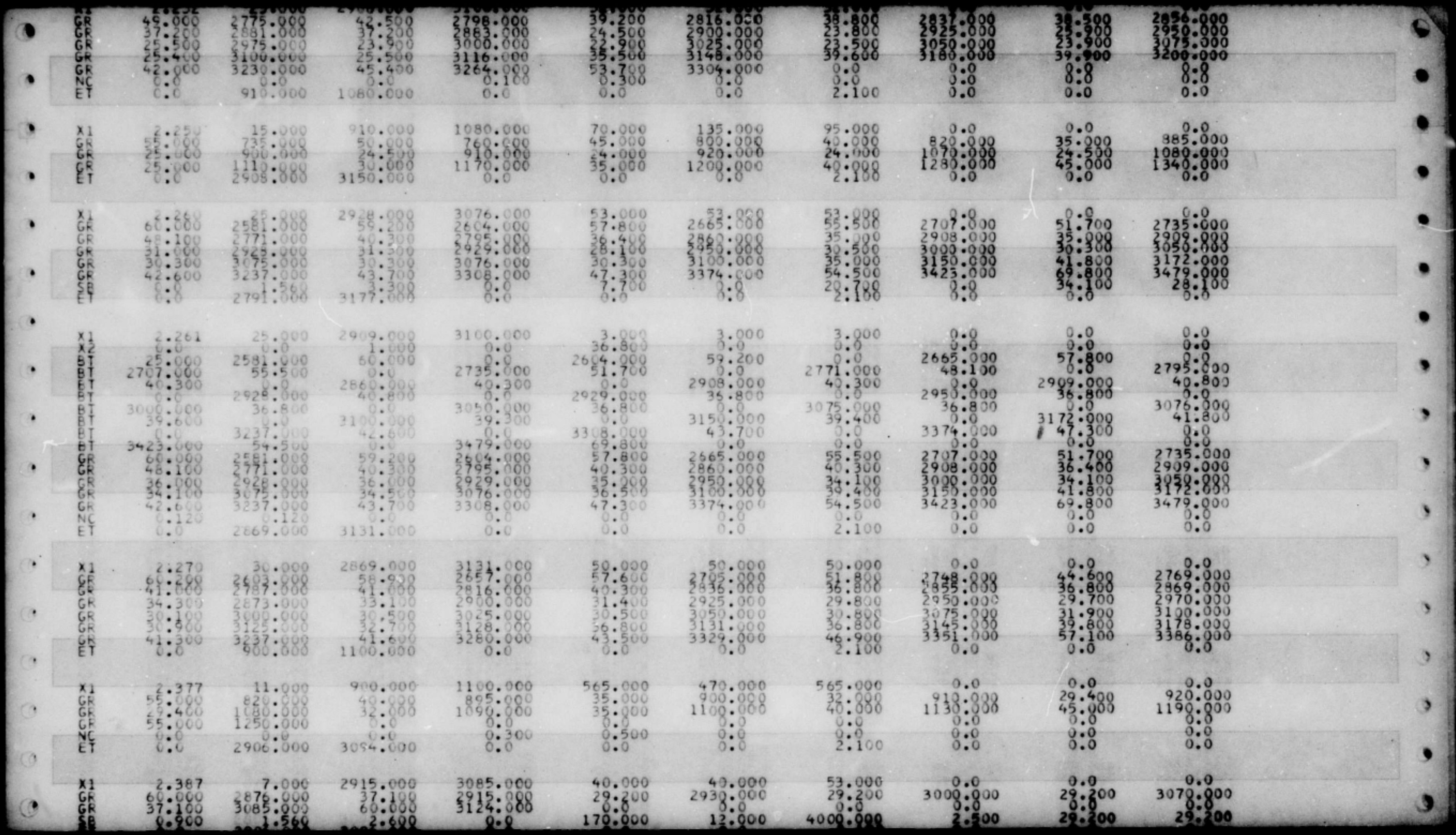
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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GR    49.000  2775.000    42.500  2798.000    39.200  2816.000    38.800  2837.000    38.500  2856.000
GR    37.200  2881.000    37.200  2883.000    24.500  2900.000    23.800  2925.000    25.900  2950.000
GR    25.500  2975.000    23.900  3000.000    22.900  3025.000    23.500  3050.000    23.900  3075.000
GR    25.400  3100.000    25.500  3116.000    35.500  3148.000    39.600  3180.000    39.900  3200.000
GR    42.000  3230.000    45.400  3264.000    53.700  3304.000     0.0       0.0       0.0       0.0
NC     0.0       0.0       0.0       0.100     0.300     0.0       0.0       0.0       0.0       0.0
ET     0.0     910.000  1080.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.250    15.000   910.000  1080.000    70.000   135.000    95.000     0.0       0.0       0.0
GR    55.000   735.000    50.000   760.000    45.000   800.000    40.000   820.000    35.000   885.000
GR    25.000   900.000    24.500   910.000    24.000   920.000    24.000  1070.000    24.500  1080.000
GR    25.000  1110.000    30.000  1170.000    35.000  1200.000    40.000  1280.000    45.000  1340.000
ET     0.0    2908.000  3150.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.260    25.000  2928.000  3076.000    53.000    53.000    53.000     0.0       0.0       0.0
GR    60.000  2581.000    59.200  2604.000    57.800  2665.000    55.500  2707.000    51.700  2735.000
GR    48.100  2771.000    40.300  2795.000    36.400  2860.000    35.000  2908.000    35.000  2909.000
GR    31.000  2925.000    31.300  2929.000    28.100  2950.000    30.500  3000.000    30.300  3050.000
GR    30.300  3075.000    30.300  3076.000    30.300  3100.000    35.000  3150.000    41.800  3172.000
GR    42.600  3237.000    43.700  3308.000    47.300  3374.000    54.500  3423.000    69.800  3479.000
SB     0.0       1.560     3.300     0.0       7.700     0.0      20.700     0.0      34.100    28.100
ET     0.0    2791.000  3177.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.261    25.000  2909.000  3100.000     3.000     3.000     3.000     0.0       0.0       0.0
X2     0.0       0.0       1.000     0.0      36.800     0.0       0.0       0.0       0.0       0.0
BT    25.000  2581.000    60.000     0.0    2604.000    59.200     0.0    2665.000    57.800     0.0
BT  2707.000    55.500     0.0    2735.000    51.700     0.0    2771.000    48.100     0.0    2795.000
BT    40.300     0.0    2860.000    40.300     0.0    2908.000    40.300     0.0    2909.000    40.800
BT     0.0    2928.000    40.800     0.0    2929.000    36.800     0.0    2950.000    36.800     0.0
BT  3000.000    36.800     0.0    3050.000    36.800     0.0    3075.000    36.800     0.0    3076.000
BT    39.600     0.0    3100.000    39.300     0.0    3150.000    39.400     0.0    3172.000    41.800
BT     0.0    3237.000    42.600     0.0    3308.000    43.700     0.0    3374.000    47.300     0.0
BT  3423.000    54.500     0.0    3479.000    69.800     0.0       0.0       0.0       0.0       0.0
GR    60.000  2581.000    59.200  2604.000    57.800  2665.000    55.500  2707.000    51.700  2735.000
GR    48.100  2771.000    40.300  2795.000    40.300  2860.000    40.300  2908.000    36.400  2909.000
GR    36.000  2928.000    36.000  2929.000    35.000  2950.000    34.100  3000.000    34.100  3050.000
GR    34.100  3075.000    34.500  3076.000    36.500  3100.000    39.400  3150.000    41.800  3172.000
GR    42.600  3237.000    43.700  3308.000    47.300  3374.000    54.500  3423.000    69.800  3479.000
NC     0.120     0.120     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
ET     0.0    2869.000  3131.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.270    30.000  2869.000  3131.000    50.000    50.000    50.000     0.0       0.0       0.0
GR    60.200  2603.000    58.900  2657.000    57.600  2705.000    51.800  2748.000    44.600  2769.000
GR    41.000  2787.000    41.000  2816.000    40.300  2836.000    36.800  2855.000    36.800  2869.000
GR    34.300  2873.000    33.100  2900.000    31.400  2925.000    29.800  2950.000    29.700  2970.000
GR    30.100  3000.000    30.500  3025.000    30.500  3050.000    30.800  3075.000    31.900  3100.000
GR    30.900  3125.000    32.700  3128.000    36.800  3131.000    36.800  3145.000    39.800  3178.000
GR    41.300  3237.000    41.600  3280.000    43.500  3329.000    46.900  3351.000    57.100  3386.000
ET     0.0     900.000  1100.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.377    11.000   900.000  1100.000   565.000   470.000   565.000     0.0       0.0       0.0
GR    55.000   820.000    40.000   895.000    35.000   900.000    32.000   910.000    29.400   920.000
GR    29.400  1080.000    32.000  1090.000    35.000  1100.000    40.000  1130.000    45.000  1190.000
GR    55.000  1250.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
NC     0.0       0.0       0.0       0.300     0.500     0.0       0.0       0.0       0.0       0.0
ET     0.0    2906.000  3094.000     0.0       0.0       0.0       2.100     0.0       0.0       0.0

X1     2.387     7.000  2915.000  3085.000    40.000    40.000    53.000     0.0       0.0       0.0
GR    60.000  2876.000    37.100  2915.000    29.200  2930.000    29.200  3000.000    29.200  3070.000
GR    37.100  3085.000    60.000  3124.000     0.0       0.0       0.0       0.0       0.0       0.0
SB     0.900     1.560     2.600     0.0     170.000    12.000  4000.000     2.500    29.200    29.200
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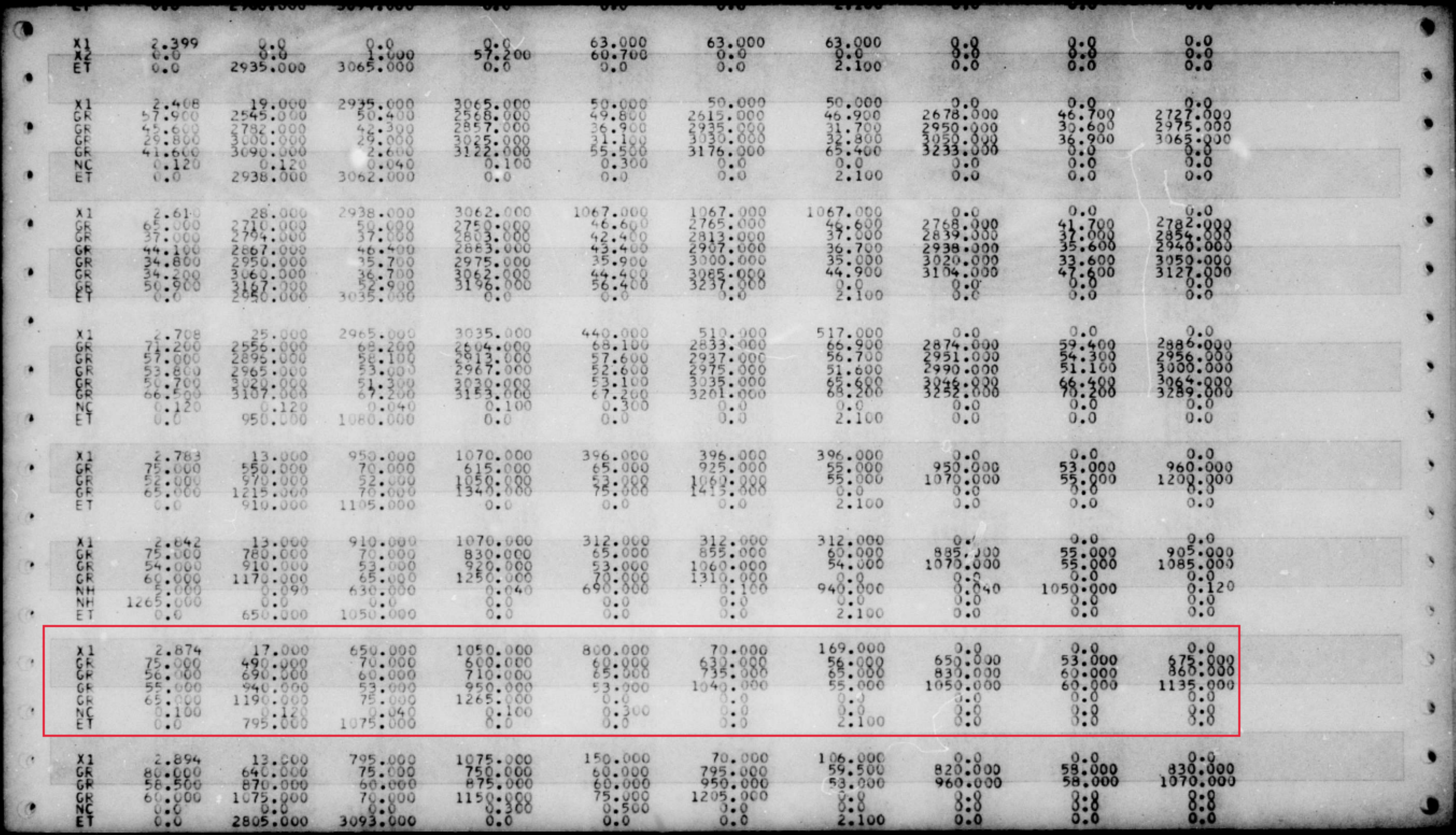
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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X1     2.399      0.0        0.0        0.0       63.000     63.000     63.000     0.0        0.0        0.0
X2     0.0        0.0        1.000     57.200     60.700      0.0        0.0       0.0        0.0        0.0
ET     0.0     2935.000   3065.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.408     19.000   2935.000   3065.000     50.000     50.000     50.000     0.0        0.0        0.0
GR    57.900   2545.000     50.400   2568.000     49.800   2615.000     46.900  2678.000     46.700   2727.000
GR    45.600   2782.000     42.300   2857.000     36.900   2935.000     31.700  2950.000     30.600   2975.000
GR    29.800   3000.000     29.000   3025.000     31.100   3030.000     32.800  3050.000     36.900   3065.000
GR    41.600   3090.000      2.600   3122.000     55.500   3176.000     65.400  3233.000      0.0        0.0
NC     0.120      0.120      0.040      0.100      0.300      0.0        0.0       0.0        0.0        0.0
ET     0.0     2938.000   3062.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.610     28.000   2938.000   3062.000   1067.000   1067.000   1067.000     0.0        0.0        0.0
GR    65.000   2710.000     50.000   2750.000     46.600   2765.000     46.600  2768.000     41.700   2782.000
GR    37.000   2794.000     37.000   2803.000     42.400   2813.000     37.000  2839.000     37.000   2854.000
GR    44.100   2867.000     46.400   2883.000     43.400   2907.000     36.700  2938.000     35.600   2940.000
GR    34.800   2950.000     35.700   2975.000     35.900   3000.000     35.000  3020.000     33.600   3050.000
GR    34.200   3060.000     36.700   3062.000     44.400   3085.000     44.900  3104.000     47.600   3127.000
GR    50.900   3167.000     52.900   3196.000     56.400   3237.000      0.0       0.0        0.0        0.0
ET     0.0     2950.000   3035.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.708     25.000   2965.000   3035.000    440.000    510.000    517.000     0.0        0.0        0.0
GR    71.200   2556.000     68.200   2604.000     68.100   2833.000     66.900  2874.000     59.400   2886.000
GR    57.000   2896.000     58.100   2913.000     57.600   2937.000     56.700  2951.000     54.300   2956.000
GR    53.800   2965.000     53.000   2967.000     52.600   2975.000     51.600  2990.000     51.100   3000.000
GR    50.700   3020.000     51.300   3030.000     53.100   3035.000     65.600  3046.000     66.400   3064.000
GR    66.500   3107.000     67.200   3153.000     67.200   3201.000     68.200  3252.000     70.200   3289.000
NC     0.120      0.120      0.040      0.100      0.300      0.0        0.0       0.0        0.0        0.0
ET     0.0      950.000   1080.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.783     13.000    950.000   1070.000    396.000    396.000    396.000     0.0        0.0        0.0
GR    75.000    550.000     70.000    615.000     65.000    925.000     55.000   950.000     53.000    960.000
GR    52.000    970.000     52.000   1050.000     53.000   1060.000     55.000  1070.000     55.000   1200.000
GR    65.000   1215.000     70.000   1340.000     75.000   1415.000      0.0       0.0        0.0        0.0
ET     0.0      910.000   1105.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.842     13.000    910.000   1070.000    312.000    312.000    312.000     0.0        0.0        0.0
GR    75.000    780.000     70.000    830.000     65.000    855.000     60.000   885.000     55.000    905.000
GR    54.000    910.000     53.000    920.000     53.000   1060.000     54.000  1070.000     55.000   1085.000
GR    60.000   1170.000     65.000   1250.000     70.000   1310.000      0.0       0.0        0.0        0.0
NH     5.000      0.090    630.000      0.040    690.000      0.100    940.000     0.040   1050.000      0.120
NH  1265.000      0.0        0.0        0.0        0.0        0.0        0.0       0.0        0.0        0.0
ET     0.0      650.000   1050.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.874     17.000    650.000   1050.000    800.000     70.000    169.000     0.0        0.0        0.0
GR    75.000    490.000     70.000    600.000     60.000    630.000     56.000   650.000     53.000    675.000
GR    56.000    690.000     60.000    710.000     65.000    735.000     65.000   830.000     60.000    860.000
GR    55.000    940.000     53.000    950.000     53.000   1040.000     55.000  1050.000     60.000   1135.000
GR    65.000   1190.000     75.000   1265.000      0.0        0.0        0.0       0.0        0.0        0.0
NC     0.100      0.120      0.040      0.100      0.300      0.0        0.0       0.0        0.0        0.0
ET     0.0      795.000   1075.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0

X1     2.894     13.000    795.000   1075.000    150.000     70.000    106.000     0.0        0.0        0.0
GR    80.000    640.000     75.000    750.000     60.000    795.000     59.500   820.000     58.000    830.000
GR    58.500    870.000     60.000    875.000     60.000    950.000     53.000   960.000     58.000   1070.000
GR    60.000   1075.000     70.000   1150.000     75.000   1205.000      0.0       0.0        0.0        0.0
NC     0.0        0.0        0.0        0.300      0.500      0.0        0.0       0.0        0.0        0.0
ET     0.0     2805.000   3093.000      0.0        0.0        0.0        2.100     0.0        0.0        0.0
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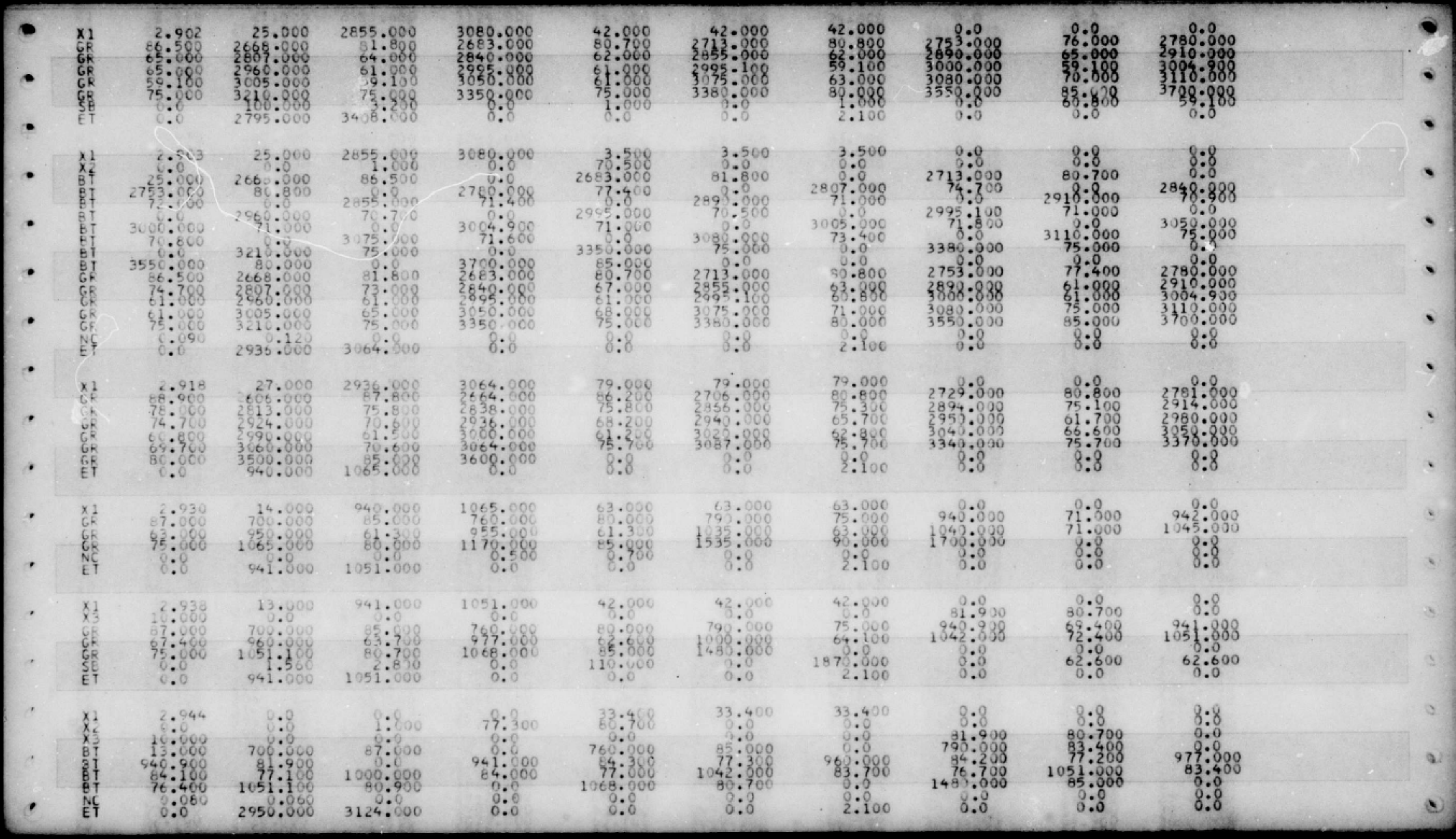
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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X1     2.902     25.000   2855.000   3080.000     42.000     42.000     42.000        0.0        0.0        0.0
GR    86.500   2668.000     81.800   2683.000     80.700   2713.000     80.800   2753.000     76.000   2780.000
GR    65.000   2807.000     64.000   2840.000     62.000   2855.000     62.000   2890.000     65.000   2910.000
GR    65.000   2960.000     61.000   2995.000     61.000   2995.100     59.100   3000.000     59.100   3004.900
GR    59.100   3005.000     59.100   3050.000     61.000   3075.000     63.000   3080.000     70.000   3110.000
GR    75.000   3210.000     75.000   3350.000     75.000   3380.000     80.000   3550.000     85.000   3700.000
SB       0.0    100.000      3.200        0.0      1.000        0.0      1.000        0.0     60.800     59.100
ET       0.0   2795.000   3408.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.903     25.000   2855.000   3080.000      3.500      3.500      3.500        0.0        0.0        0.0
X2       0.0        0.0      1.000        0.0     70.500        0.0        0.0        0.0        0.0        0.0
BT    25.000   2668.000     86.500        0.0   2683.000     81.800        0.0   2713.000     80.700        0.0
BT  2753.000     80.800        0.0   2780.000     77.400        0.0   2807.000     74.700        0.0   2840.000
BT    72.000        0.0   2855.000     71.400        0.0   2890.000     71.000        0.0   2910.000     70.900
BT       0.0   2960.000     70.700        0.0   2995.000     70.500        0.0   2995.100     71.000        0.0
BT  3000.000     71.000        0.0   3004.900     71.000        0.0   3005.000     71.800        0.0   3050.000
BT    70.800        0.0   3075.000     71.600        0.0   3080.000     73.400        0.0   3110.000     75.000
BT       0.0   3210.000     75.000        0.0   3350.000     75.000        0.0   3380.000     75.000        0.0
BT  3550.000     80.000        0.0   3700.000     85.000        0.0        0.0        0.0        0.0        0.0
GR    86.500   2668.000     81.800   2683.000     80.700   2713.000     80.800   2753.000     77.400   2780.000
GR    74.700   2807.000     73.000   2840.000     67.000   2855.000     63.000   2890.000     61.000   2910.000
GR    61.000   2960.000     61.000   2995.000     61.000   2995.100     60.800   3000.000     61.000   3004.900
GR    61.000   3005.000     65.000   3050.000     68.000   3075.000     71.000   3080.000     75.000   3110.000
GR    75.000   3210.000     75.000   3350.000     75.000   3380.000     80.000   3550.000     85.000   3700.000
NC     0.090      0.120        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
ET       0.0   2935.000   3064.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.918     27.000   2936.000   3064.000     79.000     79.000     79.000        0.0        0.0        0.0
GR    88.900   2606.000     87.800   2664.000     86.200   2706.000     80.800   2729.000     80.800   2781.000
GR    78.000   2813.000     75.800   2838.000     75.800   2856.000     75.300   2894.000     75.100   2914.000
GR    74.700   2924.000     70.600   2936.000     68.200   2940.000     65.700   2950.000     61.700   2980.000
GR    60.800   2990.000     61.500   3000.000     61.200   3020.000     62.800   3040.000     66.600   3050.000
GR    69.700   3060.000     70.600   3064.000     75.700   3087.000     75.700   3340.000     75.700   3370.000
GR    80.000   3500.000     85.000   3600.000        0.0        0.0        0.0        0.0        0.0        0.0
ET       0.0    940.000   1065.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.930     14.000    940.000   1065.000     63.000     63.000     63.000        0.0        0.0        0.0
GR    87.000    700.000     85.000    760.000     80.000    790.000     75.000    940.000     71.000    942.000
GR    63.000    950.000     61.300    955.000     61.300   1035.000     63.000   1040.000     71.000   1045.000
GR    75.000   1065.000     80.000   1170.000     85.000   1535.000     90.000   1700.000        0.0        0.0
NC       0.0        0.0        0.0      0.500      0.700        0.0        0.0        0.0        0.0        0.0
ET       0.0    941.000   1051.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.938     13.000    941.000   1051.000     42.000     42.000     42.000        0.0        0.0        0.0
X3    10.000        0.0        0.0        0.0        0.0        0.0        0.0     81.900     80.700        0.0
GR    87.000    700.000     85.000    760.000     80.000    790.000     75.000    940.900     69.400    941.000
GR    67.400    960.000     63.700    977.000     62.600   1000.000     64.100   1042.000     72.400   1051.000
GR    75.000   1051.100     80.700   1068.000     85.000   1480.000        0.0        0.0        0.0        0.0
SB       0.0      1.560      2.800        0.0    110.000        0.0   1870.000        0.0     62.600     62.600
ET       0.0    941.000   1051.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.944        0.0        0.0        0.0     33.400     33.400     33.400        0.0        0.0        0.0
X2       0.0        0.0      1.000     77.300     80.700        0.0        0.0        0.0        0.0        0.0
X3    10.000        0.0        0.0        0.0        0.0        0.0        0.0     81.900     80.700        0.0
BT    13.000    700.000     87.000        0.0    760.000     85.000        0.0    790.000     83.400        0.0
BT   940.900     81.900        0.0    941.000     84.300     77.300    960.000     84.200     77.200    977.000
BT    84.100     77.100   1000.000     84.000     77.000   1042.000     83.700     76.700   1051.000     83.400
BT    76.400   1051.100     80.900        0.0   1068.000     80.700        0.0   1480.000     85.000        0.0
NC     0.080      0.060        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
ET       0.0   2950.000   3124.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0
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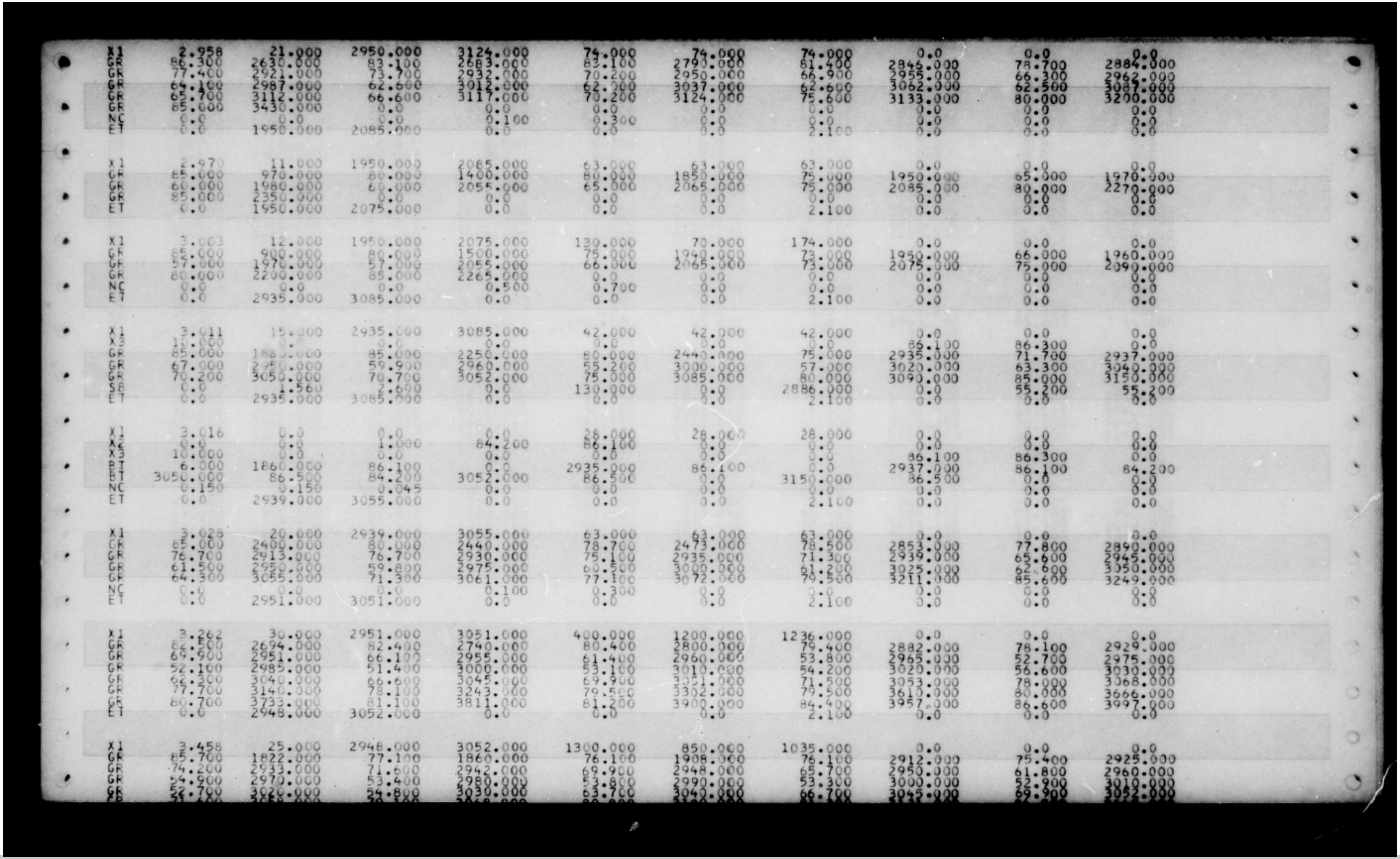
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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X1     2.958     21.000   2950.000   3124.000     74.000     74.000     74.000        0.0        0.0        0.0
GR    86.300   2630.000     83.100   2683.000     83.100   2790.000     81.400   2846.000     78.700   2884.000
GR    77.400   2921.000     73.700   2932.000     70.200   2950.000     66.900   2955.000     66.300   2962.000
GR    64.100   2987.000     62.600   3012.000     62.900   3037.000     62.600   3062.000     62.500   3087.000
GR    65.700   3112.000     66.600   3117.000     70.200   3124.000     75.600   3133.000     80.000   3200.000
GR    85.000   3430.000        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
NC       0.0        0.0        0.0      0.100      0.300        0.0        0.0        0.0        0.0        0.0
ET       0.0   1950.000   2085.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     2.970     11.000   1950.000   2085.000     63.000     63.000     63.000        0.0        0.0        0.0
GR    85.000    970.000     80.000   1400.000     80.000   1850.000     75.000   1950.000     65.000   1970.000
GR    60.000   1980.000     60.000   2055.000     65.000   2065.000     75.000   2085.000     80.000   2270.000
GR    85.000   2350.000        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
ET       0.0   1950.000   2075.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.003     12.000   1950.000   2075.000    130.000     70.000    174.000        0.0        0.0        0.0
GR    85.000    900.000     80.000   1500.000     75.000   1940.000     73.000   1950.000     66.000   1960.000
GR    57.000   1970.000     57.000   2055.000     66.000   2065.000     73.000   2075.000     75.000   2090.000
GR    80.000   2200.000     85.000   2265.000        0.0        0.0        0.0        0.0        0.0        0.0
NC       0.0        0.0        0.0      0.500      0.700        0.0        0.0        0.0        0.0        0.0
ET       0.0   2935.000   3085.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.011     15.000   2935.000   3085.000     42.000     42.000     42.000        0.0        0.0        0.0
X3    10.000        0.0        0.0        0.0        0.0        0.0        0.0     86.100     86.300        0.0
GR    85.000   1860.000     85.000   2250.000     80.000   2440.000     75.000   2935.000     71.700   2937.000
GR    67.000   2950.000     59.900   2960.000     55.200   3000.000     57.000   3020.000     63.300   3040.000
GR    70.200   3050.000     70.700   3052.000     75.000   3085.000     80.000   3090.000     85.000   3150.000
SB       0.0      1.560      2.600        0.0    130.000        0.0   2886.000        0.0     55.200     55.200
ET       0.0   2935.000   3085.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.016        0.0        0.0        0.0     28.000     28.000     28.000        0.0        0.0        0.0
X2       0.0        0.0      1.000     84.200     86.100        0.0        0.0        0.0        0.0        0.0
X3    10.000        0.0        0.0        0.0        0.0        0.0        0.0     86.100     86.300        0.0
BT     6.000   1860.000     86.100        0.0   2935.000     86.100        0.0   2937.000     86.100     84.200
BT  3050.000     86.500     84.200   3052.000     86.500        0.0   3150.000     86.500        0.0        0.0
NC     0.150      0.150      0.045        0.0        0.0        0.0        0.0        0.0        0.0        0.0
ET       0.0   2939.000   3055.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.028     20.000   2939.000   3055.000     63.000     63.000     63.000        0.0        0.0        0.0
GR    85.000   2400.000     80.000   2440.000     78.700   2473.000     78.500   2853.000     77.800   2890.000
GR    76.700   2913.000     76.700   2930.000     75.100   2935.000     71.300   2939.000     65.600   2945.000
GR    61.500   2950.000     59.800   2975.000     60.500   3000.000     61.200   3025.000     62.600   3050.000
GR    64.300   3055.000     71.300   3061.000     77.100   3072.000     79.500   3211.000     85.600   3249.000
NC       0.0        0.0        0.0      0.100      0.300        0.0        0.0        0.0        0.0        0.0
ET       0.0   2951.000   3051.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.262     30.000   2951.000   3051.000    400.000   1200.000   1236.000        0.0        0.0        0.0
GR    82.500   2694.000     82.400   2740.000     80.400   2800.000     79.400   2882.000     78.100   2929.000
GR    69.900   2951.000     66.100   2955.000     61.400   2960.000     53.800   2965.000     52.700   2975.000
GR    52.100   2985.000     51.400   3000.000     53.100   3010.000     54.200   3020.000     56.600   3030.000
GR    62.300   3040.000     66.600   3045.000     69.900   3051.000     71.500   3053.000     78.000   3068.000
GR    77.700   3140.000     78.100   3243.000     79.500   3302.000     79.500   3610.000     80.000   3666.000
GR    80.700   3733.000     81.100   3811.000     81.200   3900.000     84.400   3957.000     86.600   3997.000
ET       0.0   2948.000   3052.000        0.0        0.0        0.0      2.100        0.0        0.0        0.0

X1     3.458     25.000   2948.000   3052.000   1300.000    850.000   1035.000        0.0        0.0        0.0
GR    85.700   1822.000     77.100   1860.000     76.100   1908.000     76.100   2912.000     75.400   2925.000
GR    74.200   2933.000     71.600   2942.000     69.900   2948.000     65.700   2950.000     61.800   2960.000
GR    54.900   2970.000     53.400   2980.000     53.800   2990.000     53.300   3000.000     52.900   3010.000
GR    52.700   3020.000     54.800   3030.000     63.700   3040.000     66.700   3045.000     69.900   3052.000
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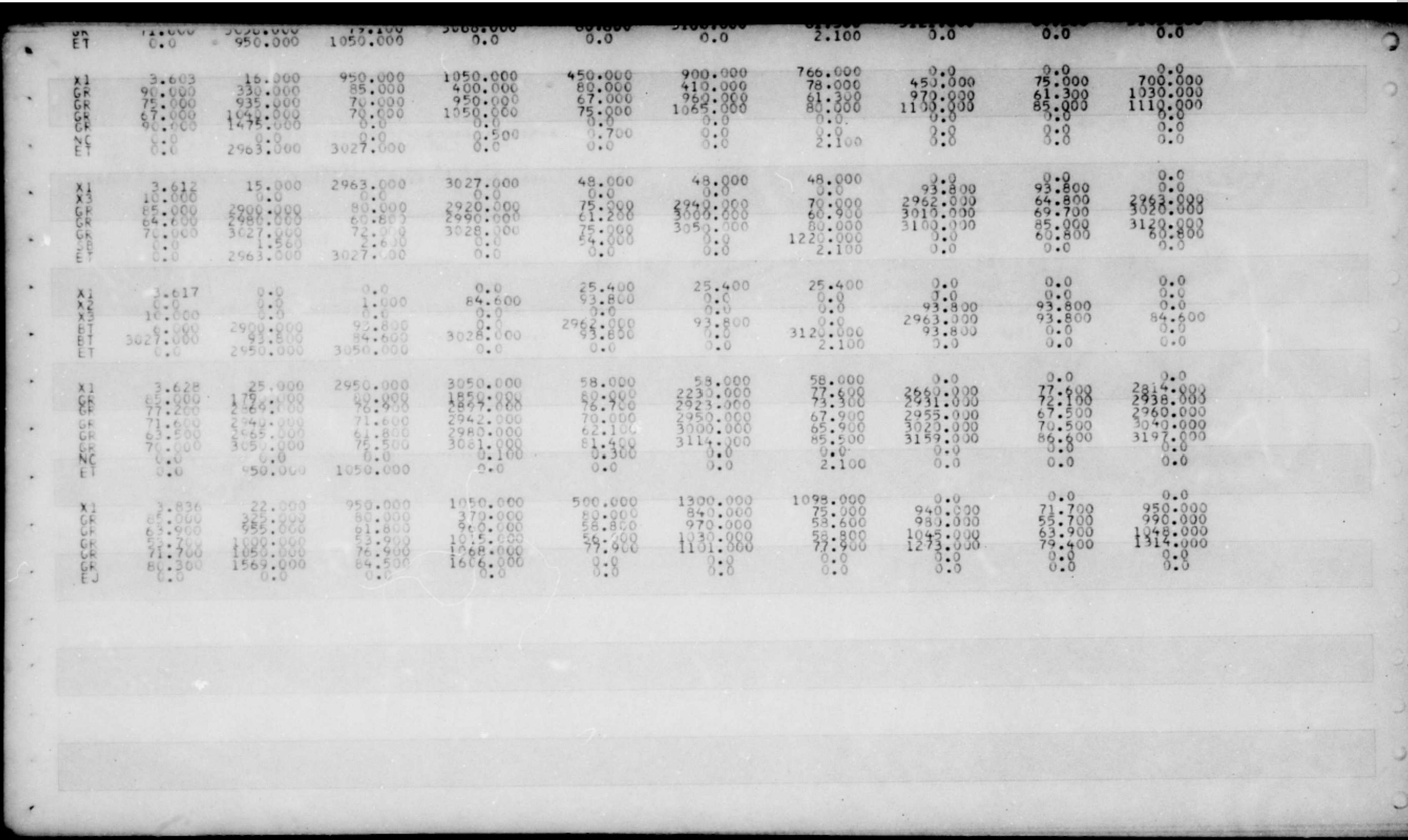
ROYAL RIVER HEC-2 HYDRAULIC MODEL



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ET       0.0     950.000    1050.000       0.0         0.0         0.0       2.100         0.0         0.0         0.0

X1     3.603      16.000     950.000    1050.000     450.000     900.000     766.000         0.0         0.0         0.0
GR    90.000     330.000      85.000     400.000      80.000     410.000      78.000     450.000      75.000     700.000
GR    75.000     935.000      70.000     950.000      67.000     960.000      61.300     970.000      61.300    1030.000
GR    67.000    1040.000      70.000    1050.000      75.000    1065.000      80.000    1100.000      85.000    1110.000
GR    90.000    1475.000         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
NC       0.0         0.0         0.0       0.500       0.700         0.0         0.0         0.0         0.0         0.0
ET       0.0    2963.000    3027.000         0.0         0.0         0.0       2.100         0.0         0.0         0.0

X1     3.612      15.000    2963.000    3027.000      48.000      48.000      48.000         0.0         0.0         0.0
X3    10.000         0.0         0.0         0.0         0.0         0.0         0.0      93.800      93.800         0.0
GR    85.000    2900.000      80.000    2920.000      75.000    2940.000      70.000    2962.000      64.800    2963.000
GR    64.600    2980.000      60.800    2990.000      61.200    3000.000      60.900    3010.000      69.700    3020.000
GR    70.000    3027.000      72.000    3028.000      75.000    3050.000      80.000    3100.000      85.000    3120.000
SB       0.0       1.560       2.600         0.0      54.000         0.0    1220.000         0.0      60.800      60.800
ET       0.0    2963.000    3027.000         0.0         0.0         0.0       2.100         0.0         0.0         0.0

X1     3.617         0.0         0.0         0.0      25.400      25.400      25.400         0.0         0.0         0.0
X2       0.0         0.0       1.000      84.600      93.800         0.0         0.0         0.0         0.0         0.0
X3    10.000         0.0         0.0         0.0         0.0         0.0         0.0      93.800      93.800         0.0
BT     6.000    2900.000      93.800         0.0    2962.000      93.800         0.0    2963.000      93.800      84.600
BT  3027.000      93.800      84.600    3028.000      93.800         0.0    3120.000      93.800         0.0         0.0
ET       0.0    2950.000    3050.000         0.0         0.0         0.0       2.100         0.0         0.0         0.0

X1     3.628      25.000    2950.000    3050.000      58.000      58.000      58.000         0.0         0.0         0.0
GR    85.000    1790.000      80.000    1850.000      80.000    2230.000      77.600    2660.000      77.600    2814.000
GR    77.200    2869.000      76.900    2897.000      76.700    2923.000      73.300    2931.000      72.100    2938.000
GR    71.600    2940.000      71.600    2942.000      70.000    2950.000      67.900    2955.000      67.500    2960.000
GR    63.500    2965.000      61.800    2980.000      62.100    3000.000      65.900    3020.000      70.500    3040.000
GR    70.000    3050.000      75.500    3081.000      81.400    3114.000      85.500    3159.000      86.600    3197.000
NC       0.0         0.0         0.0       0.100       0.300         0.0         0.0         0.0         0.0         0.0
ET       0.0     950.000    1050.000         0.0         0.0         0.0       2.100         0.0         0.0         0.0

X1     3.836      22.000     950.000    1050.000     500.000    1300.000    1098.000         0.0         0.0         0.0
GR    85.000     325.000      80.000     370.000      80.000     840.000      75.000     940.000      71.700     950.000
GR    63.900     955.000      61.800     960.000      58.800     970.000      58.600     980.000      55.700     990.000
GR    53.700    1000.000      53.900    1015.000      56.600    1030.000      58.800    1045.000      63.900    1048.000
GR    71.700    1050.000      76.900    1068.000      77.900    1101.000      77.900    1273.000      79.400    1314.000
GR    80.300    1569.000      84.500    1606.000         0.0         0.0         0.0         0.0         0.0         0.0
EJ       0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
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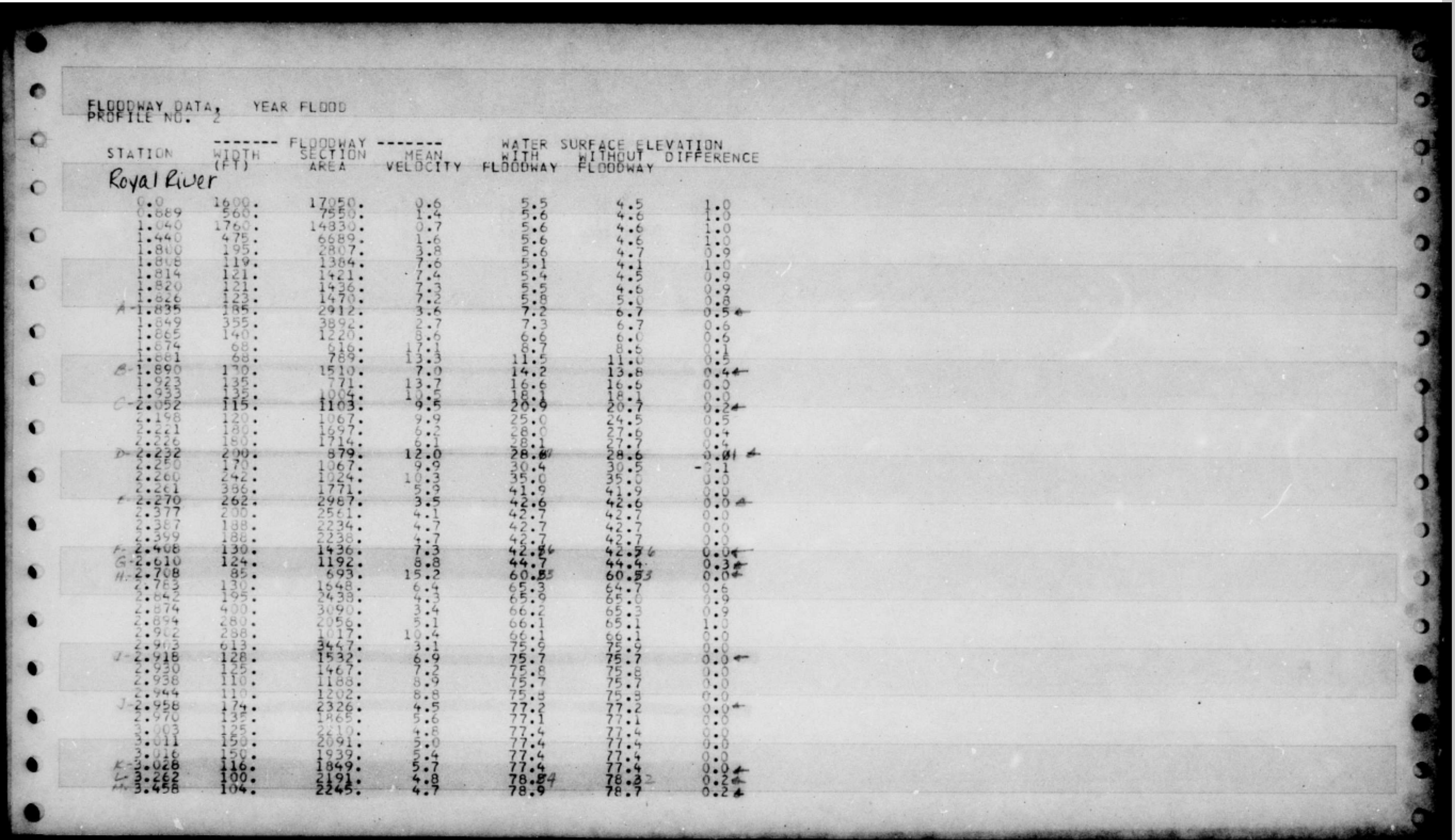
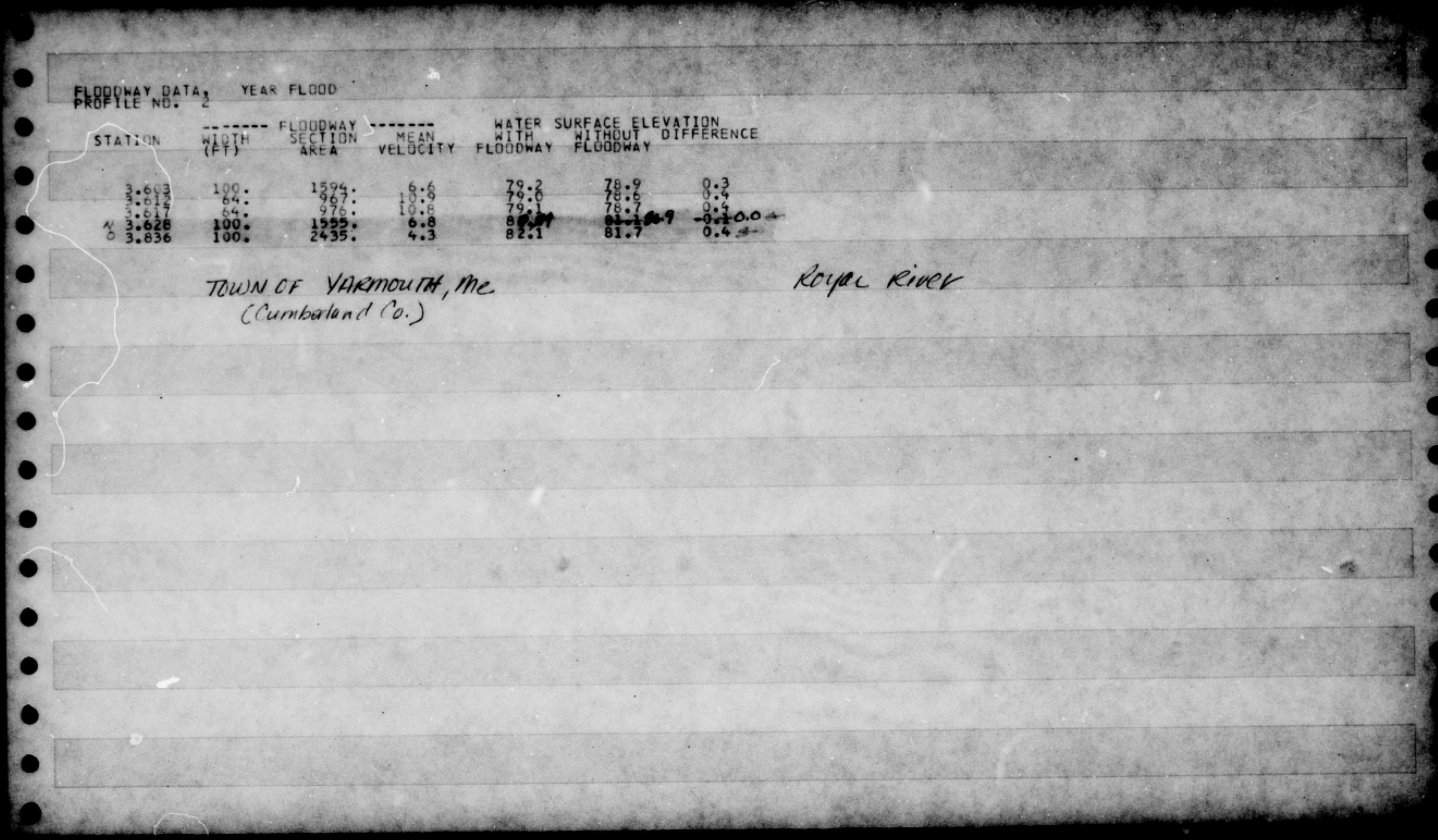
ROYAL RIVER HEC-2 HYDRAULIC MODEL – FLOODWAY RESULTS



FLOODWAY DATA, YEAR FLOOD
PROFILE NO. 2

STATION	------- FLOODWAY -------			WATER SURFACE ELEVATION		
	WIDTH (FT)	SECTION AREA	MEAN VELOCITY	WITH FLOODWAY	WITHOUT FLOODWAY	DIFFERENCE
Royal River						
0.0	1600.	17050.	0.6	5.5	4.5	1.0
0.889	560.	7550.	1.4	5.6	4.6	1.0
1.040	1760.	14830.	0.7	5.6	4.6	1.0
1.440	475.	6689.	1.6	5.6	4.6	1.0
1.800	195.	2807.	3.8	5.6	4.7	0.9
1.808	119.	1384.	7.6	5.1	4.1	1.0
1.814	121.	1421.	7.4	5.4	4.5	0.9
1.820	121.	1436.	7.3	5.5	4.6	0.9
1.826	123.	1470.	7.2	5.8	5.0	0.8
A-1.835	185.	2912.	3.6	7.2	6.7	0.5 ←
1.849	355.	3892.	2.7	7.3	6.7	0.6
1.865	140.	1220.	8.6	6.6	6.0	0.6
1.874	68.	616.	17.1	8.7	8.6	0.1
1.881	68.	789.	13.3	11.5	11.0	0.5
B-1.890	130.	1510.	7.0	14.2	13.8	0.4 ←
1.923	135.	771.	13.7	16.6	16.6	0.0
1.933	135.	1004.	10.5	18.1	18.1	0.0
C-2.052	115.	1103.	9.5	20.9	20.7	0.2 ←
2.198	120.	1067.	9.9	25.0	24.5	0.5
2.221	180.	1697.	6.2	28.0	27.6	0.4
2.226	180.	1714.	6.1	28.1	27.7	0.4
D-2.232	200.	879.	12.0	28.61	28.6	0.01 ←
2.250	170.	1067.	9.9	30.4	30.5	-0.1
2.260	242.	1024.	10.3	35.0	35.0	0.0
2.261	386.	1771.	5.9	41.9	41.9	0.0
E-2.270	262.	2987.	3.5	42.6	42.6	0.0 ←
2.377	200.	2561.	4.1	42.7	42.7	0.0
2.387	188.	2234.	4.7	42.7	42.7	0.0
2.399	188.	2238.	4.7	42.7	42.7	0.0
F-2.408	130.	1436.	7.3	42.56	42.56	0.0 ←
G-2.610	124.	1192.	8.8	44.7	44.4	0.3 ←
H-2.708	85.	693.	15.2	60.55	60.53	0.0 ←
2.783	130.	1648.	6.4	65.3	64.7	0.6
2.842	195.	2438.	4.3	65.9	65.0	0.9
2.874	400.	3090.	3.4	66.2	65.3	0.9
2.894	280.	2056.	5.1	66.1	65.1	1.0
2.902	288.	1017.	10.4	66.1	66.1	0.0
2.903	613.	3447.	3.1	75.9	75.9	0.0
I-2.918	128.	1532.	6.9	75.7	75.7	0.0 ←
2.930	125.	1467.	7.2	75.8	75.8	0.0
2.938	110.	1188.	8.9	75.7	75.7	0.0
2.944	110.	1202.	8.8	75.8	75.8	0.0
J-2.958	174.	2326.	4.5	77.2	77.2	0.0 ←
2.970	135.	1865.	5.6	77.1	77.1	0.0
3.003	125.	2210.	4.8	77.4	77.4	0.0
3.011	150.	2091.	5.0	77.4	77.4	0.0
3.016	150.	1939.	5.4	77.4	77.4	0.0
K-3.028	116.	1849.	5.7	77.4	77.4	0.0 ←
L-3.262	100.	2191.	4.8	78.54	78.32	0.2 ←
M-3.458	104.	2245.	4.7	78.9	78.7	0.2 ←

ROYAL RIVER HEC-2 HYDRAULIC MODEL – FLOODWAY RESULTS



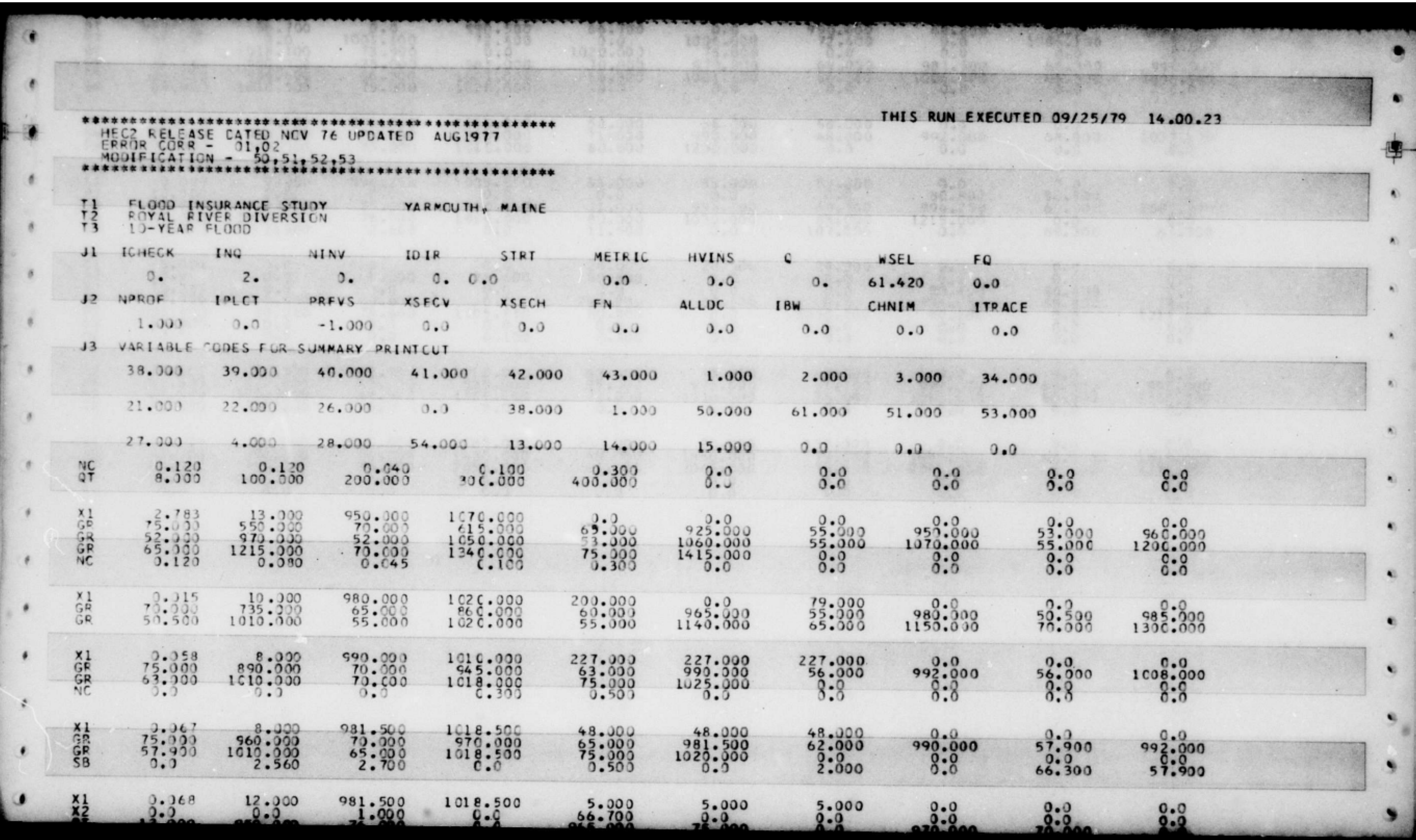
FLOODWAY DATA, YEAR FLOOD
PROFILE NO. 2

STATION	FLOODWAY WIDTH (FT)	FLOODWAY SECTION AREA	FLOODWAY MEAN VELOCITY	WATER SURFACE ELEVATION WITH FLOODWAY	WATER SURFACE ELEVATION WITHOUT FLOODWAY	DIFFERENCE
3.603	100.	1594.	6.6	79.2	78.9	0.3
3.612	64.	967.	10.9	79.0	78.6	0.4
3.617	64.	976.	10.8	79.1	78.7	0.4
N 3.628	100.	1555.	6.8	8[illegible]	~~81.1~~ 80.9	~~-0.1~~ 0.0 ←
O 3.836	100.	2435.	4.3	82.1	81.7	0.4 ←

TOWN OF YARMOUTH, Me
(Cumberland Co.)

Royal River

ROYAL RIVER HEC-2 – "DIVERSION" MODEL



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****************************************************               THIS RUN EXECUTED 09/25/79   14.00.23
  HEC2 RELEASE DATED NOV 76 UPDATED  AUG1977
  ERROR CORR -   01,02
  MODIFICATION -   50,51,52,53
****************************************************

T1    FLOOD INSURANCE STUDY           YARMOUTH, MAINE
T2    ROYAL RIVER DIVERSION
T3    10-YEAR FLOOD

J1    ICHECK      INQ       NINV      IDIR       STRT      METRIC     HVINS      Q         WSEL       FQ
        0.         2.         0.         0.   0.0           0.0        0.0        0.     61.420      0.0
J2    NPROF       IPLOT     PRFVS     XSECV      XSECH     FN         ALLDC      IBW       CHNIM      ITRACE
       1.000       0.0     -1.000      0.0        0.0        0.0        0.0        0.0        0.0        0.0
J3    VARIABLE CODES FOR SUMMARY PRINTOUT
       38.000     39.000     40.000     41.000     42.000     43.000      1.000      2.000      3.000     34.000

       21.000     22.000     26.000      0.0       38.000      1.000     50.000     61.000     51.000     53.000

       27.000      4.000     28.000     54.000     13.000     14.000     15.000      0.0        0.0        0.0
NC      0.120      0.120      0.040      0.100      0.300      0.0        0.0        0.0        0.0        0.0
QT      8.000    100.000    200.000    300.000    400.000      0.0        0.0        0.0        0.0        0.0

X1      2.783     13.000    950.000   1070.000      0.0        0.0        0.0        0.0        0.0        0.0
GR     75.000    550.000     70.000    615.000     69.000    925.000     55.000    950.000     53.000    960.000
GR     52.000    970.000     52.000   1050.000     53.000   1060.000     55.000   1070.000     55.000   1200.000
GR     65.000   1215.000     70.000   1340.000     75.000   1415.000      0.0        0.0        0.0        0.0
NC      0.120      0.080      0.045      0.100      0.300      0.0        0.0        0.0        0.0        0.0

X1      0.015     10.000    980.000   1020.000    200.000      0.0       79.000      0.0        0.0        0.0
GR     70.000    735.000     65.000    860.000     60.000    965.000     55.000    980.000     50.500    985.000
GR     50.500   1010.000     55.000   1020.000     55.000   1140.000     65.000   1150.000     70.000   1300.000

X1      0.058      8.000    990.000   1010.000    227.000    227.000    227.000      0.0        0.0        0.0
GR     75.000    890.000     70.000    945.000     63.000    990.000     56.000    992.000     56.000   1008.000
GR     63.000   1010.000     70.000   1018.000     75.000   1025.000      0.0        0.0        0.0        0.0
NC      0.0        0.0        0.0        0.300      0.500      0.0        0.0        0.0        0.0        0.0

X1      0.067      8.000    981.500   1018.500     48.000     48.000     48.000      0.0        0.0        0.0
GR     75.000    960.000     70.000    970.000     65.000    981.500     62.000    990.000     57.900    992.000
GR     57.900   1010.000     65.000   1018.500     75.000   1020.000      0.0        0.0        0.0        0.0
SB      0.0        2.560      2.700      0.0        0.500      0.0        2.000      0.0       66.300     57.900

X1      0.068     12.000    981.500   1018.500      5.000      5.000      5.000      0.0        0.0        0.0
X2      0.0        0.0        1.000      0.0       66.700      0.0        0.0        0.0        0.0        0.0
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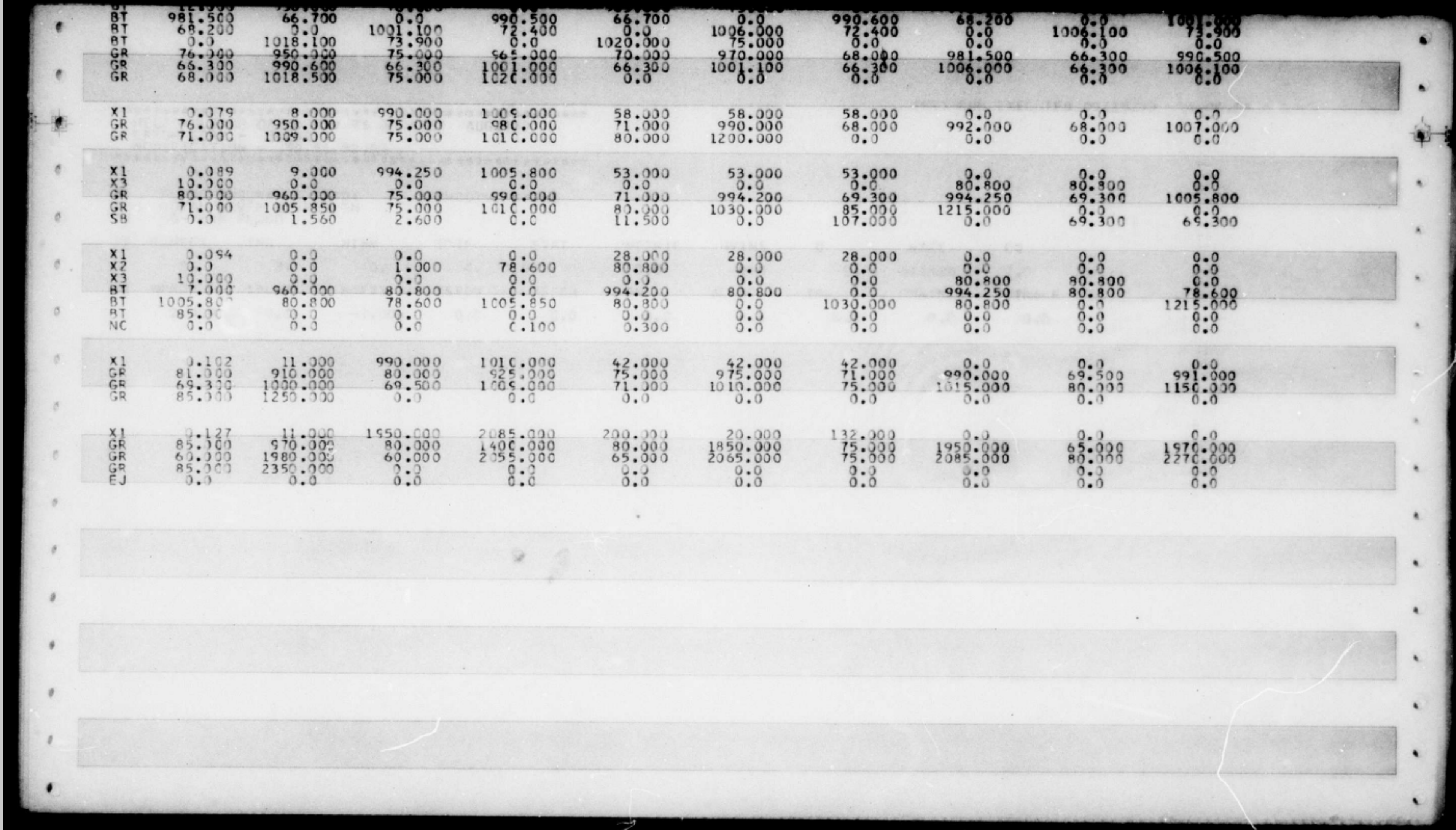
ROYAL RIVER HEC-2 – “DIVERSION” MODEL



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BT    981.500    66.700     0.0     990.500    66.700     0.0     990.600    68.200     0.0    1001.000
BT     68.200     0.0    1001.100    72.400     0.0    1006.000    72.400     0.0    1006.100    73.900
BT      0.0    1018.100    73.900     0.0    1020.000    75.000     0.0       0.0       0.0       0.0
GR     76.000   950.000    75.000   965.000    70.000   970.000    68.000   981.500    66.300   990.500
GR     66.300   990.600    66.300  1001.000    66.300  1001.100    66.300  1006.000    66.300  1006.100
GR     68.000  1018.500    75.000  1020.000     0.0       0.0       0.0       0.0       0.0       0.0

X1      0.079     8.000   990.000  1009.000    58.000    58.000    58.000     0.0       0.0       0.0
GR     76.000   950.000    75.000   980.000    71.000   990.000    68.000   992.000    68.000  1007.000
GR     71.000  1009.000    75.000  1010.000    80.000  1200.000     0.0       0.0       0.0       0.0

X1      0.089     9.000   994.250  1005.800    53.000    53.000    53.000     0.0       0.0       0.0
X3     10.000     0.0       0.0       0.0       0.0       0.0       0.0      80.800    80.800     0.0
GR     80.000   960.000    75.000   990.000    71.000   994.200    69.300   994.250    69.300  1005.800
GR     71.000  1005.850    75.000  1010.000    80.000  1030.000    85.000  1215.000     0.0       0.0
SB      0.0       1.560     2.600     0.0      11.500     0.0     107.000     0.0      69.300    69.300

X1      0.094     0.0       0.0       0.0      28.000    28.000    28.000     0.0       0.0       0.0
X2      0.0       0.0       1.000    78.600    80.800     0.0       0.0       0.0       0.0       0.0
X3     10.000     0.0       0.0       0.0       0.0       0.0       0.0      80.800    80.800     0.0
BT      7.000   960.000    80.800     0.0     994.200    80.800     0.0     994.250    80.800    78.600
BT   1005.800    80.800    78.600  1005.850    80.800     0.0    1030.000    80.800     0.0    1215.000
BT     85.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
NC      0.0       0.0       0.0       0.100     0.300     0.0       0.0       0.0       0.0       0.0

X1      0.102    11.000   990.000  1010.000    42.000    42.000    42.000     0.0       0.0       0.0
GR     81.000   910.000    80.000   925.000    75.000   975.000    71.000   990.000    69.500   991.000
GR     69.300  1000.000    69.500  1005.000    71.000  1010.000    75.000  1015.000    80.000  1150.000
GR     85.000  1250.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0

X1      0.127    11.000  1950.000  2085.000   200.000    20.000   132.000     0.0       0.0       0.0
GR     85.000   970.000    80.000  1400.000    80.000  1850.000    75.000  1950.000    65.000  1970.000
GR     60.000  1980.000    60.000  2055.000    65.000  2065.000    75.000  2085.000    80.000  2270.000
GR     85.000  2350.000     0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
EJ      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
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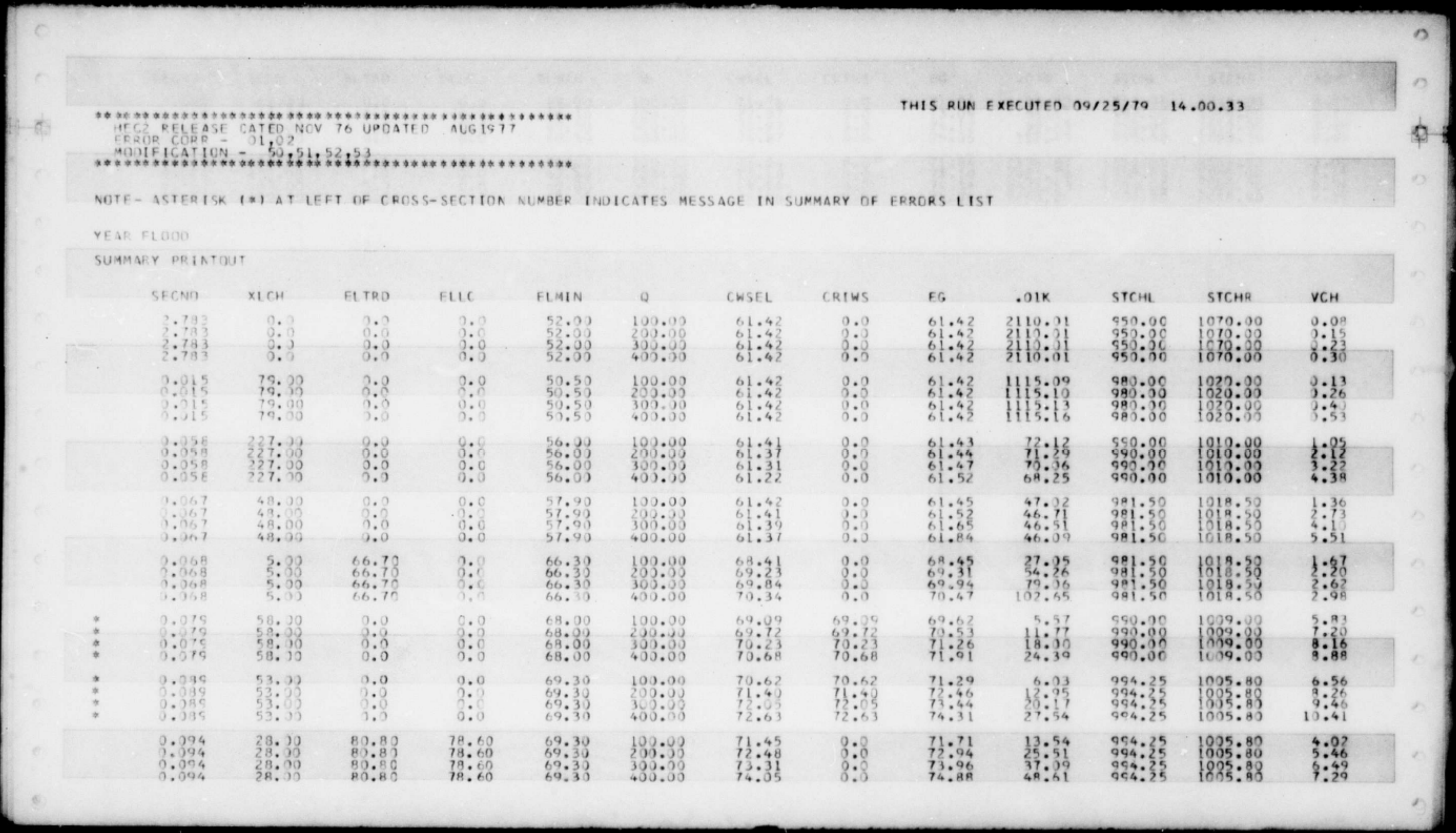
ROYAL RIVER HEC-2 – “DIVERSION” MODEL RESULTS



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                                                                         THIS RUN EXECUTED 09/25/79   14.00.33
 ******************************************************
   HEC2 RELEASE CATED NOV 76 UPDATED  AUG1977
   ERROR CORR -  01,02
   MODIFICATION -  50,51,52,53
 ******************************************************

 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

 YEAR FLOOD

 SUMMARY PRINTOUT

          SECNO      XLCH      ELTRD      ELLC      ELMIN       Q       CWSEL     CRIWS       EG       .01K      STCHL     STCHR      VCH

          2.783      0.0       0.0        0.0       52.00    100.00     61.42      0.0       61.42    2110.01    950.00   1070.00     0.08
          2.783      0.0       0.0        0.0       52.00    200.00     61.42      0.0       61.42    2110.01    950.00   1070.00     0.15
          2.783      0.0       0.0        0.0       52.00    300.00     61.42      0.0       61.42    2110.01    950.00   1070.00     0.23
          2.783      0.0       0.0        0.0       52.00    400.00     61.42      0.0       61.42    2110.01    950.00   1070.00     0.30

          0.015     79.00      0.0        0.0       50.50    100.00     61.42      0.0       61.42    1115.09    980.00   1020.00     0.13
          0.015     79.00      0.0        0.0       50.50    200.00     61.42      0.0       61.42    1115.10    980.00   1020.00     0.26
          0.015     79.00      0.0        0.0       50.50    300.00     61.42      0.0       61.42    1115.13    980.00   1020.00     0.40
          0.015     79.00      0.0        0.0       50.50    400.00     61.42      0.0       61.42    1115.16    980.00   1020.00     0.53

          0.058    227.00      0.0        0.0       56.00    100.00     61.41      0.0       61.43      72.12    990.00   1010.00     1.05
          0.058    227.00      0.0        0.0       56.00    200.00     61.37      0.0       61.44      71.29    990.00   1010.00     2.12
          0.058    227.00      0.0        0.0       56.00    300.00     61.31      0.0       61.47      70.06    990.00   1010.00     3.22
          0.058    227.00      0.0        0.0       56.00    400.00     61.22      0.0       61.52      68.25    990.00   1010.00     4.38

          0.067     48.00      0.0        0.0       57.90    100.00     61.42      0.0       61.45      47.02    981.50   1018.50     1.36
          0.067     48.00      0.0        0.0       57.90    200.00     61.41      0.0       61.52      46.71    981.50   1018.50     2.73
          0.067     48.00      0.0        0.0       57.90    300.00     61.39      0.0       61.65      46.51    981.50   1018.50     4.10
          0.067     48.00      0.0        0.0       57.90    400.00     61.37      0.0       61.84      46.09    981.50   1018.50     5.51

          0.068      5.00     66.70       0.0       66.30    100.00     68.41      0.0       68.45      27.05    981.50   1018.50     1.67
          0.068      5.00     66.70       0.0       66.30    200.00     69.23      0.0       69.31      54.26    981.50   1018.50     2.20
          0.068      5.00     66.70       0.0       66.30    300.00     69.84      0.0       69.94      79.06    981.50   1018.50     2.62
          0.068      5.00     66.70       0.0       66.30    400.00     70.34      0.0       70.47     102.65    981.50   1018.50     2.98

 *        0.079     58.00      0.0        0.0       68.00    100.00     69.09     69.09      69.62       5.57    990.00   1009.00     5.83
 *        0.079     58.00      0.0        0.0       68.00    200.00     69.72     69.72      70.53      11.77    990.00   1009.00     7.20
 *        0.079     58.00      0.0        0.0       68.00    300.00     70.23     70.23      71.26      18.00    990.00   1009.00     8.16
 *        0.079     58.00      0.0        0.0       68.00    400.00     70.68     70.68      71.91      24.39    990.00   1009.00     8.88

 *        0.089     53.00      0.0        0.0       69.30    100.00     70.62     70.62      71.29       6.03    994.25   1005.80     6.56
 *        0.089     53.00      0.0        0.0       69.30    200.00     71.40     71.40      72.46      12.95    994.25   1005.80     8.26
 *        0.089     53.00      0.0        0.0       69.30    300.00     72.05     72.05      73.44      20.17    994.25   1005.80     9.46
 *        0.089     53.00      0.0        0.0       69.30    400.00     72.63     72.63      74.31      27.54    994.25   1005.80    10.41

          0.094     28.00     80.80      78.60      69.30    100.00     71.45      0.0       71.71      13.54    994.25   1005.80     4.02
          0.094     28.00     80.80      78.60      69.30    200.00     72.48      0.0       72.94      25.51    994.25   1005.80     5.46
          0.094     28.00     80.80      78.60      69.30    300.00     73.31      0.0       73.96      37.09    994.25   1005.80     6.49
          0.094     28.00     80.80      78.60      69.30    400.00     74.05      0.0       74.88      48.61    994.25   1005.80     7.29
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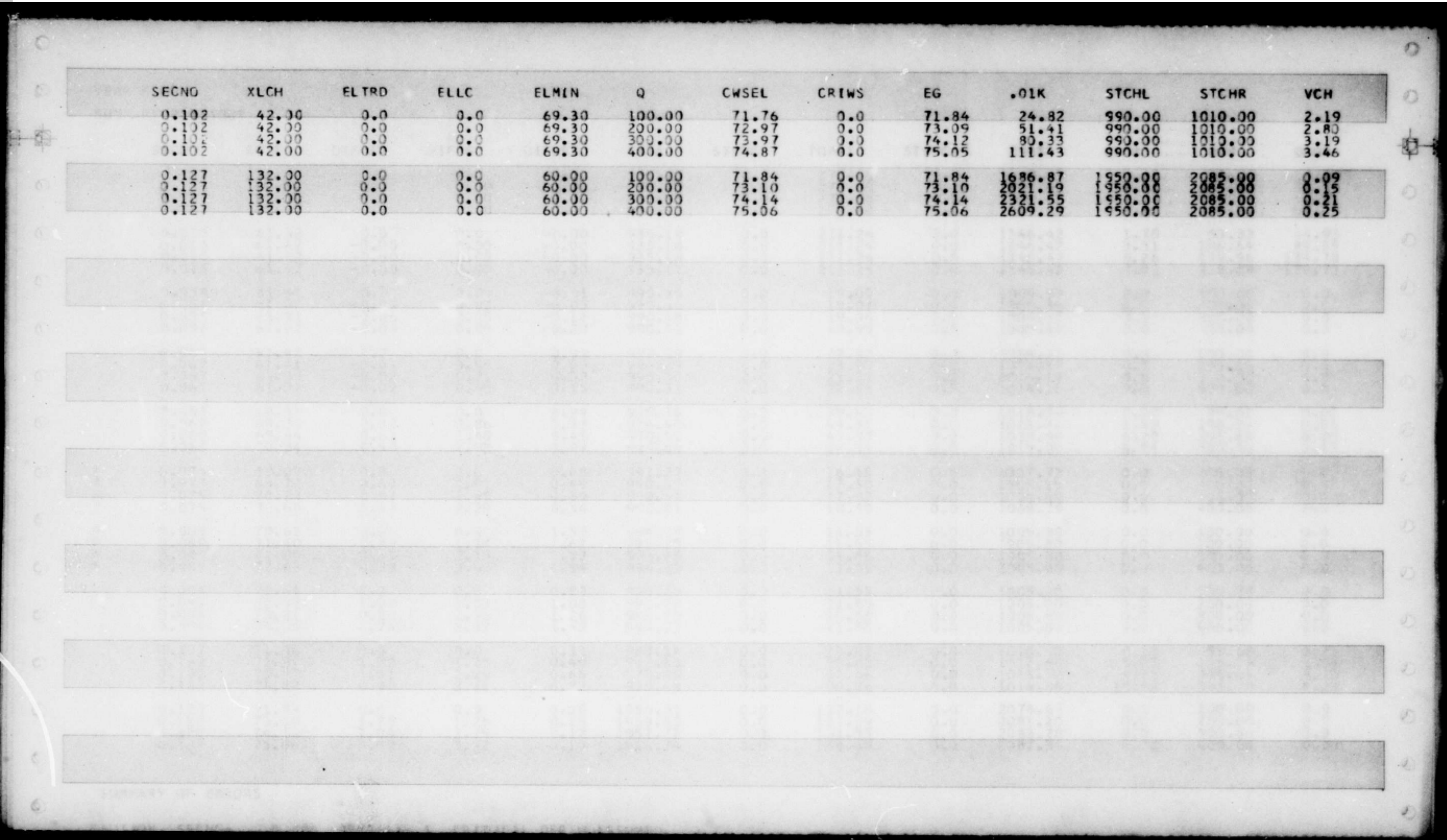
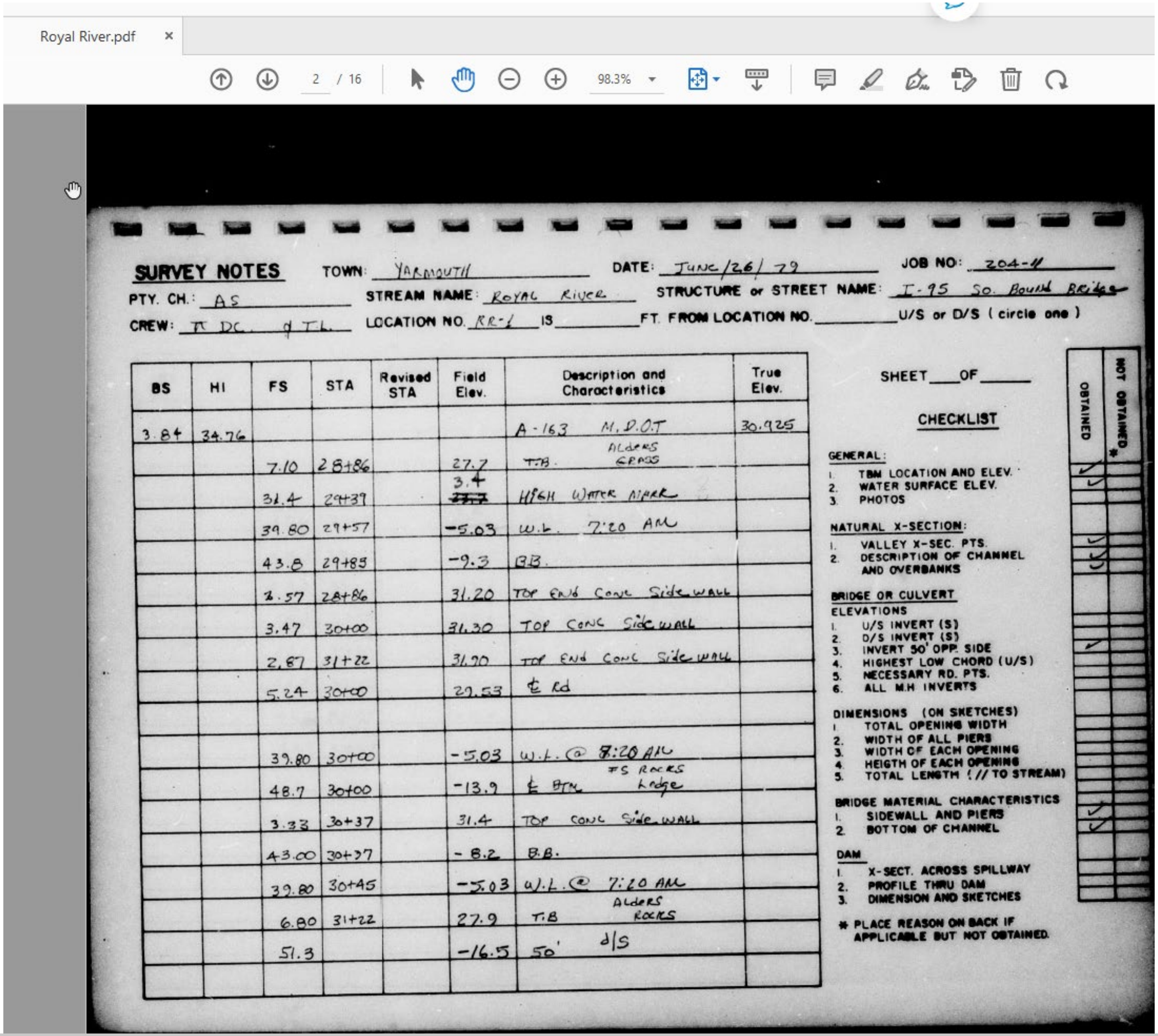
ROYAL RIVER HEC-2 – “DIVERSION” MODEL RESULTS



SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	.01K	STCHL	STCHR	VCH
0.102	42.00	0.0	0.0	69.30	100.00	71.76	0.0	71.84	24.82	990.00	1010.00	2.19
0.102	42.00	0.0	0.0	69.30	200.00	72.97	0.0	73.09	51.41	990.00	1010.00	2.80
0.102	42.00	0.0	0.0	69.30	300.00	73.97	0.0	74.12	80.33	990.00	1010.00	3.19
0.102	42.00	0.0	0.0	69.30	400.00	74.87	0.0	75.05	111.43	990.00	1010.00	3.46
0.127	132.00	0.0	0.0	60.00	100.00	71.84	0.0	71.84	1686.87	1950.00	2085.00	0.09
0.127	132.00	0.0	0.0	60.00	200.00	73.10	0.0	73.10	2021.19	1950.00	2085.00	0.15
0.127	132.00	0.0	0.0	60.00	300.00	74.14	0.0	74.14	2321.55	1950.00	2085.00	0.21
0.127	132.00	0.0	0.0	60.00	400.00	75.06	0.0	75.06	2609.29	1950.00	2085.00	0.25

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: YARMOUTH DATE: JUNE/26/ 79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: I-95 So. Bound Bridge

CREW: π DC. ɸ T.L. LOCATION NO. RR-1 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
3.84	34.76					A-163 M.D.O.T	30.925
		7.10	28+86		27.7	T.B. Alders Grass	
		31.4	29+39		3.4 ~~27.7~~	HIGH WATER MARK	
		39.80	29+57		-5.03	W.L. 7:20 AM	
		43.8	29+85		-9.3	BB.	
		3.57	28+86		31.20	TOP END CONC SIDE WALL	
		3.47	30+00		31.30	TOP CONC Side WALL	
		2.87	31+22		31.90	TOP END CONC Side WALL	
		5.24	30+00		29.53	℄ Rd	
		39.80	30+00		-5.03	W.L. @ 8:20 AM	
		48.7	30+00		-13.9	℄ BTM. FS ROCKS Ledge	
		3.33	30+37		31.4	TOP CONC Side WALL	
		43.00	30+37		- 8.2	B.B.	
		39.80	30+45		-5.03	W.L. @ 7:20 AM	
		6.80	31+22		27.9	T.B ALDERS ROCKS	
		51.3			-16.5	50' d/s	

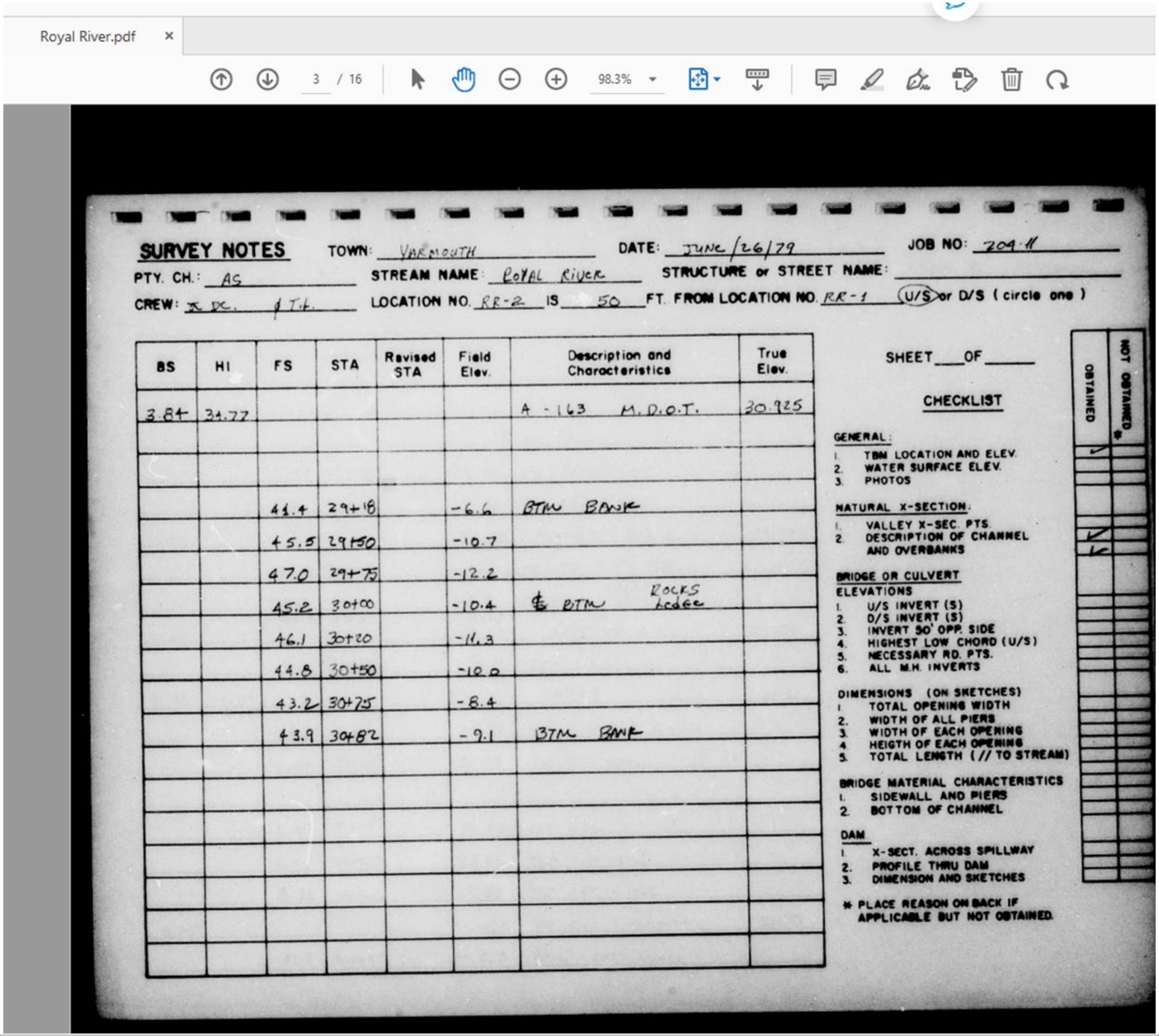
SHEET ___ OF ______

CHECKLIST

	OBTAINED	NOT OBTAINED*
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE	✓	
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H INVERTS		
DIMENSIONS (ON SKETCHES)		
1 TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL	✓	
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: Yarmouth DATE: June/26/79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: Royal River STRUCTURE or STREET NAME:

CREW: π DC. ∮ T.L. LOCATION NO. RR-2 IS 50 FT. FROM LOCATION NO. RR-1 [✓ U/S] or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
3.84	34.77					A - 163 M.D.O.T.	30.925
		41.4	29+18		-6.6	BTM BANK	
		45.5	29+50		-10.7		
		47.0	29+75		-12.2		
		45.2	30+00		-10.4	℄ BTM ROCKS Ledge	
		46.1	30+20		-11.3		
		44.8	30+50		-10.0		
		43.2	30+75		-8.4		
		43.9	30+82		-9.1	BTM BANK	

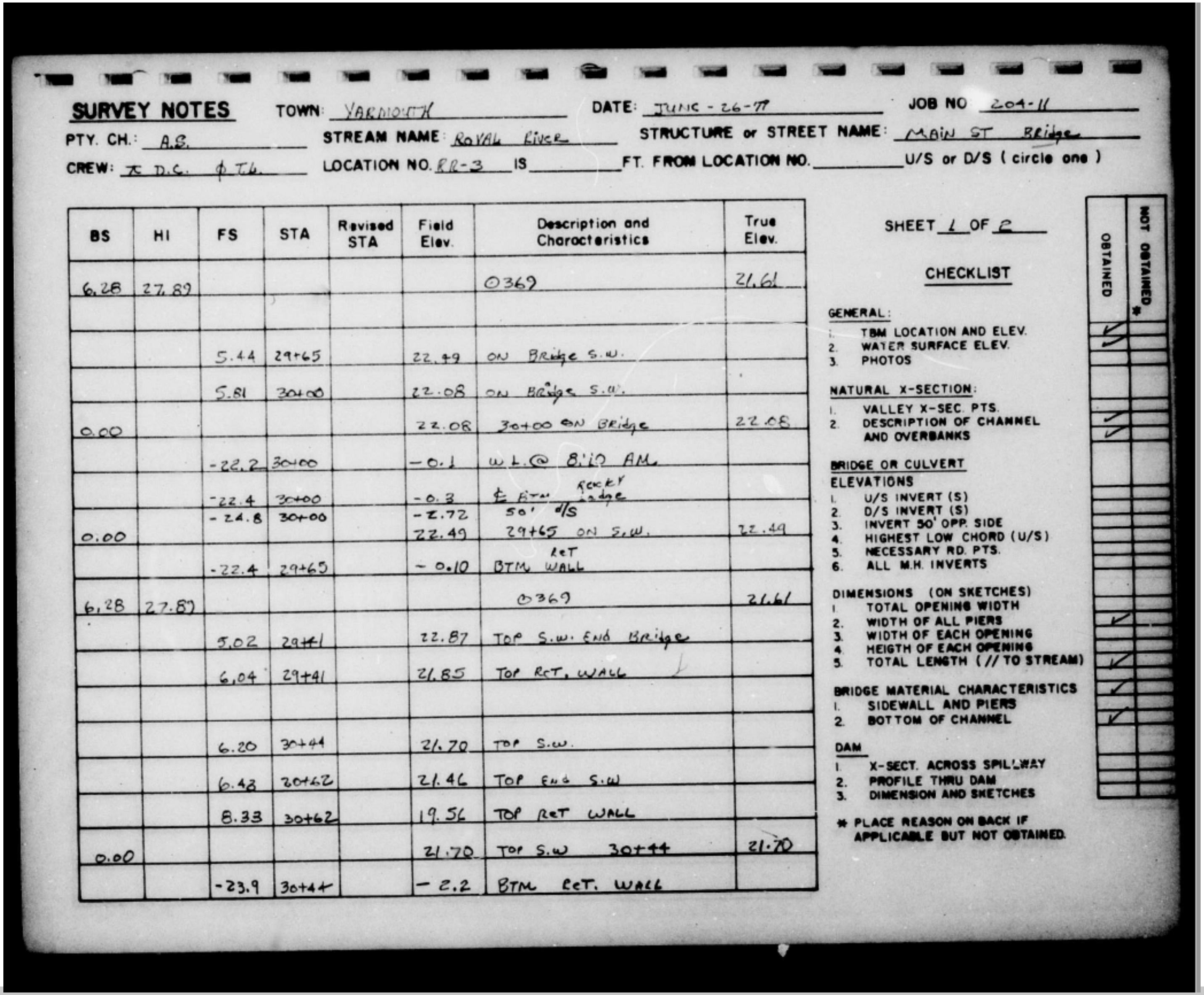
SHEET___OF_____

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.		
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1 TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: YARMOUTH DATE: JUNE - 26 - 77 JOB NO 204-11

PTY. CH.: A.S. STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: MAIN ST Bridge

CREW: π D.C. ϕ T.L. LOCATION NO. RR-3 IS _____ FT. FROM LOCATION NO. _____ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
6.28	27.89					⊙369	21.61
		5.44	29+65		22.49	ON Bridge S.W.	
		5.81	30+00		22.08	ON Bridge S.W.	
0.00					22.08	30+00 ON Bridge	22.08
		-22.2	30+00		-0.1	W.L.@ 8:10 AM.	
		-22.4	30+00		-0.3	℄ BTM ROCKY ledge	
		-24.8	30+00		-2.72	50' d/s	
0.00					22.49	29+65 ON S.W.	22.49
		-22.4	29+65		-0.10	BTM RET WALL	
6.28	27.89					⊙369	21.61
		5.02	29+41		22.87	TOP S.W. END Bridge	
		6.04	29+41		21.85	TOP RET. WALL	
		6.20	30+44		21.70	TOP S.W.	
		6.43	30+62		21.46	TOP END S.W	
		8.33	30+62		19.56	TOP RET WALL	
0.00					21.70	TOP S.W 30+44	21.70
		-23.9	30+44		-2.2	BTM RET. WALL	

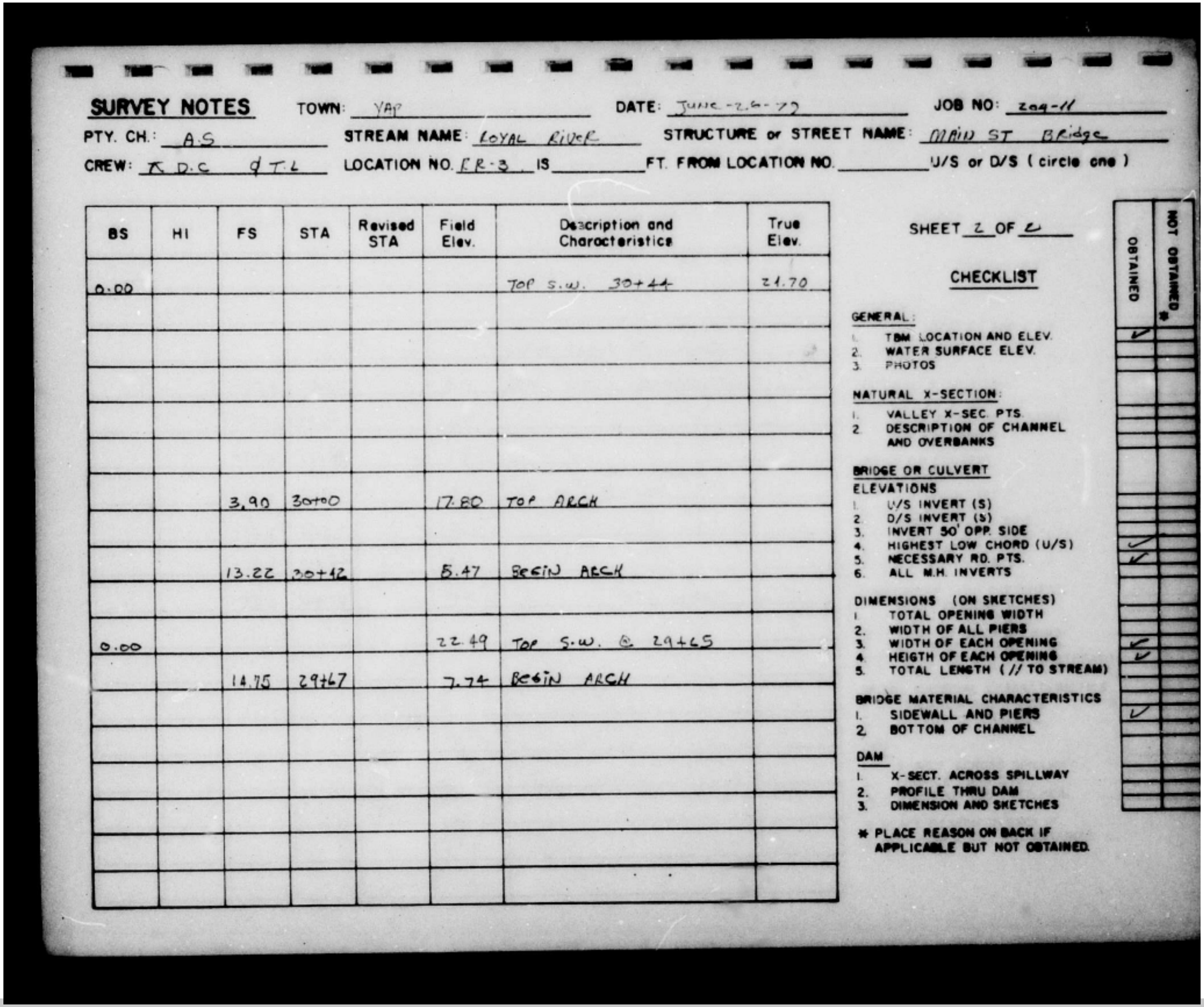
SHEET 1 OF 2

CHECKLIST

	OBTAINED	NOT OBTAINED*
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS	✓	
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)	✓	
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL	✓	
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: YAP DATE: JUNE-26-77 JOB NO: 209-11

PTY. CH.: A.S STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: MAIN ST Bridge

CREW: K D.C & T.L LOCATION NO. ER-3 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00						TOP S.W. 30+44	21.70
		3.90	30+00		17.80	TOP ARCH	
		13.22	30+12		5.47	BEGIN ARCH	
0.00					22.49	TOP S.W. @ 29+65	
		14.75	29+67		7.74	BEGIN ARCH	

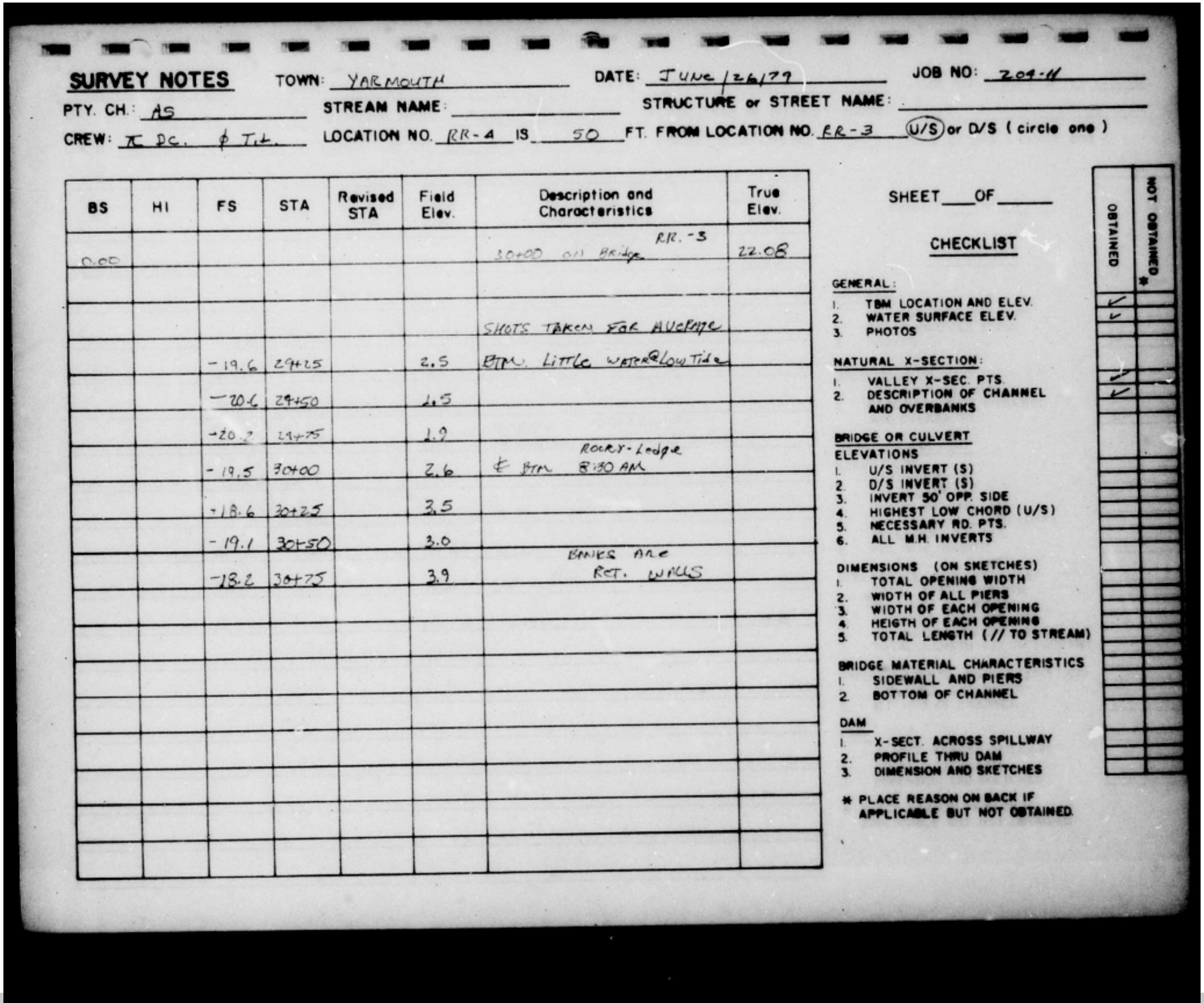
SHEET 2 OF 2

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.		
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.		
2. DESCRIPTION OF CHANNEL AND OVERBANKS		
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)	✓	
5. NECESSARY RD. PTS.	✓	
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING	✓	
4. HEIGTH OF EACH OPENING	✓	
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: YARMOUTH DATE: JUNE/26/79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: STRUCTURE or STREET NAME:

CREW: π DC. ϕ T.L. LOCATION NO. RR-4 IS 50 FT. FROM LOCATION NO. RR-3 [✓ U/S] or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00						RR.-3 30+00 on Bridge	22.08
						SHOTS TAKEN FOR AVERAGE	
		-19.6	29+25		2.5	BTM. Little water@Low Tide	
		-20.6	29+50		1.5		
		-20.2	29+75		1.9		
		-19.5	30+00		2.6	Rocky-Ledge ℄ BTM 8:30 AM	
		+18.6	30+25		3.5		
		-19.1	30+50		3.0		
		-18.2	30+75		3.9	BANKS ARE RET. WALLS	

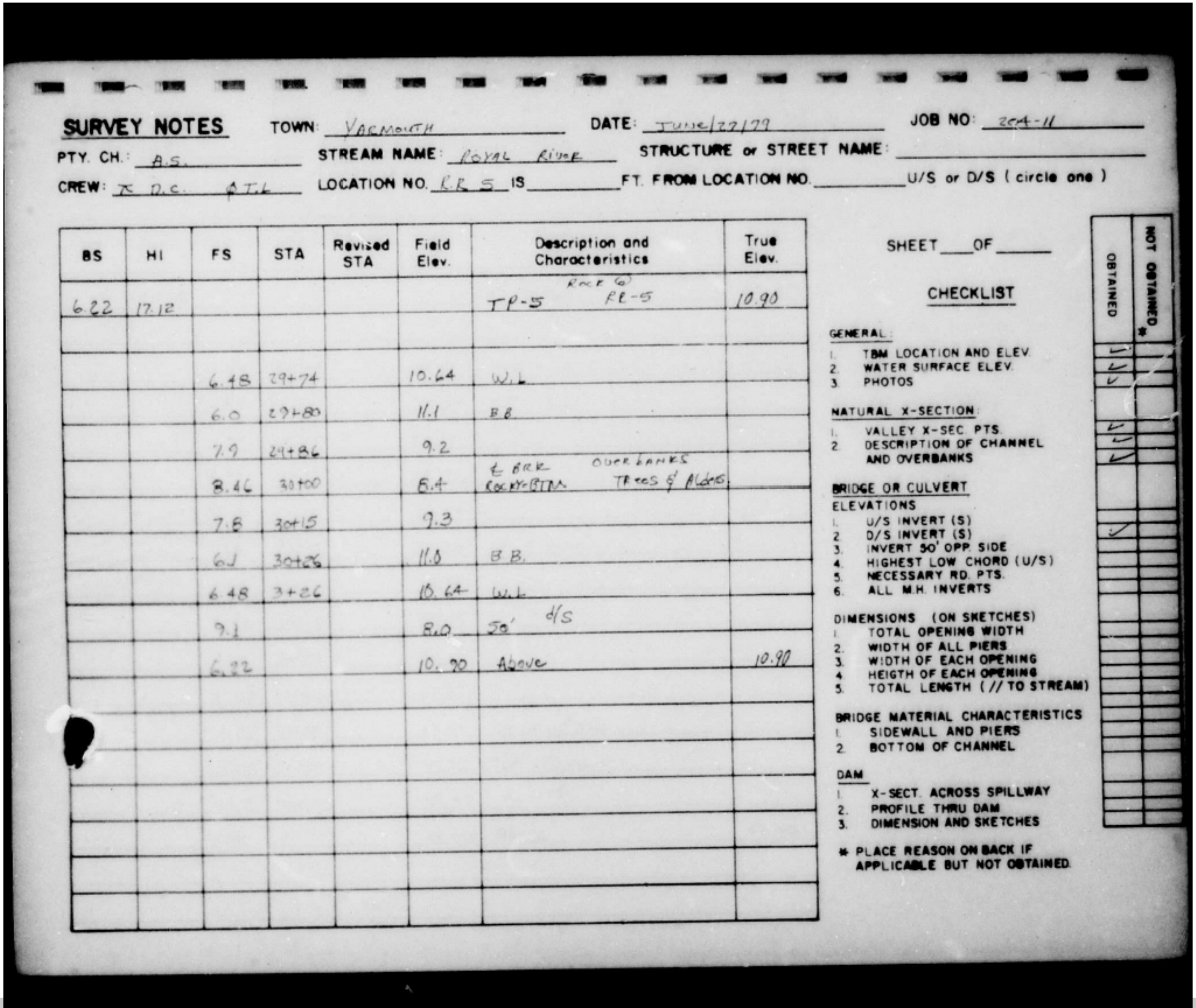
SHEET ___ OF ___

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: Yarmouth DATE: June/22/79 JOB NO: 264-11

PTY. CH.: A.S. STREAM NAME: Royal River STRUCTURE or STREET NAME:

CREW: π D.C. ϕ T.L LOCATION NO. R.R 5 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
6.22	17.12					TP-5 Rock @ RR-5	10.90
		6.48	29+74		10.64	W.L	
		6.0	29+80		11.1	B.B.	
		7.9	29+86		9.2		
		8.46	30+00		8.4	℄ BRK Rocky-BTM Overbanks Trees & Alders	
		7.8	30+15		9.3		
		6.J	30+26		11.0	B.B.	
		6.48	3+26		10.64	W.L	
		9.1			8.0	50' d/s	
		6.22			10.90	Above	10.90

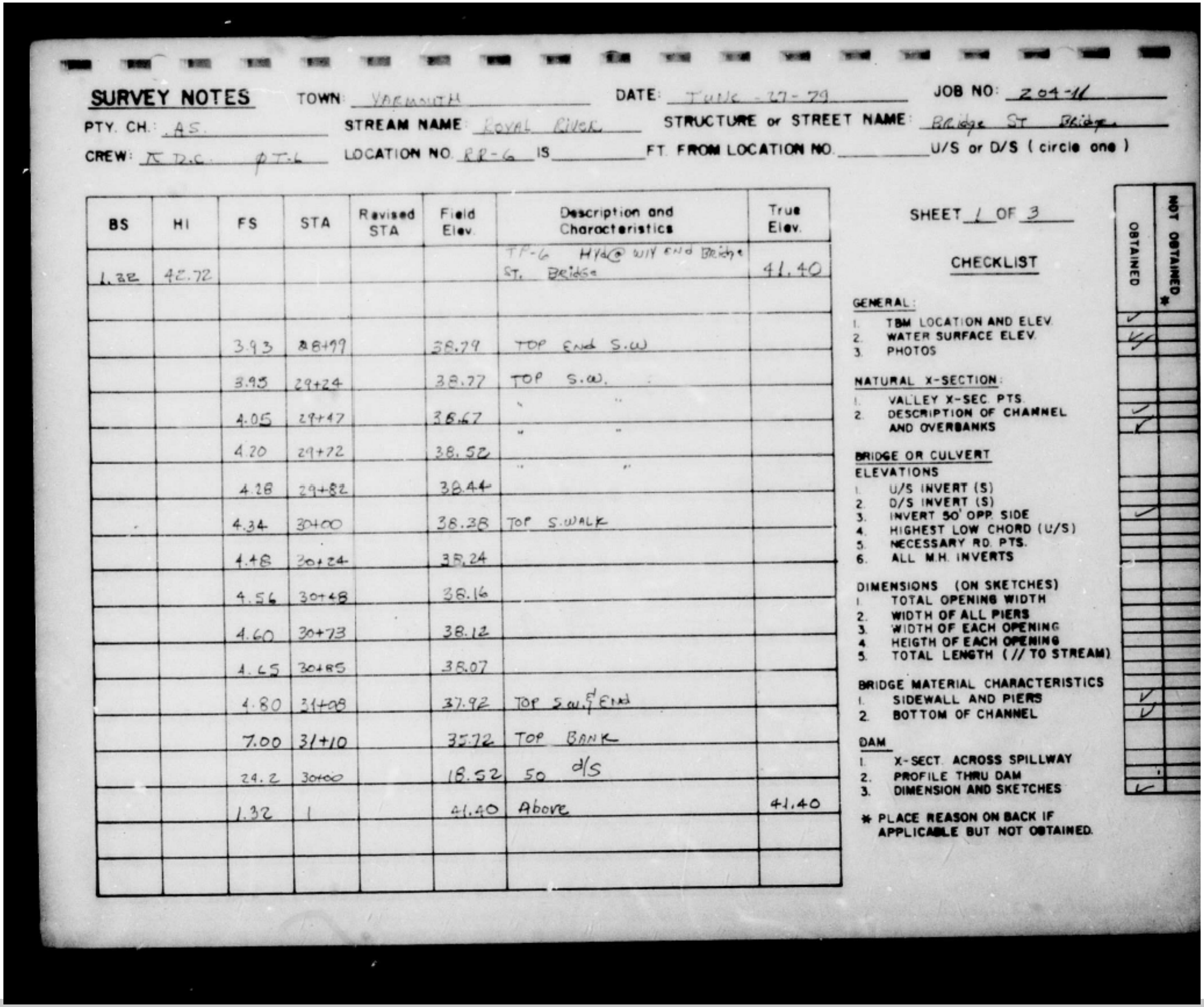
SHEET ____ OF ______

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS	✓	
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL	✓	
AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)	✓	
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

ROYAL RIVER FEMA SURVEY



SURVEY NOTES TOWN: YARMOUTH DATE: June - 27 - 79 JOB NO: 204-11

PTY. CH.: A.S. STREAM NAME: Royal River STRUCTURE or STREET NAME: Bridge St Bridge.

CREW: π D.C. ϕ T.L LOCATION NO. RR-6 IS ____ FT. FROM LOCATION NO. ____ U/S or D/S (circle one)

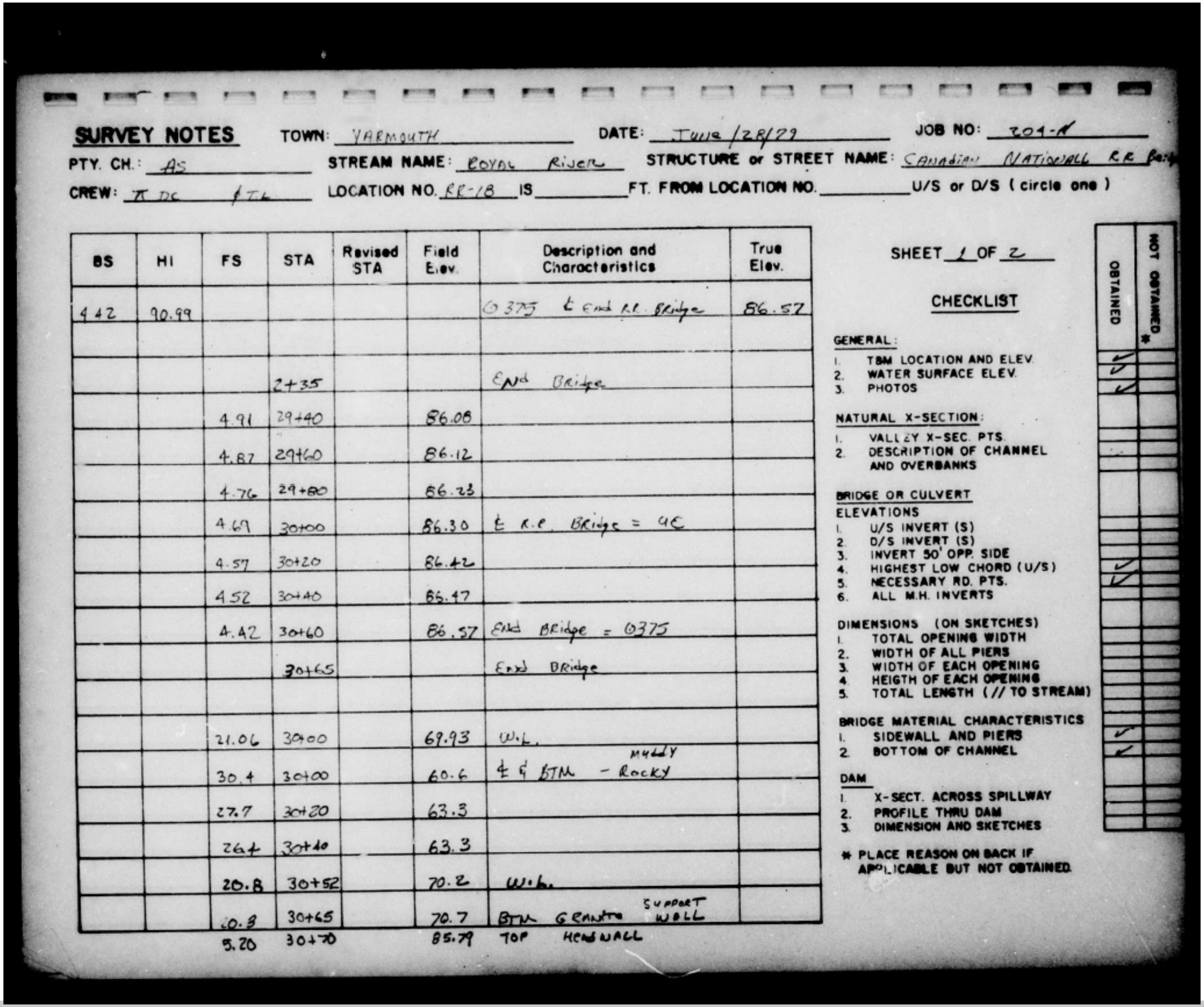
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
1.32	42.72					TP-6 Hyd@ w/y End Bridge St. Bridge	41.40
		3.93	28+99		38.79	TOP End S.W	
		3.95	29+24		38.77	TOP S.W.	
		4.05	29+47		38.67	" "	
		4.20	29+72		38.52	" "	
		4.28	29+82		38.44	" "	
		4.34	30+00		38.38	TOP S.WALK	
		4.48	30+24		38.24		
		4.56	30+48		38.16		
		4.60	30+73		38.12		
		4.65	30+85		38.07		
		4.80	31+08		37.92	TOP S.W. & End	
		7.00	31+10		35.72	TOP BANK	
		24.2	30+00		18.52	50 d/s	
		1.32	|		41.40	Above	41.40

SHEET 1 OF 3

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS	✓	
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE	✓	
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL	✓	
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES	✓	

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES

TOWN: YARMOUTH DATE: June /28/79 JOB NO: 304-A

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: CANADIAN NATIONALL RR Br

CREW: π DC ∮ TL LOCATION NO. RR-18 IS ____ FT. FROM LOCATION NO. ____ U/S or D/S (circle one)

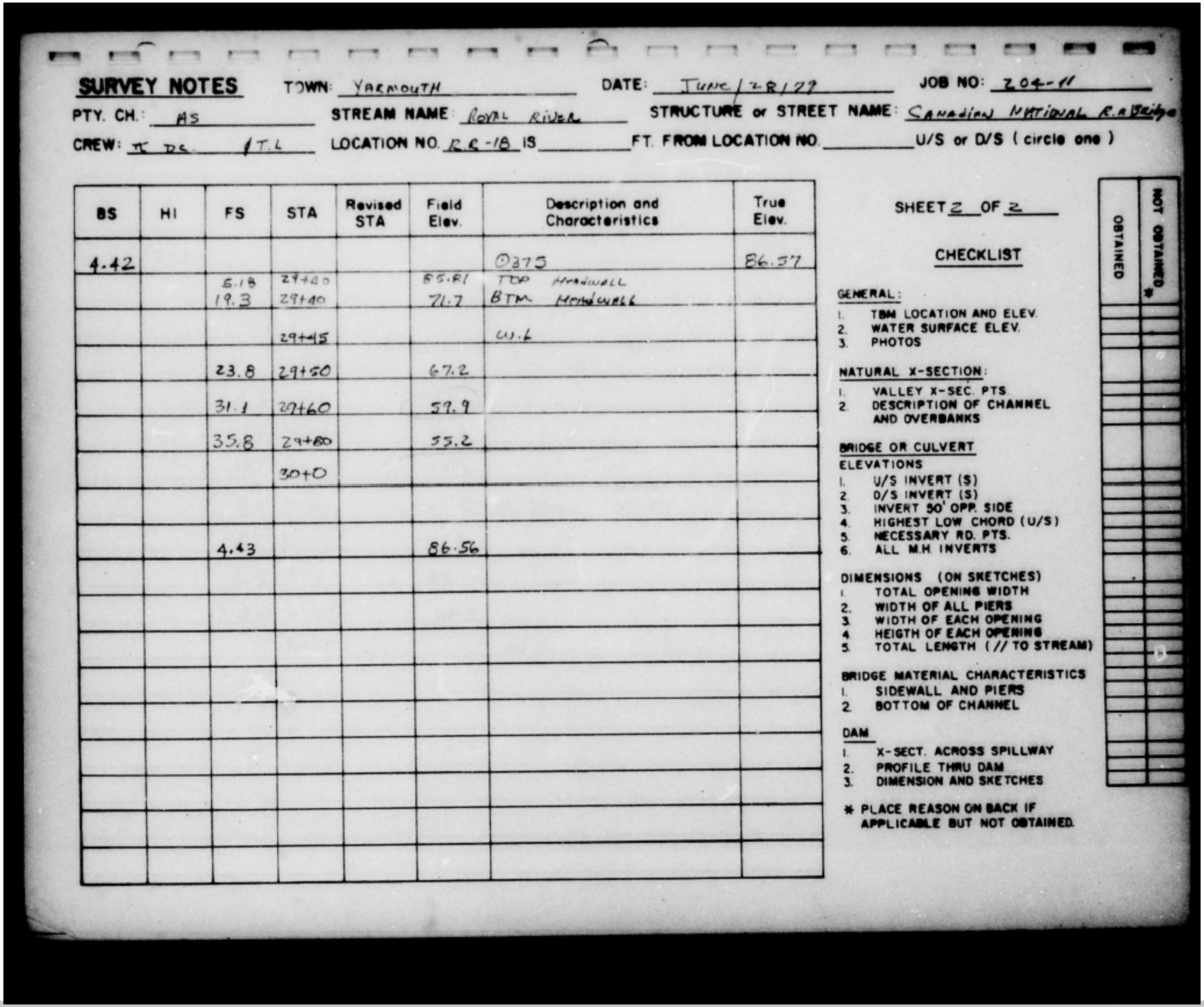
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
4.42	90.99					⊙375 ℄ End RR Bridge	86.57
			2+35			End Bridge	
		4.91	29+40		86.08		
		4.87	29+60		86.12		
		4.76	29+80		86.23		
		4.69	30+00		86.30	℄ R.R. Bridge = 4C	
		4.57	30+20		86.42		
		4.52	30+40		86.47		
		4.42	30+60		86.57	End Bridge = ⊙375	
			30+65			End Bridge	
		21.06	30+00		69.93	W.L.	
		30.4	30+00		60.6	Muddy ℄ & BTM - Rocky	
		27.7	30+20		63.3		
		26.4	30+40		63.3		
		20.8	30+52		70.2	W.L.	
		20.3	30+65		70.7	Support BTM Granite Wall	
		5.20	30+70		85.79	TOP HEADWALL	

SHEET 1 OF 2

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS	✓	
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.		
2. DESCRIPTION OF CHANNEL AND OVERBANKS		
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)	✓	
5. NECESSARY RD. PTS.	✓	
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL	✓	
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YARMOUTH DATE: June / 28 / 77 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: Royal River STRUCTURE or STREET NAME: Canadian National R.R Bridge

CREW: π DC / T.L LOCATION NO. R.C-18 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
4.42						⊙375	86.57
		5.18 19.3	29+40 29+40		85.81 71.7	TOP Headwall BTM Headwall	
			29+45			W.L	
		23.8	29+50		67.2		
		31.1	29+60		59.9		
		35.8	29+80		55.2		
			30+0				
		4.43			86.56		

SHEET 2 OF 2

CHECKLIST

OBTAINED | NOT OBTAINED*

GENERAL:
1. TBM LOCATION AND ELEV.
2. WATER SURFACE ELEV.
3. PHOTOS

NATURAL X-SECTION:
1. VALLEY X-SEC. PTS.
2. DESCRIPTION OF CHANNEL AND OVERBANKS

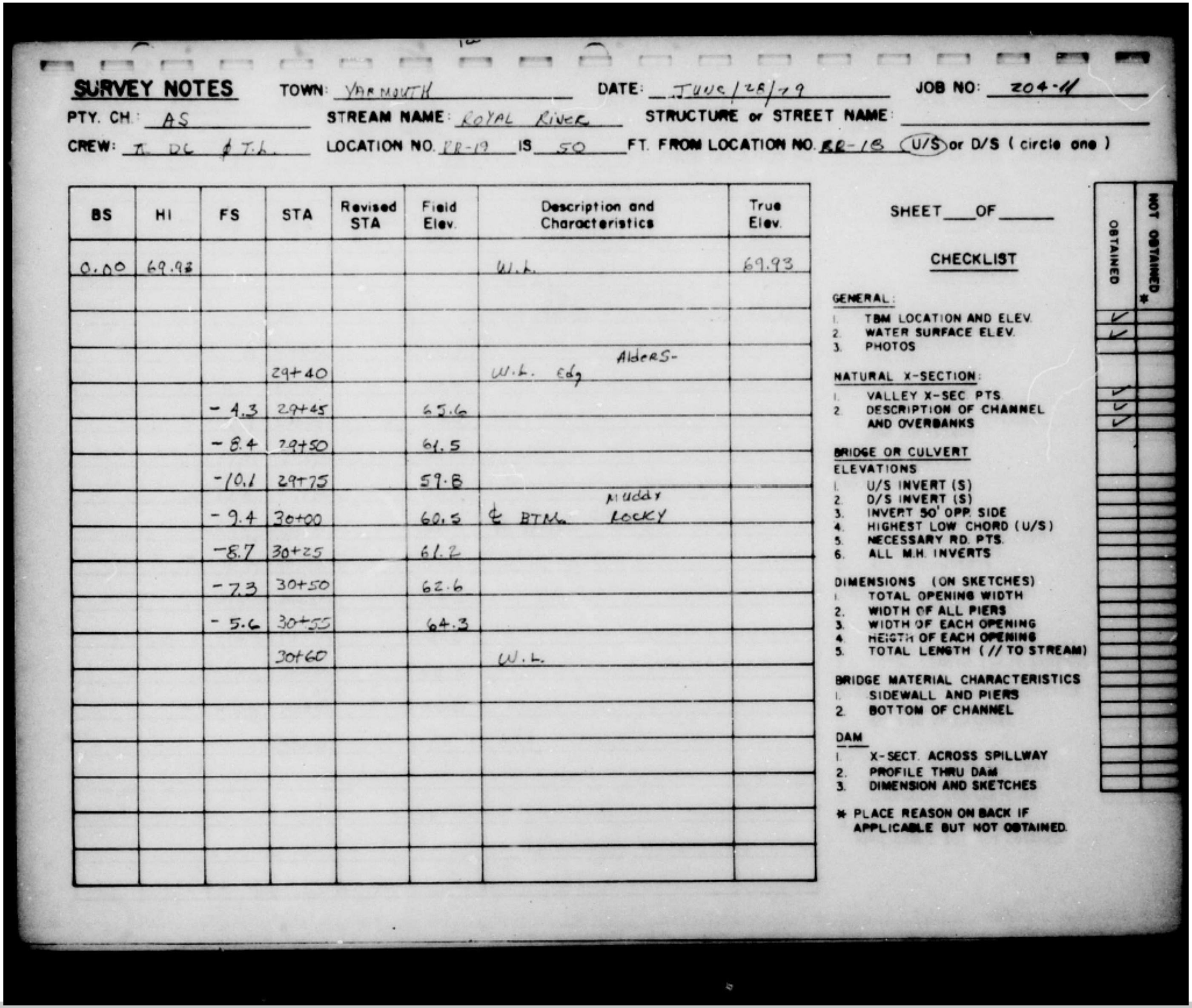
BRIDGE OR CULVERT
ELEVATIONS
1. U/S INVERT (S)
2. D/S INVERT (S)
3. INVERT 50' OPP. SIDE
4. HIGHEST LOW CHORD (U/S)
5. NECESSARY RD. PTS.
6. ALL M.H. INVERTS

DIMENSIONS (ON SKETCHES)
1. TOTAL OPENING WIDTH
2. WIDTH OF ALL PIERS
3. WIDTH OF EACH OPENING
4. HEIGTH OF EACH OPENING
5. TOTAL LENGTH (// TO STREAM)

BRIDGE MATERIAL CHARACTERISTICS
1. SIDEWALL AND PIERS
2. BOTTOM OF CHANNEL

DAM
1. X-SECT. ACROSS SPILLWAY
2. PROFILE THRU DAM
3. DIMENSION AND SKETCHES

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES

TOWN: YARMOUTH

DATE: June/28/79

JOB NO: 204-11

PTY. CH.: AS

STREAM NAME: ROYAL RIVER

STRUCTURE or STREET NAME:

CREW: T. DC & T.L.

LOCATION NO. RR-19 IS 50 FT. FROM LOCATION NO. RR-18 [✓ U/S] or D/S (circle one)

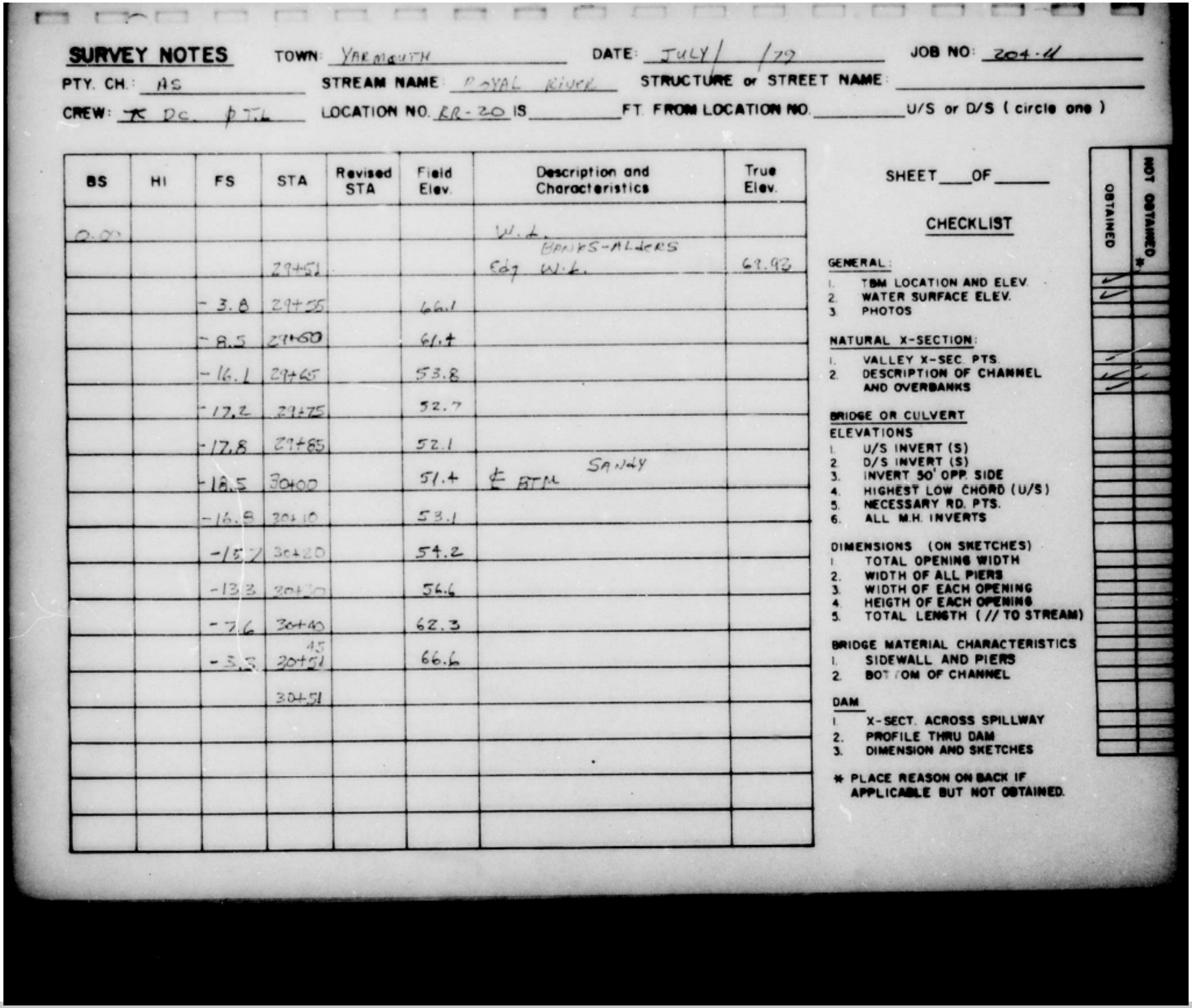
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00	69.93					W.L.	69.93
			29+40			Alders- W.L. Edg	
		- 4.3	29+45		65.6		
		- 8.4	29+50		61.5		
		-10.1	29+75		59.8		
		- 9.4	30+00		60.5	Muddy ℄ BTM. Rocky	
		-8.7	30+25		61.2		
		-7.3	30+50		62.6		
		- 5.6	30+55		64.3		
			30+60			W.L.	

SHEET ___ OF ______

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL	✓	
AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YARMOUTH DATE: JULY / /79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: ______

CREW: X DC. PTL LOCATION NO. RR-20 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

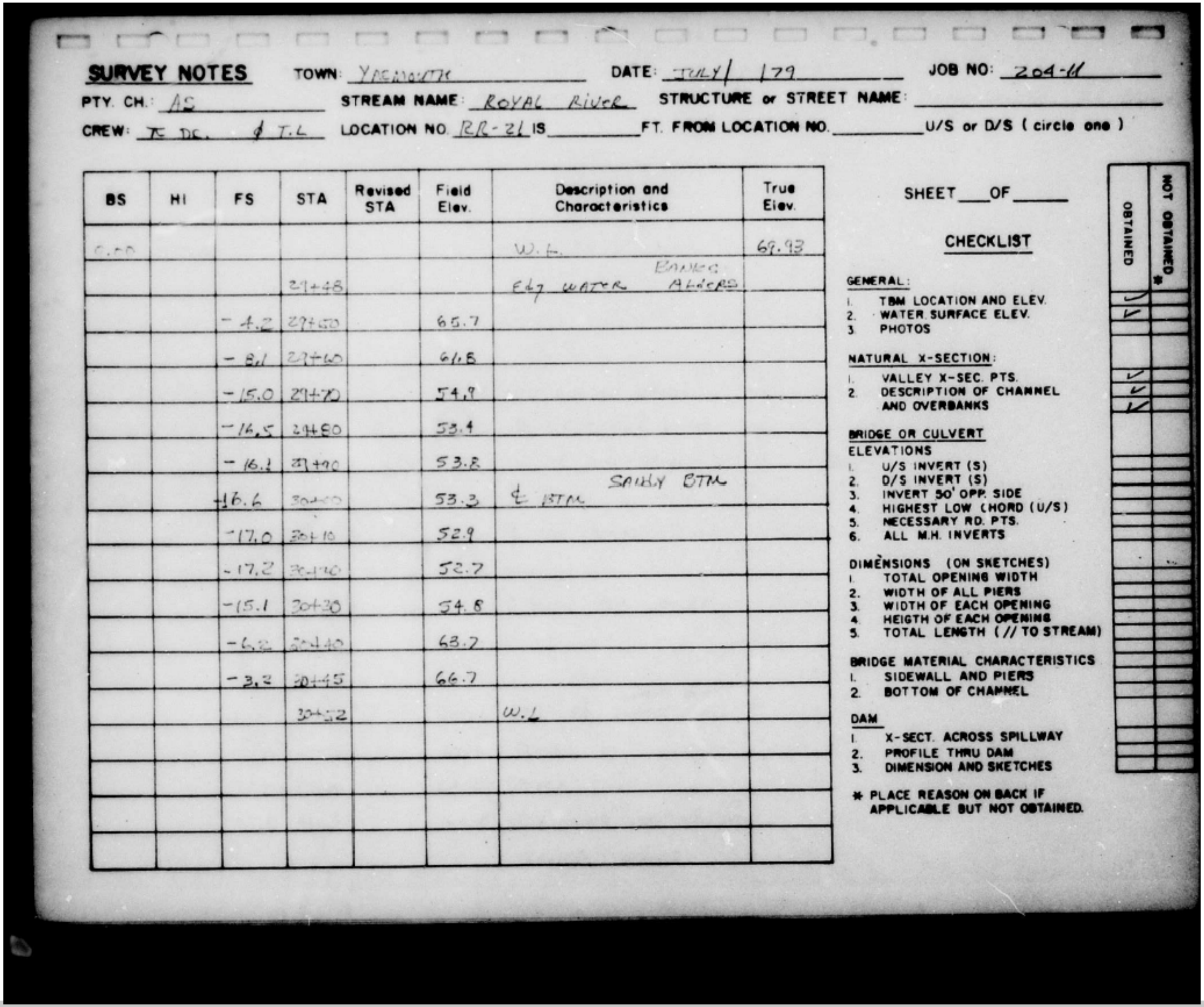
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00						W.L.	
			29+51			BANKS-ALDERS Edg W.L.	69.93
		-3.8	29+55		66.1		
		-8.5	29+60		61.4		
		-16.1	29+65		53.8		
		-17.2	29+75		52.7		
		-17.8	29+85		52.1		
		-18.5	30+00		51.4	℄ BTM SANDY	
		-16.9	30+10		53.1		
		-15.7	30+20		54.2		
		-13.3	30+30		56.6		
		-7.6	30+40		62.3		
		-3.3	45 30+51		66.6		
			30+51				

SHEET ___ OF ______

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YARMOUTH DATE: JULY/ 79 JOB NO: 204-11
PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: ____
CREW: π DC. ∮ T.L LOCATION NO. RR-21 IS ____ FT. FROM LOCATION NO. ____ U/S or D/S (circle one)

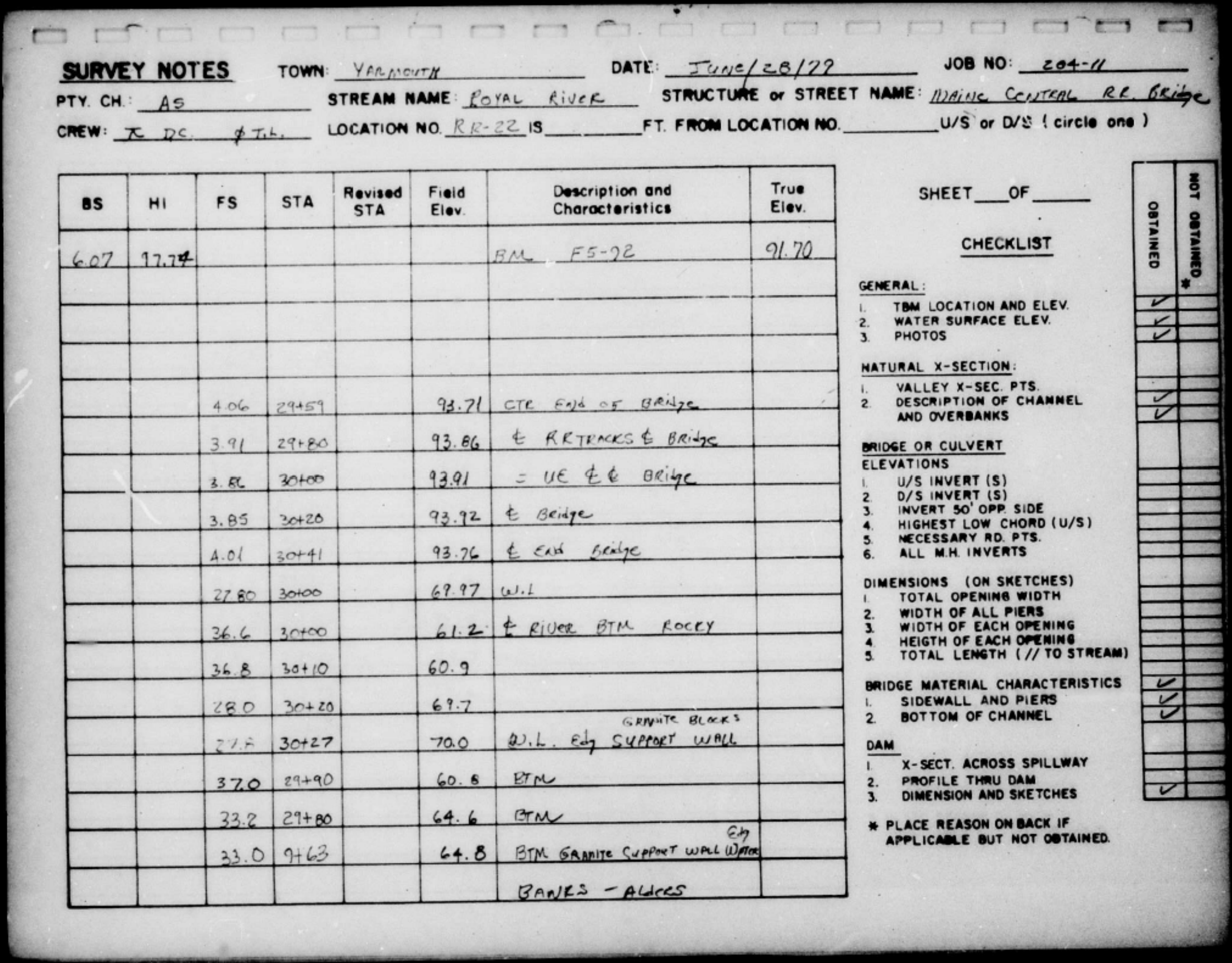
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00						W.L.	69.93
			29+48			Edg WATER BANKS ALDERS	
		- 4.2	29+50		65.7		
		- 8.1	29+60		61.8		
		-15.0	29+70		54.9		
		-16.5	29+80		53.4		
		- 16.1	29+90		53.8		
		-16.6	30+00		53.3	℄ BTM SANDY BTM	
		-17.0	30+10		52.9		
		-17.2	30+20		52.7		
		-15.1	30+30		54.8		
		-6.2	30+40		63.7		
		-3.2	30+45		66.7		
			30+52			W.L	

SHEET ___ OF ____

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3 PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL	✓	
AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2 BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YARMOUTH DATE: JUNE/28/77 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: MAINE CENTRAL RR. Bridge

CREW: ⊼ DC. ϕ T.L. LOCATION NO. RR-22 IS ______ FT. FROM LOCATION NO. ______ U/S or D/S (circle one)

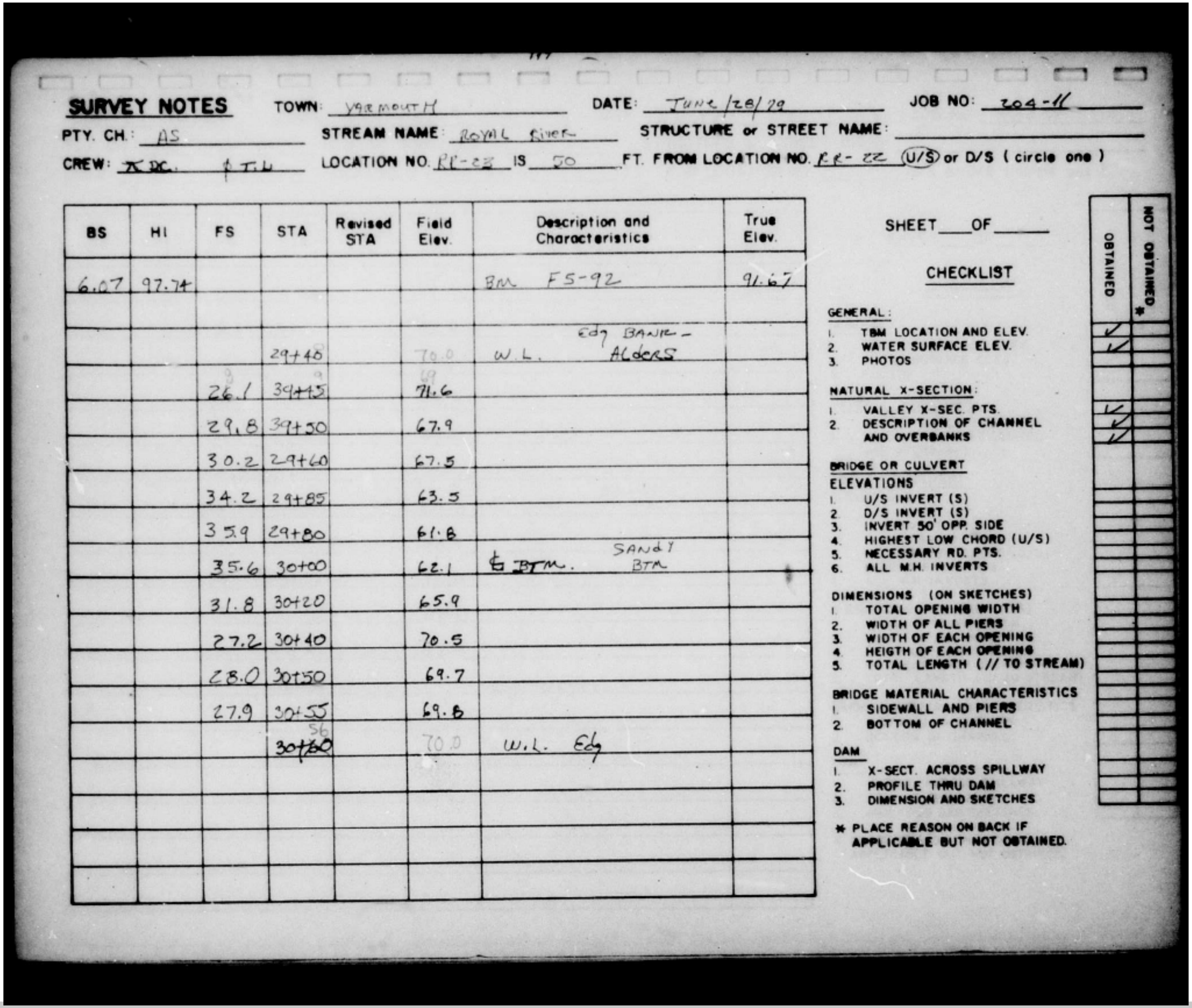
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
6.07	97.77					BM F5-92	91.70
		4.06	29+59		93.71	CTR End of Bridge	
		3.91	29+80		93.86	℄ RR TRACKS ℄ Bridge	
		3.86	30+00		93.91	= UE ℄ ℄ Bridge	
		3.85	30+20		93.92	℄ Bridge	
		4.01	30+41		93.76	℄ End Bridge	
		27.80	30+00		69.97	W.L	
		36.6	30+00		61.2	℄ RIVER BTM ROCKY	
		36.8	30+10		60.9		
		28.0	30+20		69.7		
		27.8	30+27		70.0	W.L. Edg SUPPORT WALL GRANITE BLOCKS	
		37.0	29+90		60.8	BTM	
		33.2	29+80		64.6	BTM	
		33.0	9+63		64.8	BTM GRANITE SUPPORT WALL WATER Edg	
						BANKS - ALDERS	

SHEET ___ OF ______

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS	✓	
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS	✓	
1. SIDEWALL AND PIERS	✓	
2. BOTTOM OF CHANNEL	✓	
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES	✓	

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YARMOUTH DATE: JUNE /28/ 79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME:

CREW: ЖDC. ϕ T.L LOCATION NO. RR-23 IS 50 FT. FROM LOCATION NO. RR-22 [✓ U/S] or D/S (circle one)

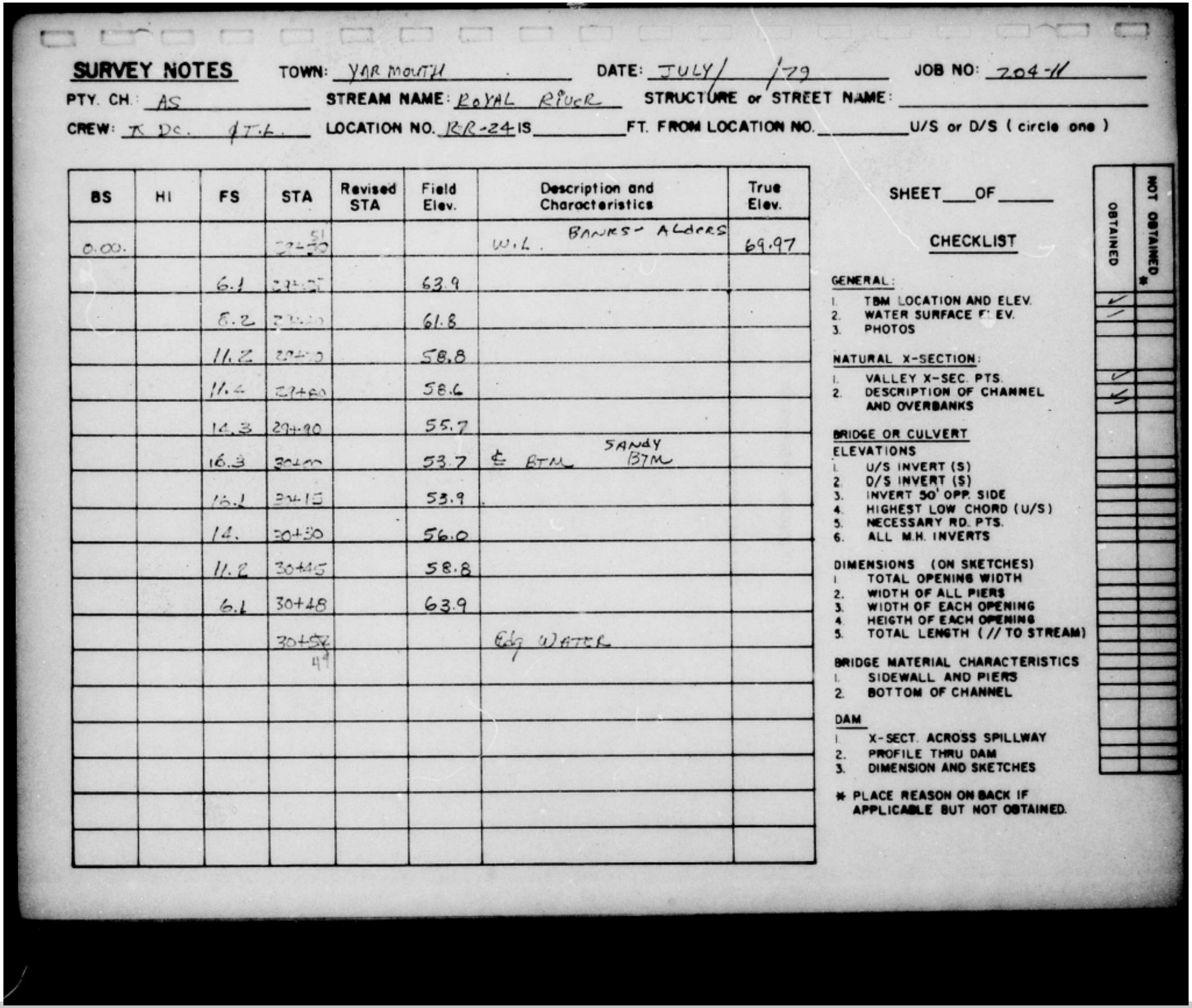
BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
6.07	97.74					BM FS-92	91.67
			29+40		70.0	W.L. Edg BANK - Alders	
		26.1	39+45		71.6		
		29.8	39+50		67.9		
		30.2	29+60		67.5		
		34.2	29+85		63.5		
		35.9	29+80		61.8		
		35.6	30+00		62.1	℄ BTM. SANDY BTM	
		31.8	30+20		65.9		
		27.2	30+40		70.5		
		28.0	30+50		69.7		
		27.9	30+55		69.8		
			56 30+60		70.0	W.L. Edg	

SHEET ___ OF ___

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL	✓	
AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.



SURVEY NOTES TOWN: YAR MOUTH DATE: JULY/ /79 JOB NO: 204-11

PTY. CH.: AS STREAM NAME: ROYAL RIVER STRUCTURE or STREET NAME: ____

CREW: K DC. ϕ T.L. LOCATION NO. RR-24 IS ____ FT. FROM LOCATION NO. ____ U/S or D/S (circle one)

BS	HI	FS	STA	Revised STA	Field Elev.	Description and Characteristics	True Elev.
0.00.			51 29+20			W.L. BANKS- ALDERS	69.97
		6.1	29+25		63.9		
		8.2	29+40		61.8		
		11.2	29+50		58.8		
		11.4	29+60		58.6		
		14.3	29+90		55.7		
		16.3	30+00		53.7	℄ BTM SANDY BTM	
		16.1	30+15		53.9		
		14.	30+30		56.0		
		11.2	30+45		58.8		
		6.1	30+48		63.9		
			30+52			Edg WATER	
			49				

SHEET ____ OF ____

CHECKLIST

	OBTAINED	NOT OBTAINED *
GENERAL:		
1. TBM LOCATION AND ELEV.	✓	
2. WATER SURFACE ELEV.	✓	
3. PHOTOS		
NATURAL X-SECTION:		
1. VALLEY X-SEC. PTS.	✓	
2. DESCRIPTION OF CHANNEL AND OVERBANKS	✓	
BRIDGE OR CULVERT		
ELEVATIONS		
1. U/S INVERT (S)		
2. D/S INVERT (S)		
3. INVERT 50' OPP. SIDE		
4. HIGHEST LOW CHORD (U/S)		
5. NECESSARY RD. PTS.		
6. ALL M.H. INVERTS		
DIMENSIONS (ON SKETCHES)		
1. TOTAL OPENING WIDTH		
2. WIDTH OF ALL PIERS		
3. WIDTH OF EACH OPENING		
4. HEIGTH OF EACH OPENING		
5. TOTAL LENGTH (// TO STREAM)		
BRIDGE MATERIAL CHARACTERISTICS		
1. SIDEWALL AND PIERS		
2. BOTTOM OF CHANNEL		
DAM		
1. X-SECT. ACROSS SPILLWAY		
2. PROFILE THRU DAM		
3. DIMENSION AND SKETCHES		

* PLACE REASON ON BACK IF APPLICABLE BUT NOT OBTAINED.

Attachment B

Select As-Built Plans and Terrain Model Topographic Workmaps

30AUG24 - SECTION 206
ROYAL RIVER FISH PASSAGE

YARMOUTH, MAINE

ATTACHMENT B
SELECT AS-BUILT PLANS AND TERRAIN MODEL TOPOGRAPHIC WORKMAPS

US Army Corps of Engineers®

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	I 295 NB / ROYAL RIVER	Location	1.2 MI N US1
Bridge Number	5834	Route Number	0295X
Feature On	I 295 NORTHBOUND	Bridge Region	1 - Southern Region
Feature Under	Royal River	Border Bridge	
Bridge Road Width (Feet)	30	Bridge or Minor Span	Bridge on State Highway

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	80	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	6 - Satisfactory Condition (minor deterioration)	Channel Condition	4 - Protect. severely undermined. sev. damage
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1959	Annual Average Daily Traffic	20370

INSPECTION AND APPRAISAL

Date of Inspection	12/12/19	Federal Sufficiency Rating	70.8

STRUCTURE TYPE AND MATERIAL

Span Material	Steel continuous	Span Type	Stringer/Multi-beam or Girder
Number of Main Spans	3		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	I295 SB / ROYAL RIVER	Location	1.2 MI N US 1
Bridge Number	1508	Route Number	0295S
Feature On	I 295 SOUTHBOUND	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	30	Bridge or Minor Span	Bridge on State Highway

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	80	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	7 - Good Condition (some minor problems)	Channel Condition	5 - Bank eroded.. major damage
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1959	Annual Average Daily Traffic	21730

INSPECTION AND APPRAISAL

Date of Inspection	12/12/19	Federal Sufficiency Rating	74.8

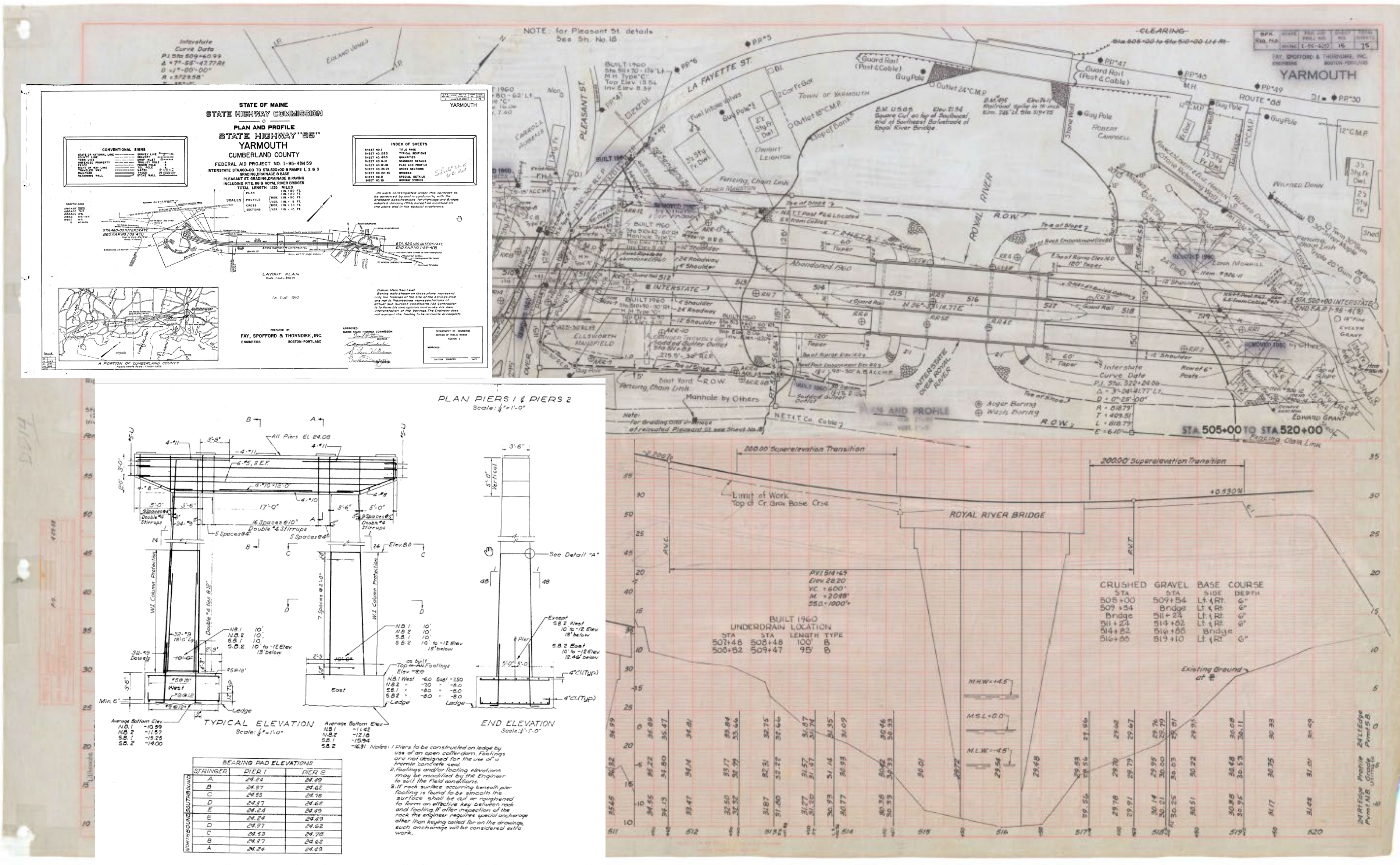
STRUCTURE TYPE AND MATERIAL

Span Material	Steel continuous	Span Type	Stringer/Multi-beam or Girder
Number of Main Spans	3		

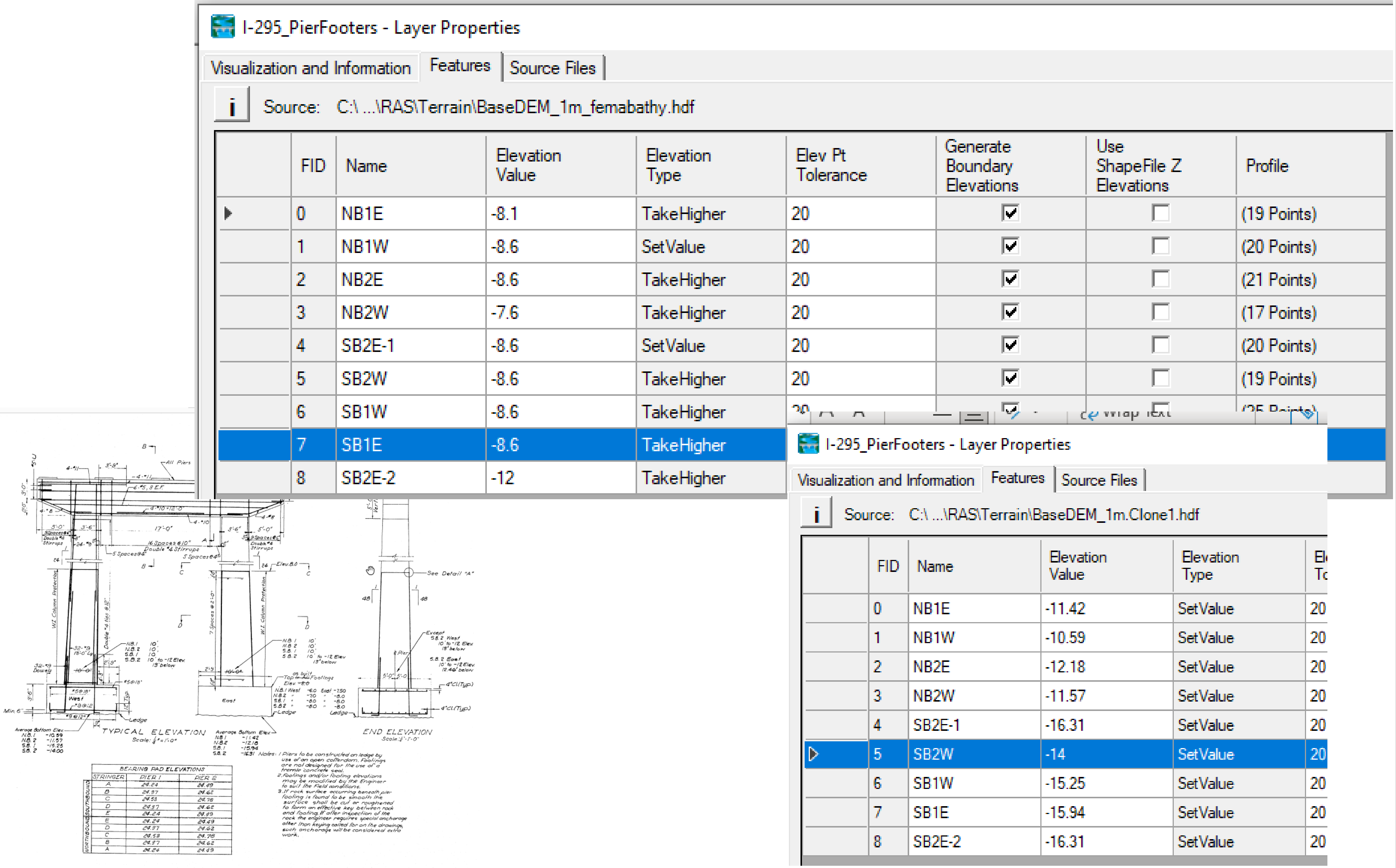
LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

INTERSTATE "95" – 1959/60 AS-BUILTS



INTERSTATE "95" – 1959/60 AS-BUILTS / PIERS & FOOTERS



Source: C:\ ...\RAS\Terrain\BaseDEM_1m_femabathy.hdf

FID	Name	Elevation Value	Elevation Type	Elev Pt Tolerance	Generate Boundary Elevations	Use ShapeFile Z Elevations	Profile
0	NB1E	-8.1	TakeHigher	20	☑	☐	(19 Points)
1	NB1W	-8.6	SetValue	20	☑	☐	(20 Points)
2	NB2E	-8.6	TakeHigher	20	☑	☐	(21 Points)
3	NB2W	-7.6	TakeHigher	20	☑	☐	(17 Points)
4	SB2E-1	-8.6	SetValue	20	☑	☐	(20 Points)
5	SB2W	-8.6	TakeHigher	20	☑	☐	(19 Points)
6	SB1W	-8.6	TakeHigher	20	☑	☐	(25 Points)
7	SB1E	-8.6	TakeHigher				
8	SB2E-2	-12	TakeHigher				

Source: C:\ ...\RAS\Terrain\BaseDEM_1m.Clone1.hdf

FID	Name	Elevation Value	Elevation Type	El To
0	NB1E	-11.42	SetValue	20
1	NB1W	-10.59	SetValue	20
2	NB2E	-12.18	SetValue	20
3	NB2W	-11.57	SetValue	20
4	SB2E-1	-16.31	SetValue	20
5	SB2W	-14	SetValue	20
6	SB1W	-15.25	SetValue	20
7	SB1E	-15.94	SetValue	20
8	SB2E-2	-16.31	SetValue	20

N.B.1 West	-6.0	East -7.50
N.B.2 "	-7.0	" -8.0
S.B.1 "	-8.0	" -8.0
S.B.2 "	-8.0	" -8.0

Average Bottom Elev.

N.B.1	-10.59
N.B.2	-11.57
S.B.1	-15.25
S.B.2	-14.00

TYPICAL ELEVATION
Scale: $\frac{1}{4}$" = 1'-0"

Average Bottom Elev.

N.B.1	-11.42
N.B.2	-12.18
S.B.1	-15.94
S.B.2	-16.31

END ELEVATION
Scale: $\frac{1}{4}$" - 1'-0"

Notes: 1. Piers to be constructed on ledge by use of an open cofferdam. Footings are not designed for the use of a tremie concrete seal.
2. Footings and/or footing elevations may be modified by the Engineer to suit the Field conditions.
3. If rock surface occurring beneath pier footing is found to be smooth the surface shall be cut or roughened to form an effective key between rock and footing. If after inspection of the rock the engineer requires special anchorage other than keying called for on the drawings, such anchorage will be considered extra work.

BEARING PAD ELEVATIONS

	STRINGER	PIER 1	PIER 2
SOUTHBOUND	A	24.24	24.49
	B	24.37	24.62
	C	24.53	24.78
	D	24.37	24.62
	E	24.24	24.49
NORTHBOUND	E	24.24	24.49
	D	24.37	24.62
	C	24.53	24.78
	B	24.37	24.62
	A	24.24	24.49

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	FALLS	Location	0.1 MI E JCT RTE 115
Bridge Number	2272	Route Number	0088X
Feature On	ROUTE 88	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	32	Bridge or Minor Span	Bridge on State Highway

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	75	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	4 - Poor Condition (advanced deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	4 - Poor Condition (advanced deterioration)	Channel Condition	3 - Protection failure
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1930	Annual Average Daily Traffic	4867

INSPECTION AND APPRAISAL

Date of Inspection	10/07/20	Federal Sufficiency Rating	63.9

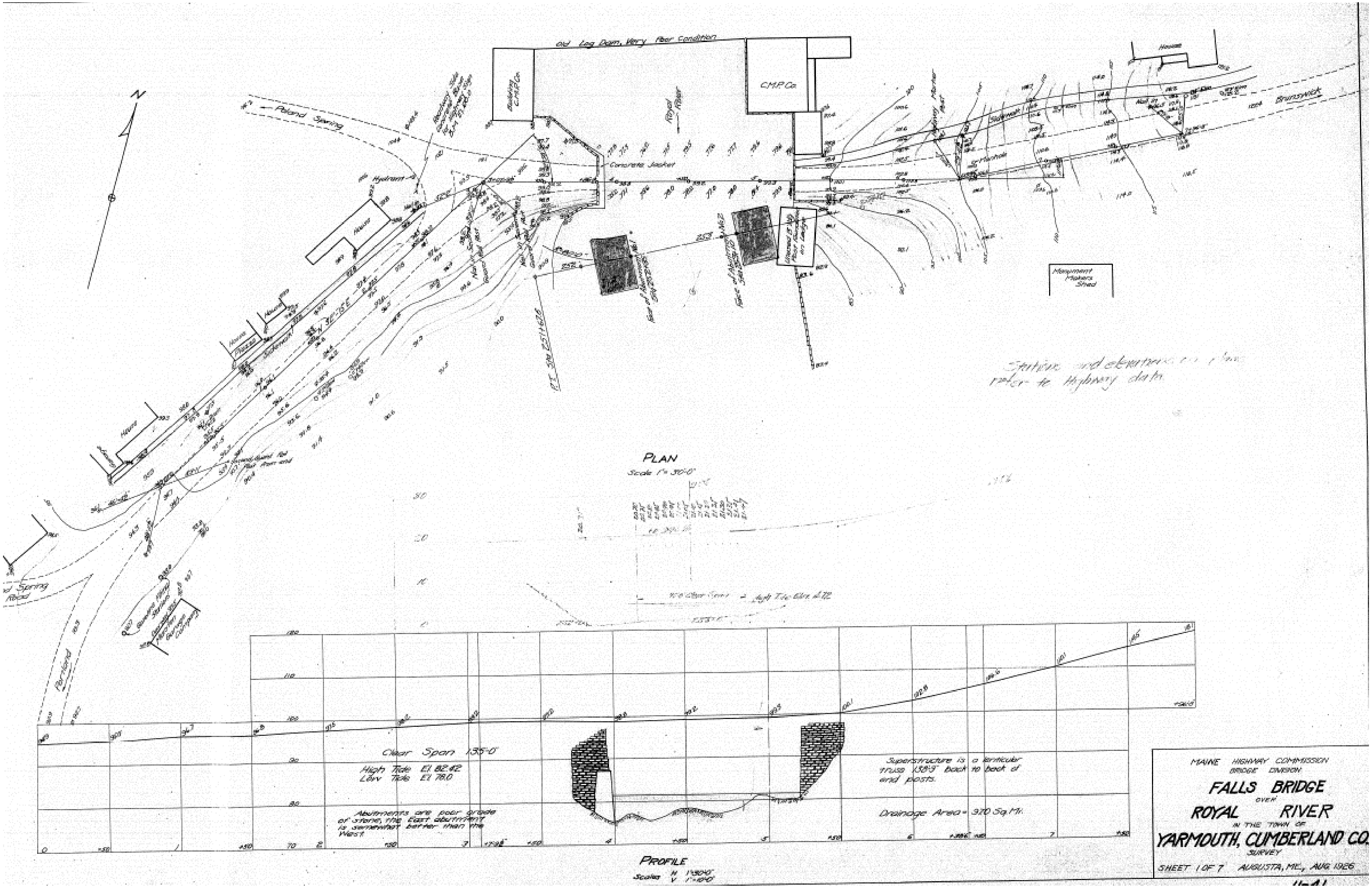
STRUCTURE TYPE AND MATERIAL

Span Material	Concrete	Span Type	Arch - Deck
Number of Main Spans	1		

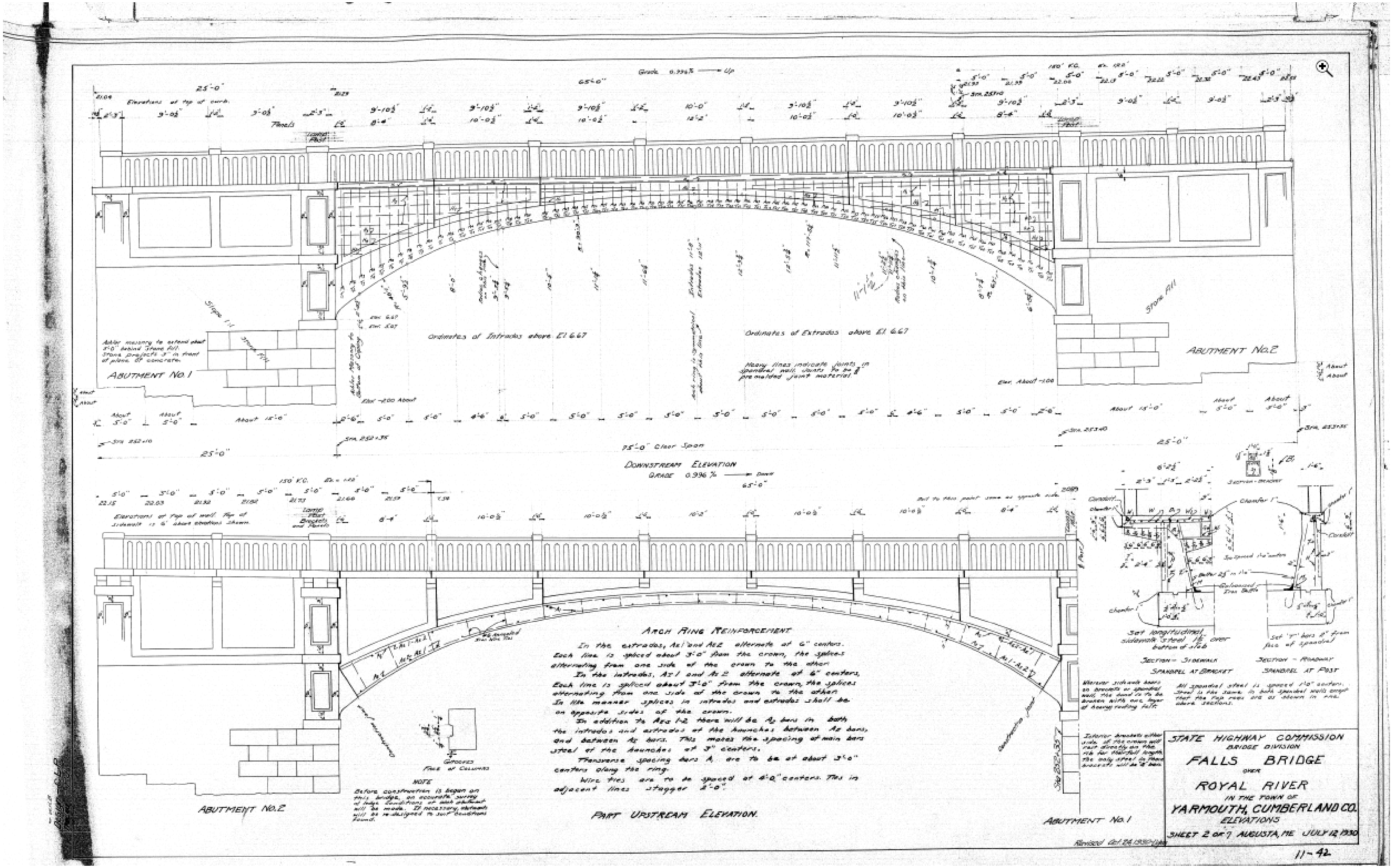
LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

FALLS BRIDGE – MAIN ST – ROUTE 88



FALLS BRIDGE – MAIN ST – RT 88



Ashlar masonry to extend about 3'-0" behind Stone fill. Stone projects 3" in front of plane of concrete.

Heavy lines indicate joints in spandrel wall. Joints to be ½" premolded joint material.

ARCH RING REINFORCEMENT

In the extrados, As1 and As2 alternate at 6" centers. Each line is spliced about 3'-0" from the crown, the splices alternating from one side of the crown to the other.

In the intrados, Ai1 and Ai2 alternate at 6" centers. Each line is spliced about 3'-0" from the crown, the splices alternating from one side of the crown to the other. In like manner splices in intrados and extrados shall be on opposite sides of the crown.

In addition to As 1-2 there will be A3 bars in both the intrados and extrados at the haunches between A2 bars, and between A3 bars. This makes the spacing of main bars steel at the haunches at 3" centers.

Transverse spacing bars A4 are to be at about 3'-0" centers along the ring.

Wire ties are to be spaced at 4'-0" centers. Ties in adjacent lines stagger 2'-0".

PART UPSTREAM ELEVATION.

NOTE

Before construction is begun on this bridge, an accurate survey of ledge conditions at each abutment will be made. If necessary, abutments will be re-designed to suit conditions found.

Set longitudinal sidewalk steel 1½" over bottom of slab

Set "F" bars 2" from face of spandrel

Wherever sidewalk bears on brackets or spandrel wall, the bond is to be broken with one layer of heavy roofing felt.

All spandrel steel is spaced 1'-0" centers. Steel is the same in both spandrel walls except that the top rows are as shown in the above sections.

Interior brackets either side of the crown will rest directly on the rib for their full length. The only steel in these brackets will be "B" bars.

STATE HIGHWAY COMMISSION
BRIDGE DIVISION
FALLS BRIDGE
OVER
ROYAL RIVER
IN THE TOWN OF
YARMOUTH, CUMBERLAND CO.
ELEVATIONS
SHEET 2 OF 7 AUGUSTA, ME JULY 12 1930

Revised Oct. 24 1930

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	COTTON MILL	Location	0.2 MI NE JCT RTE 115
Bridge Number	3983	Route Number	05Y0006
Feature On	BRIDGE STREET	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	22	Bridge or Minor Span	Bridge on Townway or State Aid Road

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	58.9	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	8 - Very Good Condition (no problems noted)	Culvert Condition	N - Not Applicable
Superstructure Condition	6 - Satisfactory Condition (minor deterioration)	Channel Condition	7 - Bank protection needs minor repairs
Substructure Condition	5 - Fair Condition (minor section loss)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1948	Annual Average Daily Traffic	711

INSPECTION AND APPRAISAL

Date of Inspection	05/26/21	Federal Sufficiency Rating	62

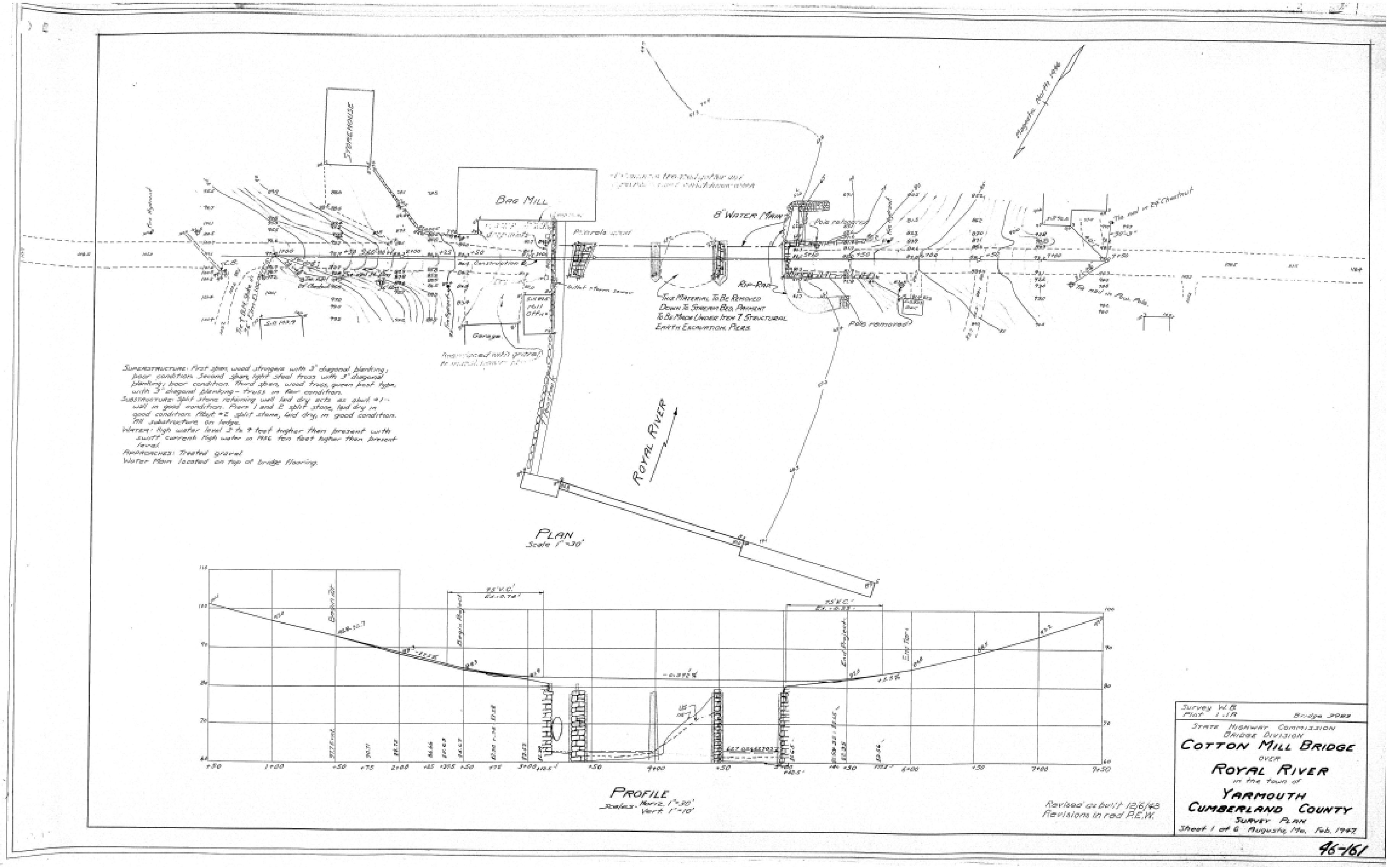
STRUCTURE TYPE AND MATERIAL

Span Material	Steel	Span Type	Stringer/Multi-beam or Girder
Number of Main Spans	3		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

COTTON MILL BRIDGE – BRIDGE ST



Superstructure: First span, wood stringers with 3" diagonal planking, poor condition. Second span, light steel truss with 3" diagonal planking, poor condition. Third span, wood truss, queen post type, with 3" diagonal planking – truss in fair condition.
Substructure: Split stone retaining wall laid dry acts as abut #1 – wall in good condition. Piers 1 and 2 split stone, laid dry in good condition. Abut #2 split stone, laid dry, in good condition. All substructure on ledge.
Water: High water level 3 to 4 feet higher than present with swift current. High water in 1936 ten feet higher than present level.
Approaches: Treated gravel.
Water Main located on top of bridge flooring.

Plan
Scale 1"=30'

Profile
Scales - Horiz. 1"=30'
Vert. 1"=10'

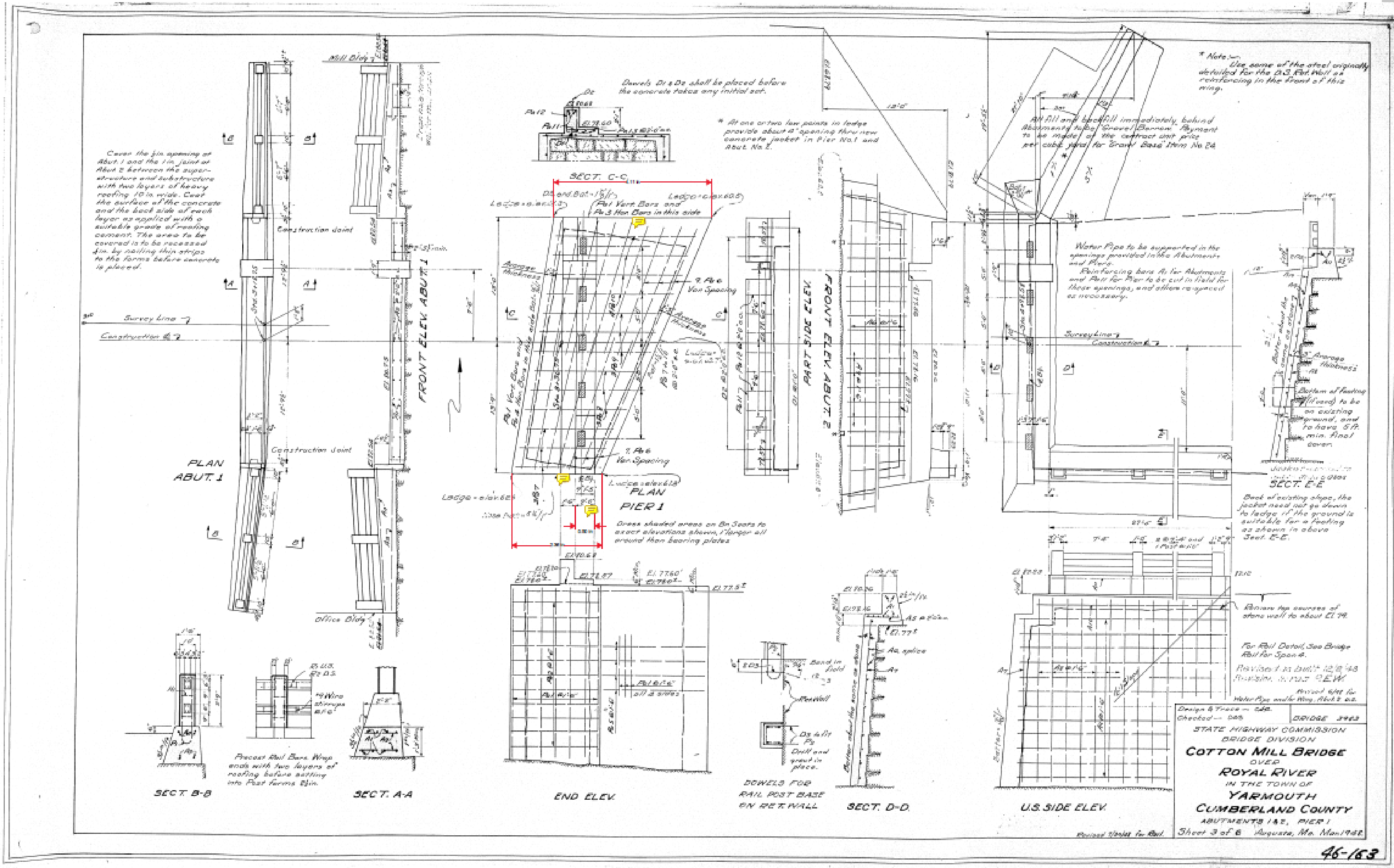
Revised as built 12/6/48
Revisions in red P.E.W.

Survey W.B.
Plot I.J.R.
Bridge 3088

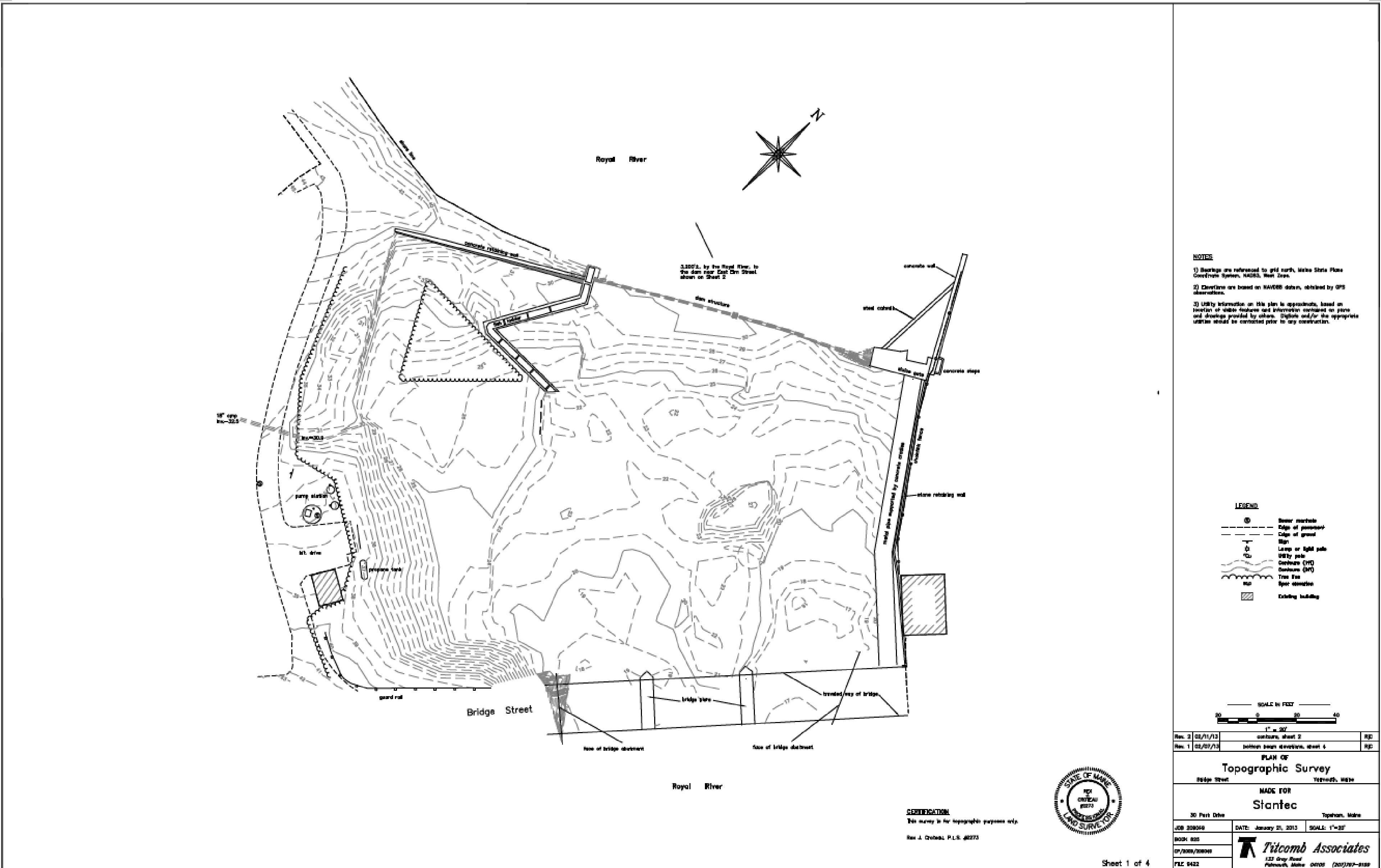
State Highway Commission
Bridge Division
COTTON MILL BRIDGE
over
ROYAL RIVER
in the town of
YARMOUTH
CUMBERLAND COUNTY
Survey Plan
Sheet 1 of 6 Augusta, Me. Feb. 1947

46-161

COTTON MILL BRIDGE – BRIDGE ST



TOPOGRAPHIC SURVEY BRIDGE STREET DAM



MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	ROYAL RIVER	Location	1 MI S I95
Bridge Number	3800	Route Number	0001X
Feature On	US 1	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	58	Bridge or Minor Span	Bridge on State Highway

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	83	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	8 - Very Good Condition (no problems noted)	Culvert Condition	N - Not Applicable
Superstructure Condition	7 - Good Condition (some minor problems)	Channel Condition	7 - Bank protection needs minor repairs
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	7 - Better than present minimum criteria
Year Built	1948	Annual Average Daily Traffic	5640

INSPECTION AND APPRAISAL

Date of Inspection	03/19/21	Federal Sufficiency Rating	98

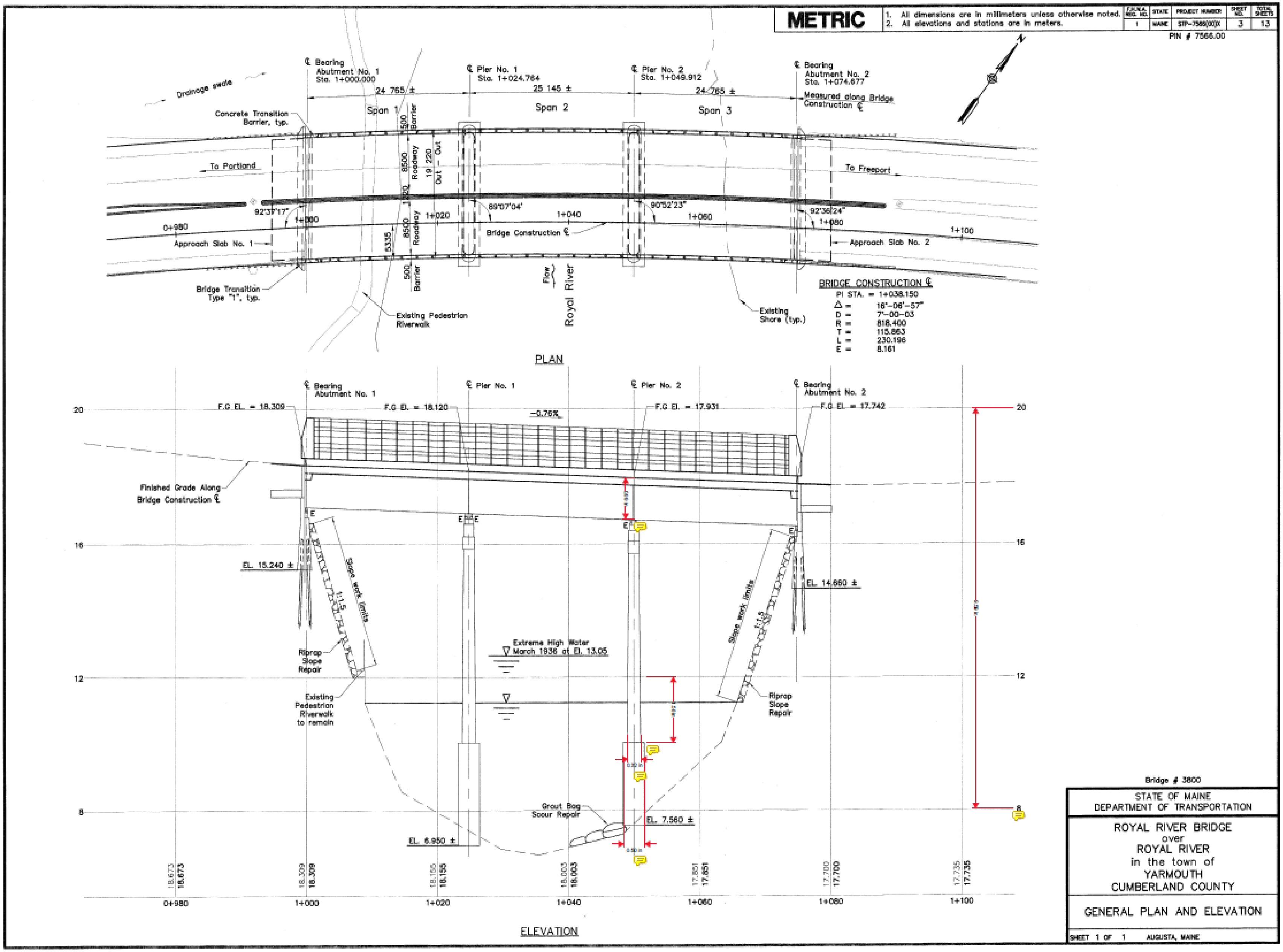
STRUCTURE TYPE AND MATERIAL

Span Material	Steel	Span Type	Stringer/Multi-beam or Girder
Number of Main Spans	3		

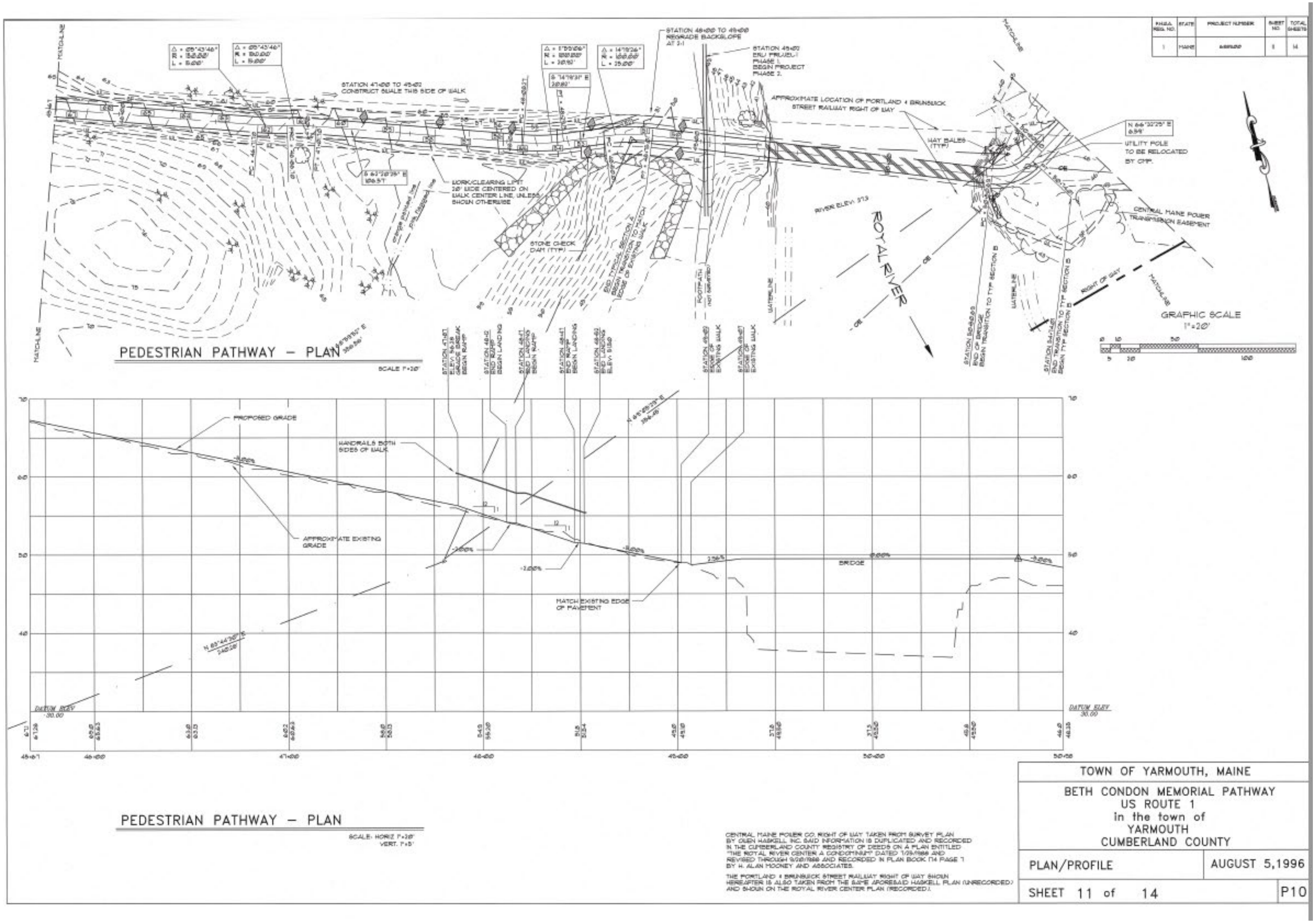
LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

US ROUTE 1


METRIC
1. All dimensions are in millimeters unless otherwise noted.
2. All elevations and stations are in meters.
STATE MAINE
PROJECT NUMBER STP-7566(00)X
SHEET NO. 3
TOTAL SHEETS 13
PIN # 7566.00
N
Drainage swale
℄ Bearing Abutment No. 1 Sta. 1+000.000
℄ Pier No. 1 Sta. 1+024.764
℄ Pier No. 2 Sta. 1+049.912
℄ Bearing Abutment No. 2 Sta. 1+074.677
24 765 ±
25 145 ±
24 765 ±
Measured along Bridge Construction ℄
Span 1
Span 2
Span 3
Concrete Transition Barrier, typ.
500 Barrier
8500 Roadway
19 220 Out - Out
1300
8500 Roadway
500 Barrier
5335
To Portland
To Freeport
92°37'17"
89°07'04"
90°52'23"
92°36'24"
0+980
1+000
1+020
1+040
1+060
1+080
1+100
Bridge Construction ℄
Approach Slab No. 1
Approach Slab No. 2
Bridge Transition Type "1", typ.
Existing Pedestrian Riverwalk
Flow
Royal River
Existing Shore (typ.)
BRIDGE CONSTRUCTION ℄
PI STA. = 1+038.150
Δ = 16°-06'-57"
D = 7°-00-03
R = 818.400
T = 115.863
L = 230.196
E = 8.161
PLAN
℄ Bearing Abutment No. 1
℄ Pier No. 1
℄ Pier No. 2
℄ Bearing Abutment No. 2
F.G. EL. = 18.309
F.G. EL. = 18.120
-0.76%
F.G. EL. = 17.931
F.G. EL. = 17.742
20
16
12
8
Finished Grade Along Bridge Construction ℄
E
EL. 15.240 ±
EL. 14.660 ±
Slope work limits
1:1.5
Riprap Slope Repair
Extreme High Water March 1936 at El. 13.05
Existing Pedestrian Riverwalk to remain
Grout Bag Scour Repair
EL. 7.560 ±
EL. 6.950 ±
18.673
18.309
18.155
18.003
17.851
17.700
17.735
ELEVATION
Bridge # 3800
STATE OF MAINE DEPARTMENT OF TRANSPORTATION
ROYAL RIVER BRIDGE over ROYAL RIVER in the town of YARMOUTH CUMBERLAND COUNTY
GENERAL PLAN AND ELEVATION
SHEET 1 OF 1
AUGUSTA, MAINE
PLANS
TWM 10/99
SAM RMH 10/99
RRYOGPL.DWG

BETH CONDON MEMORIAL PATHWAY



CENTRAL MAINE POWER CO. RIGHT OF WAY TAKEN FROM SURVEY PLAN BY OWEN HASKELL INC. SAID INFORMATION IS DUPLICATED AND RECORDED IN THE CUMBERLAND COUNTY REGISTRY OF DEEDS ON A PLAN ENTITLED "THE ROYAL RIVER CENTER A CONDOMINIUM" DATED 1/29/1988 AND REVISED THROUGH 9/20/1988 AND RECORDED IN PLAN BOOK 174 PAGE 7 BY H. ALAN MOONEY AND ASSOCIATES.

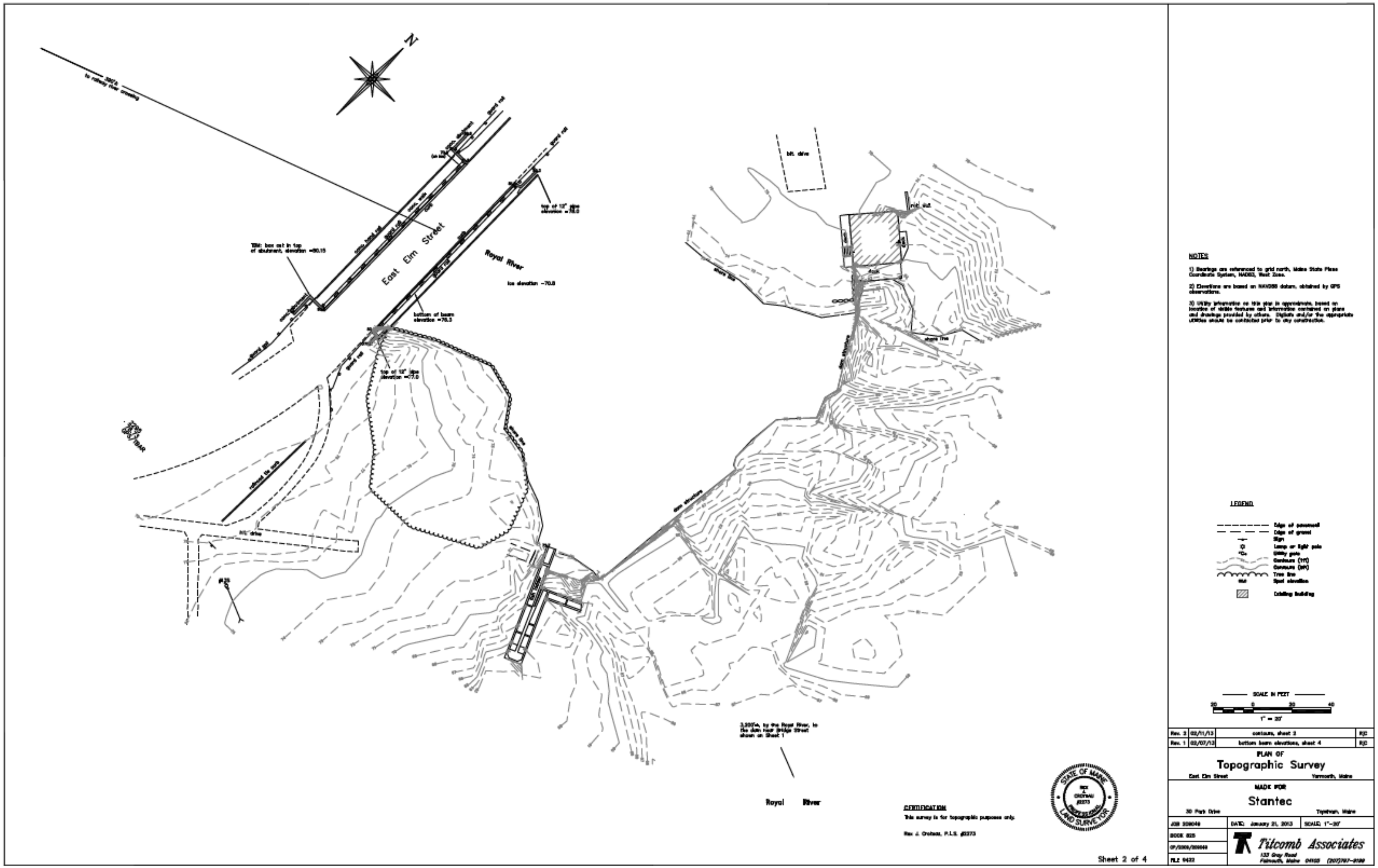
THE PORTLAND & BRUNSWICK STREET RAILWAY RIGHT OF WAY SHOWN HEREAFTER IS ALSO TAKEN FROM THE SAME AFORESAID HASKELL PLAN (UNRECORDED) AND SHOWN ON THE ROYAL RIVER CENTER PLAN (RECORDED).

TOWN OF YARMOUTH, MAINE

BETH CONDON MEMORIAL PATHWAY
US ROUTE 1
in the town of
YARMOUTH
CUMBERLAND COUNTY

PLAN/PROFILE	AUGUST 5,1996
SHEET 11 of 14	P10

TOPOGRAPHIC SURVEY EAST ELM STREET DAM



NOTES:

1) Bearings are referenced to grid north, Maine State Plane Coordinate System, NAD83, West Zone.

2) Elevations are based on NAVD88 datum, obtained by GPS observations.

3) Utility information on this plan is approximate, based on location of visible features and information contained on plans and drawings provided by others. Digsafe and/or the appropriate utilities should be contacted prior to any construction.

LEGEND

– – – – – –	Edge of pavement
— — — —	Edge of gravel
┷	Sign
☼	Lamp or light pole
⊙	Utility pole
∼ ∼ ∼	Contours (1ft)
∼∼∼	Contours (5ft)
⌒⌒⌒⌒	Tree line
×0.0	Spot elevation
▨	Existing building

CERTIFICATION

This survey is for topographic purposes only.

Rex J. Croteau, P.L.S. #2273

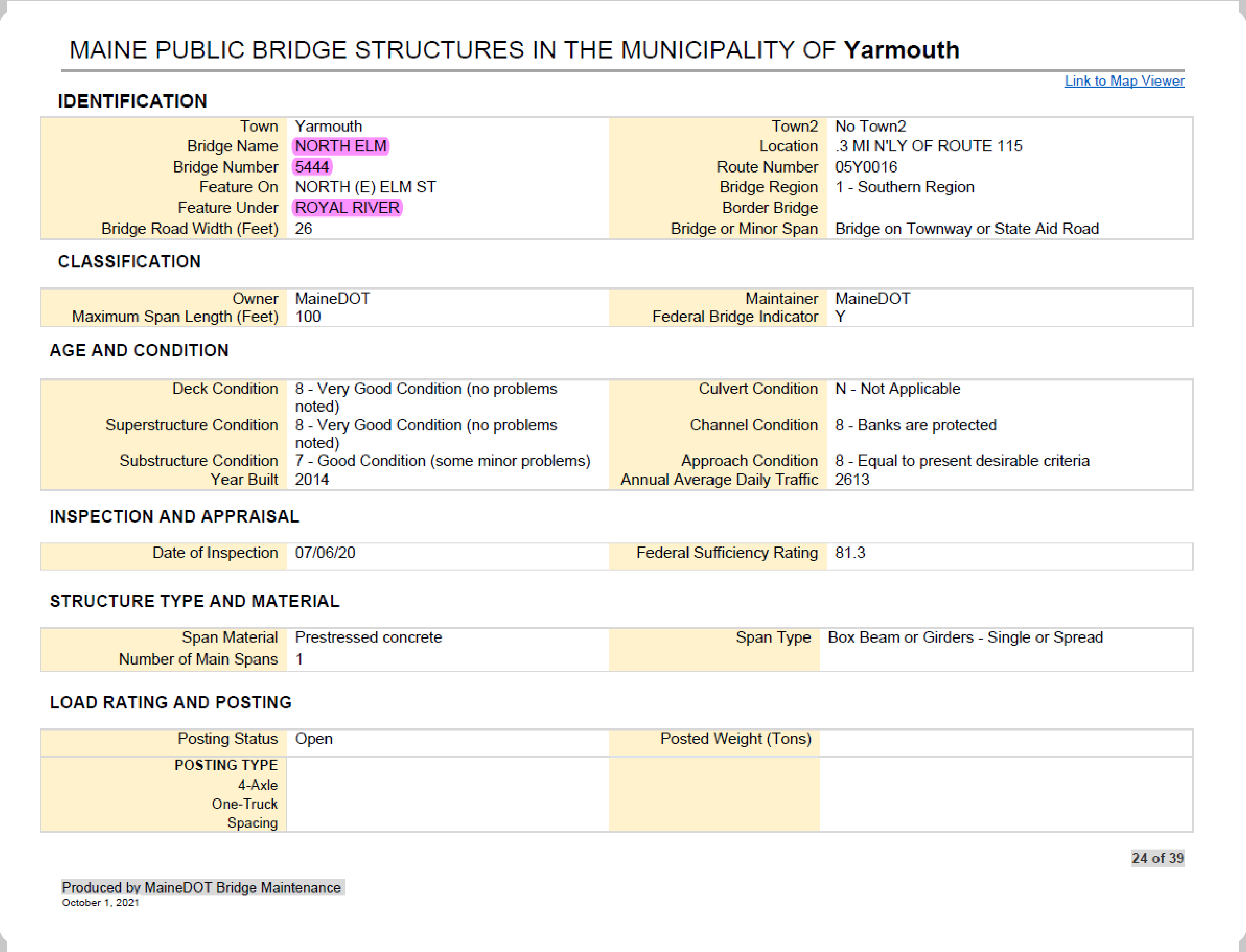
Rev. 2	02/11/13	contours, sheet 2	RJC
Rev. 1	02/07/13	bottom beam elevations, sheet 4	RJC

PLAN OF
Topographic Survey
East Elm Street Yarmouth, Maine

MADE FOR
Stantec
30 Park Drive Topsham, Maine

JOB 209046
DATE: January 21, 2013
SCALE: 1"=20'
BOOK 825
CP/2009/209046
FILE 9432

Titcomb Associates
133 Gray Road
Falmouth, Maine 04105 (207)797-9199



MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	NORTH ELM	Location	.3 MI N'LY OF ROUTE 115
Bridge Number	5444	Route Number	05Y0016
Feature On	NORTH (E) ELM ST	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	26	Bridge or Minor Span	Bridge on Townway or State Aid Road

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	100	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	8 - Very Good Condition (no problems noted)	Culvert Condition	N - Not Applicable
Superstructure Condition	8 - Very Good Condition (no problems noted)	Channel Condition	8 - Banks are protected
Substructure Condition	7 - Good Condition (some minor problems)	Approach Condition	8 - Equal to present desirable criteria
Year Built	2014	Annual Average Daily Traffic	2613

INSPECTION AND APPRAISAL

Date of Inspection	07/06/20	Federal Sufficiency Rating	81.3

STRUCTURE TYPE AND MATERIAL

Span Material	Prestressed concrete	Span Type	Box Beam or Girders - Single or Spread
Number of Main Spans	1		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	Yarmouth	Town2	No Town2
Bridge Name	HODSON	Location	0.3 MI NE RT 115
Bridge Number	0338	Route Number	05Y0016
Feature On	EAST ELM STREET	Bridge Region	1 - Southern Region
Feature Under	ROYAL RV. AUX. CHNL.	Border Bridge	
Bridge Road Width (Feet)	23	Bridge or Minor Span	Minor Span on Town Way

CLASSIFICATION

Owner	Municipality	Maintainer	Municipality
Maximum Span Length (Feet)	14	Federal Bridge Indicator	N

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	6 - Satisfactory Condition (minor deterioration)	Channel Condition	8 - Banks are protected
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	6 - Equal to present minimum criteria
Year Built	1930	Annual Average Daily Traffic	2896

INSPECTION AND APPRAISAL

Date of Inspection	10/10/19	Federal Sufficiency Rating	65.8

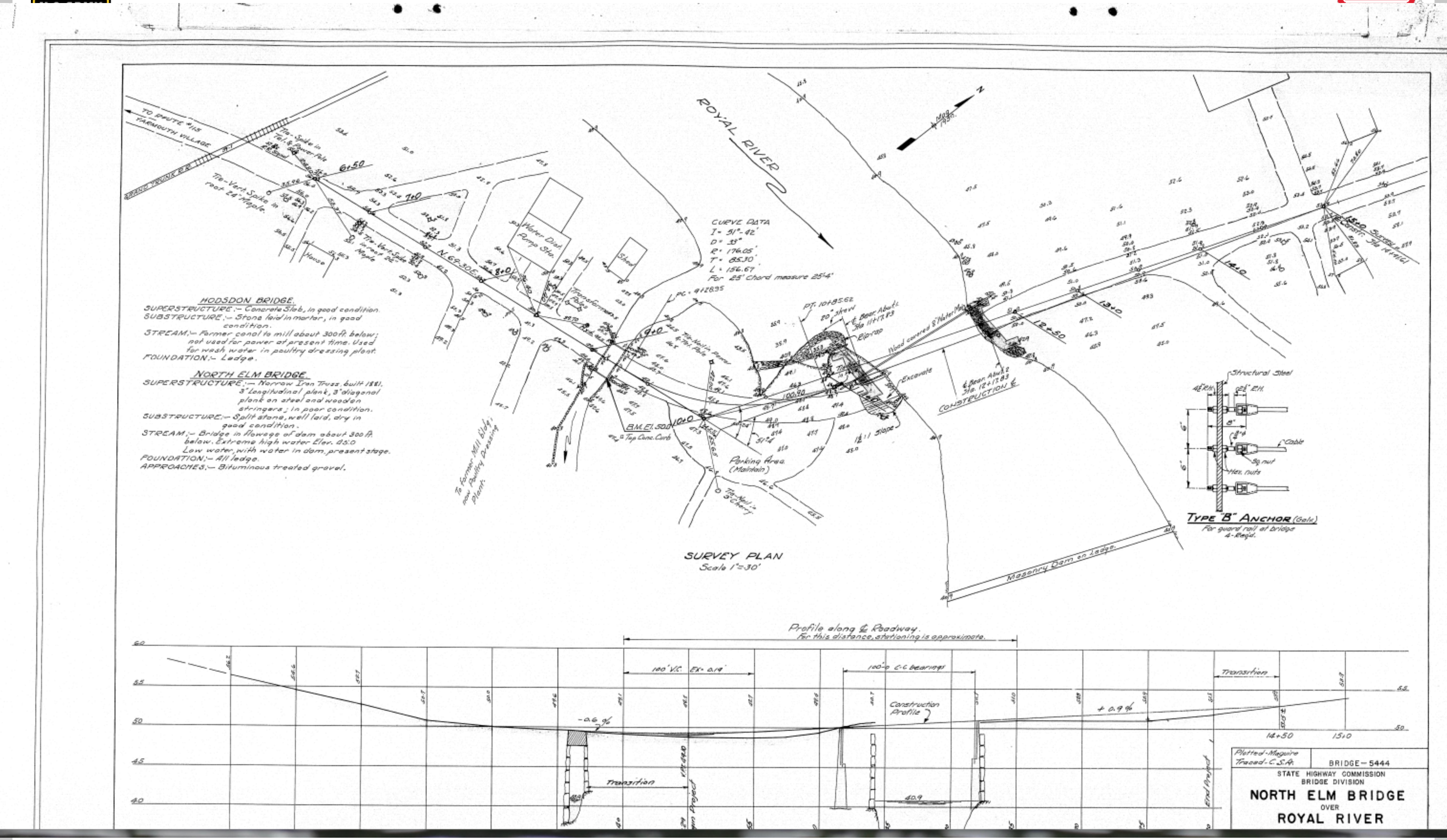
STRUCTURE TYPE AND MATERIAL

Span Material	Concrete	Span Type	Slab
Number of Main Spans	1		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

EAST ELM STREET BRIDGE & FOUNDRY CHANNEL CULVERT



HODSDON BRIDGE.

SUPERSTRUCTURE:– Concrete Slab, in good condition.
SUBSTRUCTURE;– Stone laid in mortar, in good condition.
STREAM;– Former canal to mill about 300ft. below; not used for power at present time. Used for wash water in poultry dressing plant.
FOUNDATION;– Ledge.

NORTH ELM BRIDGE.

SUPERSTRUCTURE;– Narrow Iron Truss, built 1881, 3" Longitudinal plank, 3" diagonal plank on steel and wooden stringers; in poor condition.
SUBSTRUCTURE;– Split stone, well laid, dry in good condition.
STREAM;– Bridge in flowage of dam about 300 ft. below. Extreme high water Elev. 45:0 Low water, with water in dam, present stage.
FOUNDATION;– All ledge.
APPROACHES;– Bituminous treated gravel.

CURVE DATA
I = 51°-42'
D = 33°
R = 176.05'
T = 85.30'
L = 156.67'
For 25' chord measure 25'-4"

SURVEY PLAN
Scale 1"=30'

TYPE "B" ANCHOR (Galv.)
For guard rail at bridge
4-Req'd.

Profile along ℄ Roadway.
For this distance, stationing is approximate.

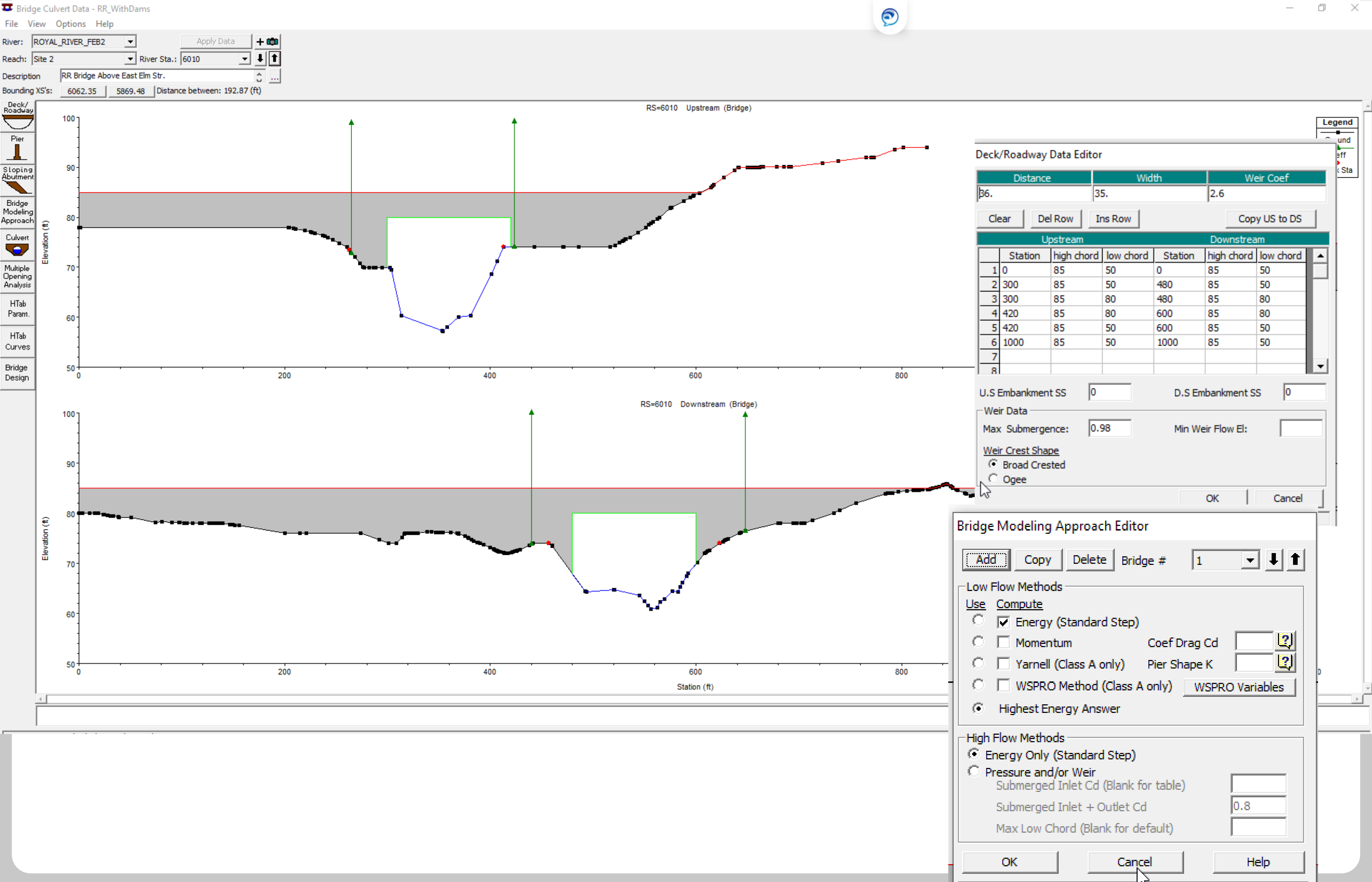
Plotted-Maguire
Traced-C.S.A.

BRIDGE – 5444

STATE HIGHWAY COMMISSION
BRIDGE DIVISION

NORTH ELM BRIDGE
OVER
ROYAL RIVER

GRAND TRUNK RAILROAD BRIDGE – NO AS-BUILTS - STANTEC 2013 HEC-RAS



Bridge Culvert Data - RR_WithDams

River: ROYAL_RIVER_FEB2

Reach: Site 2

River Sta.: 6010

Description: RR Bridge Above East Elm Str.

Bounding XS's: 6062.35 5869.48 Distance between: 192.87 (ft)

Deck/Roadway Data Editor

Distance	Width	Weir Coef
36.	35.	2.6

	Upstream			Downstream		
	Station	high chord	low chord	Station	high chord	low chord
1	0	85	50	0	85	50
2	300	85	50	480	85	50
3	300	85	80	480	85	80
4	420	85	80	600	85	80
5	420	85	50	600	85	50
6	1000	85	50	1000	85	50
7						
8						

U.S Embankment SS: 0

D.S Embankment SS: 0

Weir Data

Max Submergence: 0.98

Min Weir Flow El:

Weir Crest Shape

● Broad Crested

○ Ogee

Bridge Modeling Approach Editor

Bridge #: 1

Low Flow Methods

Use Compute

○ ☑ Energy (Standard Step)

○ ☐ Momentum — Coef Drag Cd:

○ ☐ Yarnell (Class A only) — Pier Shape K:

○ ☐ WSPRO Method (Class A only)

● Highest Energy Answer

High Flow Methods

● Energy Only (Standard Step)

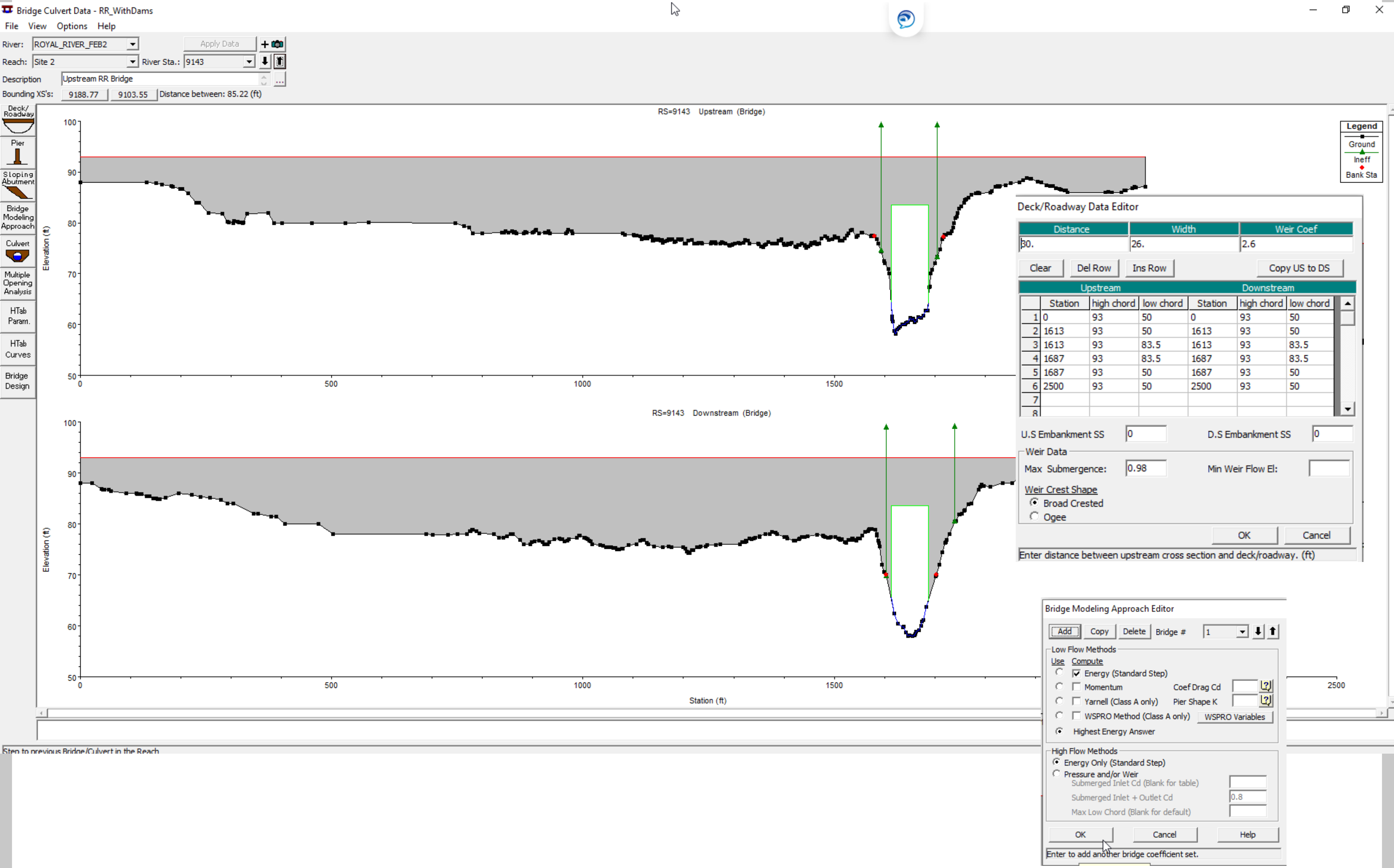
○ Pressure and/or Weir

Submerged Inlet Cd (Blank for table):

Submerged Inlet + Outlet Cd: 0.8

Max Low Chord (Blank for default):

MAINE CENTRAL RAILROAD BRIDGE – NO AS-BUILTS - STANTEC 2013 HEC-RAS



River: ROYAL_RIVER_FEB2

Reach: Site 2 River Sta.: 9143

Description: Upstream RR Bridge

Bounding XS's: 9188.77 9103.55 Distance between: 85.22 (ft)

Step to previous Bridge/Culvert in the Reach

Deck/Roadway Data Editor

Distance	Width	Weir Coef
30.	26.	2.6

Clear · Del Row · Ins Row · Copy US to DS

	Upstream			Downstream		
	Station	high chord	low chord	Station	high chord	low chord
1	0	93	50	0	93	50
2	1613	93	50	1613	93	50
3	1613	93	83.5	1613	93	83.5
4	1687	93	83.5	1687	93	83.5
5	1687	93	50	1687	93	50
6	2500	93	50	2500	93	50
7						
8						

U.S Embankment SS: 0 D.S Embankment SS: 0

Weir Data

Max Submergence: 0.98 Min Weir Flow El:

Weir Crest Shape

● Broad Crested

○ Ogee

OK · Cancel

Enter distance between upstream cross section and deck/roadway. (ft)

Bridge Modeling Approach Editor

Add · Copy · Delete · Bridge # 1

Low Flow Methods

Use Compute

○ ☑ Energy (Standard Step)

○ ☐ Momentum Coef Drag Cd

○ ☐ Yarnell (Class A only) Pier Shape K

○ ☐ WSPRO Method (Class A only) WSPRO Variables

● Highest Energy Answer

High Flow Methods

● Energy Only (Standard Step)

○ Pressure and/or Weir

Submerged Inlet Cd (Blank for table)

Submerged Inlet + Outlet Cd: 0.8

Max Low Chord (Blank for default)

OK · Cancel · Help

Enter to add another bridge coefficient set.

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **North Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	North Yarmouth	Town2	No Town2
Bridge Name	DUNNS	Location	1.5 MI SW'LY POWNAL T.L.
Bridge Number	5535	Route Number	0009X
Feature On	9	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	24	Bridge or Minor Span	Bridge on Townway or State Aid Road

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	25	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	6 - Satisfactory Condition (minor deterioration)	Channel Condition	6 - Bank slump. widespread minor damage
Substructure Condition	6 - Satisfactory Condition (minor deterioration)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1953	Annual Average Daily Traffic	1591

INSPECTION AND APPRAISAL

Date of Inspection	06/08/20	Federal Sufficiency Rating	66.9

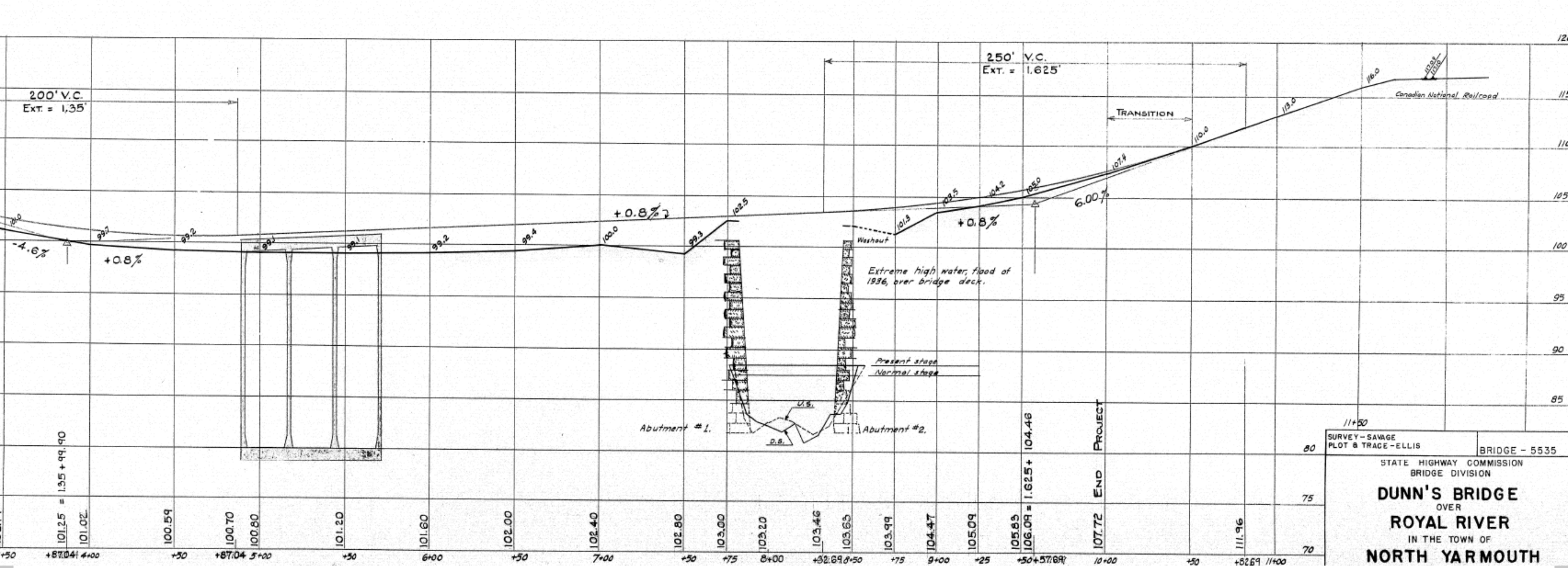
STRUCTURE TYPE AND MATERIAL

Span Material	Concrete continuous	Span Type	Frame (except frame culverts)
Number of Main Spans	3		

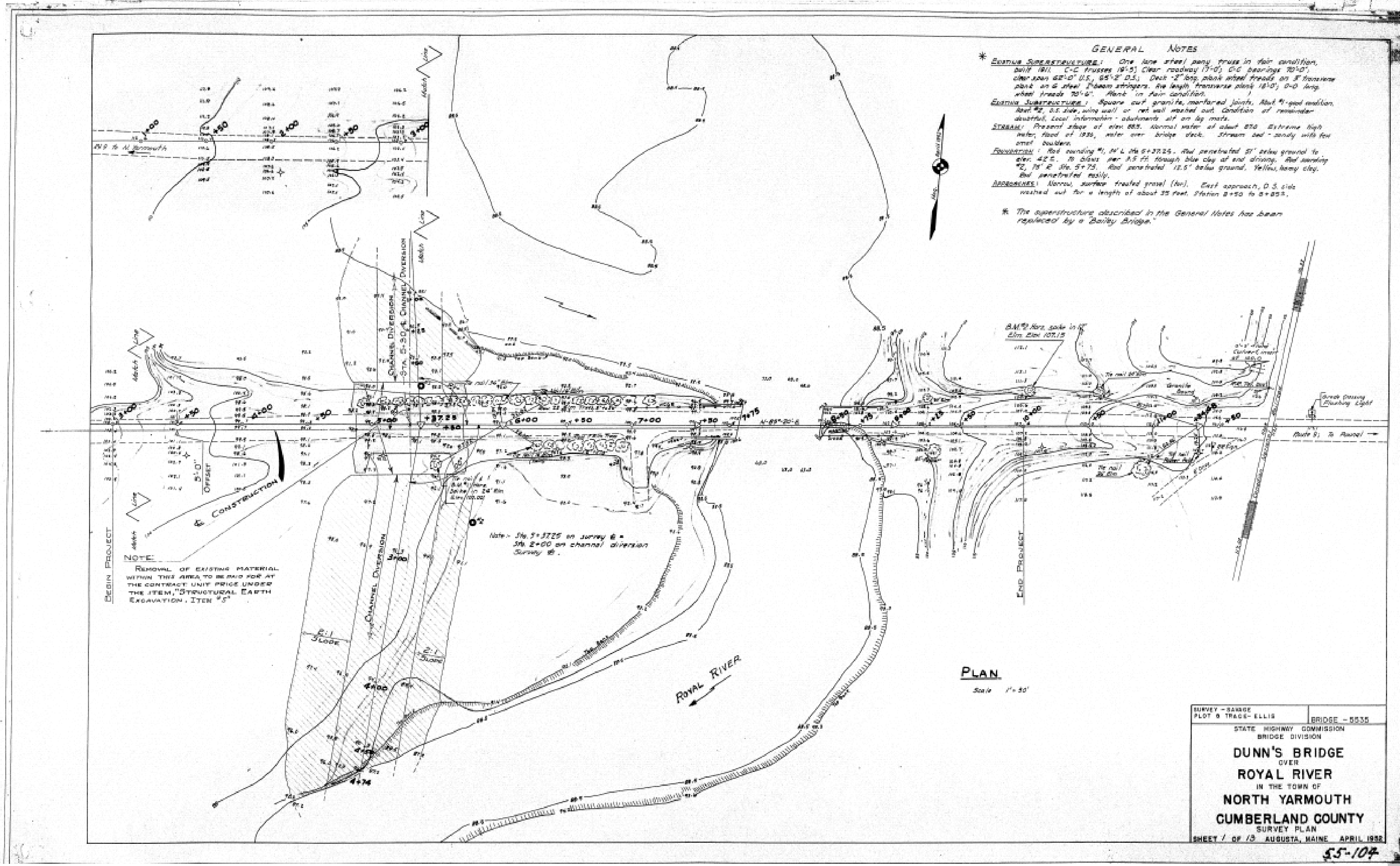
LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

MEMORIAL HIGHWAY / STATE ROUTE 9 / DUNNS BRIDGE



MEMORIAL HIGHWAY / STATE ROUTE 9 / DUNNS BRIDGE



GENERAL NOTES

* EXISTING SUPERSTRUCTURE: One lane steel pony truss in fair condition, built 1911. C-C trusses 16'-5"; Clear roadway 17'-0"; C-C bearings 70'-0", clear span 62'-0" U.S., 65'-2" D.S.; Deck 2" long. plank wheel treads on 3" transverse plank on 6 steel I-beam stringers. Ave length transverse plank 18'-0"; O-O long. wheel treads 70'-6". Plank in fair condition.

EXISTING SUBSTRUCTURE: Square cut granite, mortared joints. Abut. #1 - good condition. Abut. #2, D.S. side, wing wall or ret. wall washed out. Condition of remainder doubtful. Local information - abutments sit on log mats.

STREAM: Present stage at elev. 88.5. Normal water at about 87.0. Extreme high water, flood of 1936, water over bridge deck. Stream bed - sandy with few small boulders.

FOUNDATION: Rod sounding #1, 14' L Sta. 5+37.24. Rod penetrated 51' below ground to elev. 42.5. 18 blows per 9.5 ft. through blue clay at end driving. Rod sounding #2, 15' R Sta. 5+75. Rod penetrated 12.5' below ground. Yellow, loamy clay. Rod penetrated easily.

APPROACHES: Narrow, surface treated gravel (tar). East approach, D.S. side washed out for a length of about 35 feet. Station 8+50 to 8+85±.

* The superstructure described in the General Notes has been replaced by a "Bailey Bridge."

NOTE:
Removal of existing material within this area to be paid for at the contract unit price under the item, "Structural Earth Excavation, Item #5"

Note:- Sta. 5+3725 on survey ℄ = Sta. 2+00 on channel diversion Survey ℄.

SURVEY - SAVAGE
PLOT & TRACE - ELLIS

BRIDGE - 5535

STATE HIGHWAY COMMISSION
BRIDGE DIVISION
DUNN'S BRIDGE
OVER
ROYAL RIVER
IN THE TOWN OF
NORTH YARMOUTH
CUMBERLAND COUNTY
SURVEY PLAN
SHEET 1 OF 13 AUGUSTA, MAINE APRIL 1952

55-104

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **North Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	North Yarmouth	Town2	No Town2
Bridge Name	HAYS	Location	1.7 MI N JCT 115
Bridge Number	5048	Route Number	0231X
Feature On	231	Bridge Region	1 - Southern Region
Feature Under	ROYAL RIVER	Border Bridge	
Bridge Road Width (Feet)	21	Bridge or Minor Span	Bridge on Townway or State Aid Road

CLASSIFICATION

Owner	MaineDOT	Maintainer	MaineDOT
Maximum Span Length (Feet)	45	Federal Bridge Indicator	Y

AGE AND CONDITION

Deck Condition	6 - Satisfactory Condition (minor deterioration)	Culvert Condition	N - Not Applicable
Superstructure Condition	6 - Satisfactory Condition (minor deterioration)	Channel Condition	6 - Bank slump. widespread minor damage
Substructure Condition	5 - Fair Condition (minor section loss)	Approach Condition	8 - Equal to present desirable criteria
Year Built	1926	Annual Average Daily Traffic	1221

INSPECTION AND APPRAISAL

Date of Inspection	03/16/21	Federal Sufficiency Rating	40.6

STRUCTURE TYPE AND MATERIAL

Span Material	Concrete	Span Type	Tee Beam
Number of Main Spans	1		

LOAD RATING AND POSTING

Posting Status	Open	Posted Weight (Tons)	
POSTING TYPE			
4-Axle			
One-Truck			
Spacing			

MAINE PUBLIC BRIDGE STRUCTURES IN THE MUNICIPALITY OF **North Yarmouth**

Link to Map Viewer

IDENTIFICATION

Town	North Yarmouth
Bridge Name	HAYS MILL
Bridge Number	6156
Feature On	MILL RD
Feature Under	ROYAL RIVER
Bridge Road Width (Feet)	28

Town2	No Town2
Location	1.2 MI W JCT 231
Route Number	0500404

CLASSIFICATION

Owner	MaineDOT
Maximum Span Length (Feet)	70

AGE AND CONDITION

Deck Condition	7 - Good Condition (some m
Superstructure Condition	6 - Satisfactory Condition (m deterioration)
Substructure Condition	6 - Satisfactory Condition (m deterioration)
Year Built	1969

INSPECTION AND APPRAISAL

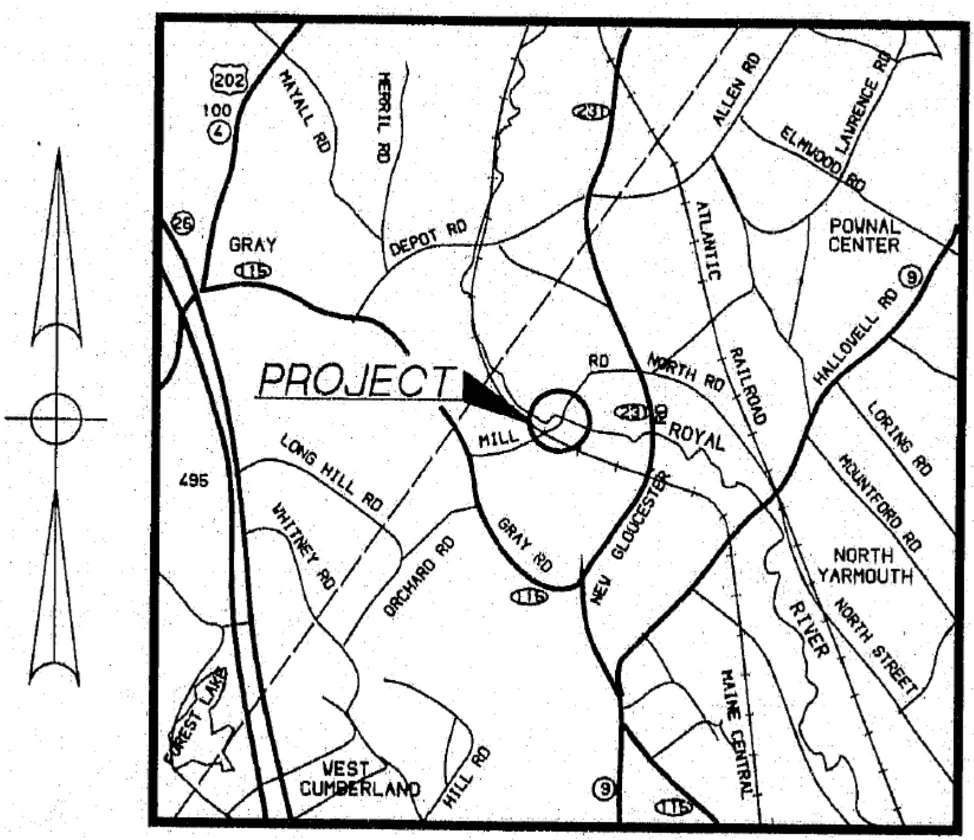
Date of Inspection	06/08/20

STRUCTURE TYPE AND MATERIAL

Span Material	Steel
Number of Main Spans	1

LOAD RATING AND POSTING

Posting Status	Open
POSTING TYPE 4-Axle One-Truck Spacing	



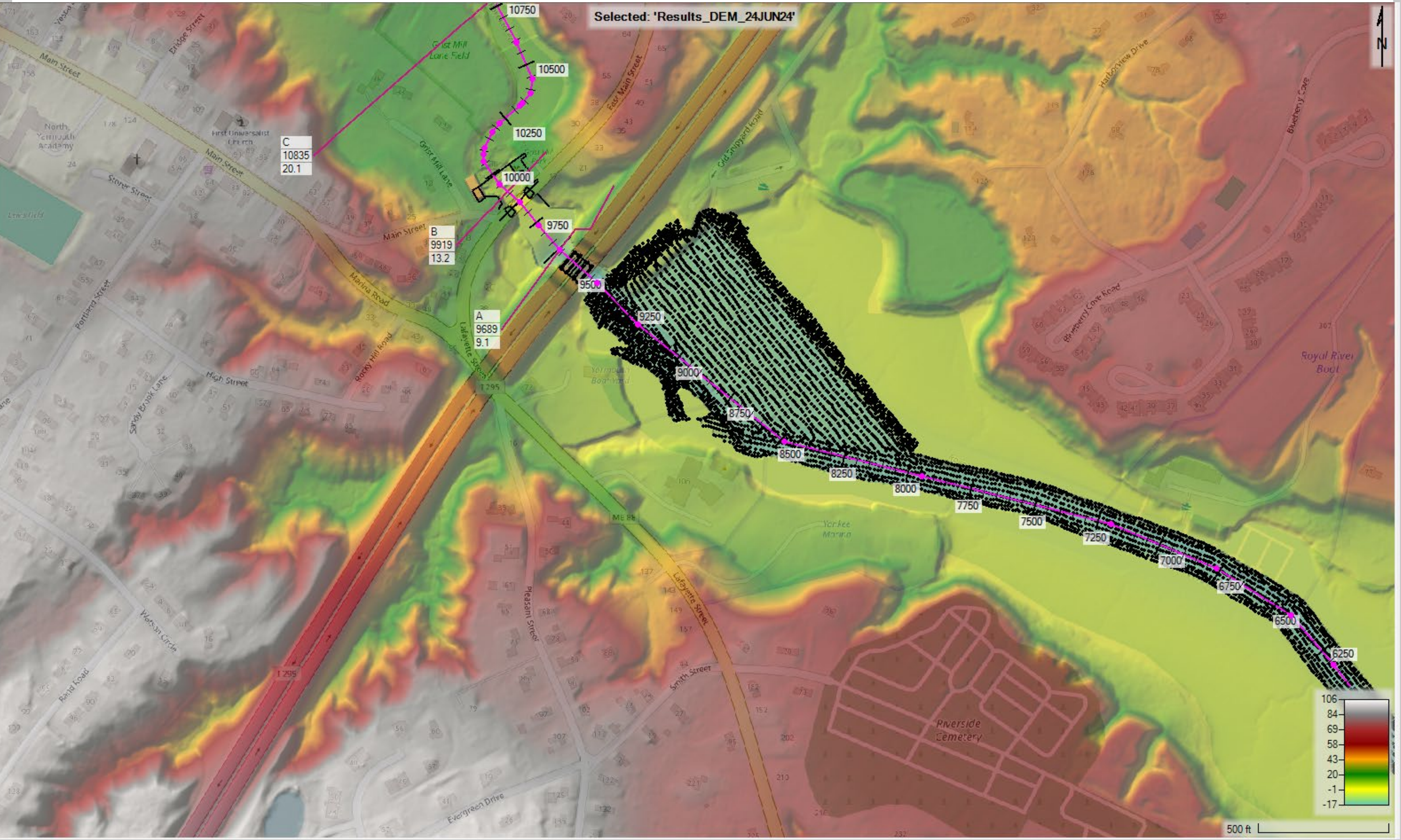
LOCATION MAP

1 0 1 2
Scale in Miles

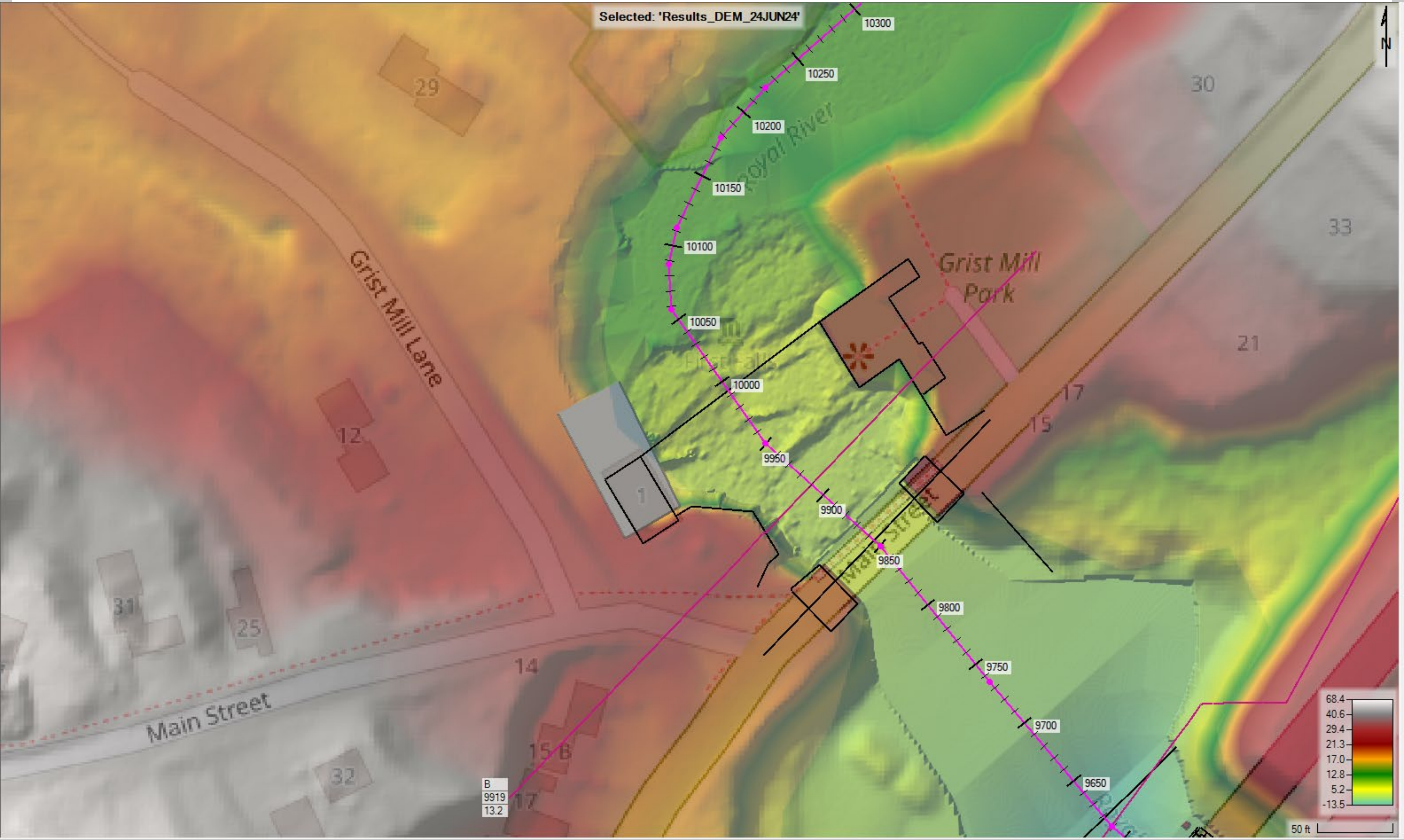
Produced by MaineDOT Bridge Maintenance
October 1, 2021

ROYAL RIVER - TERRAIN MODEL

HARBOR TO LOWER FALLS OVERVIEW

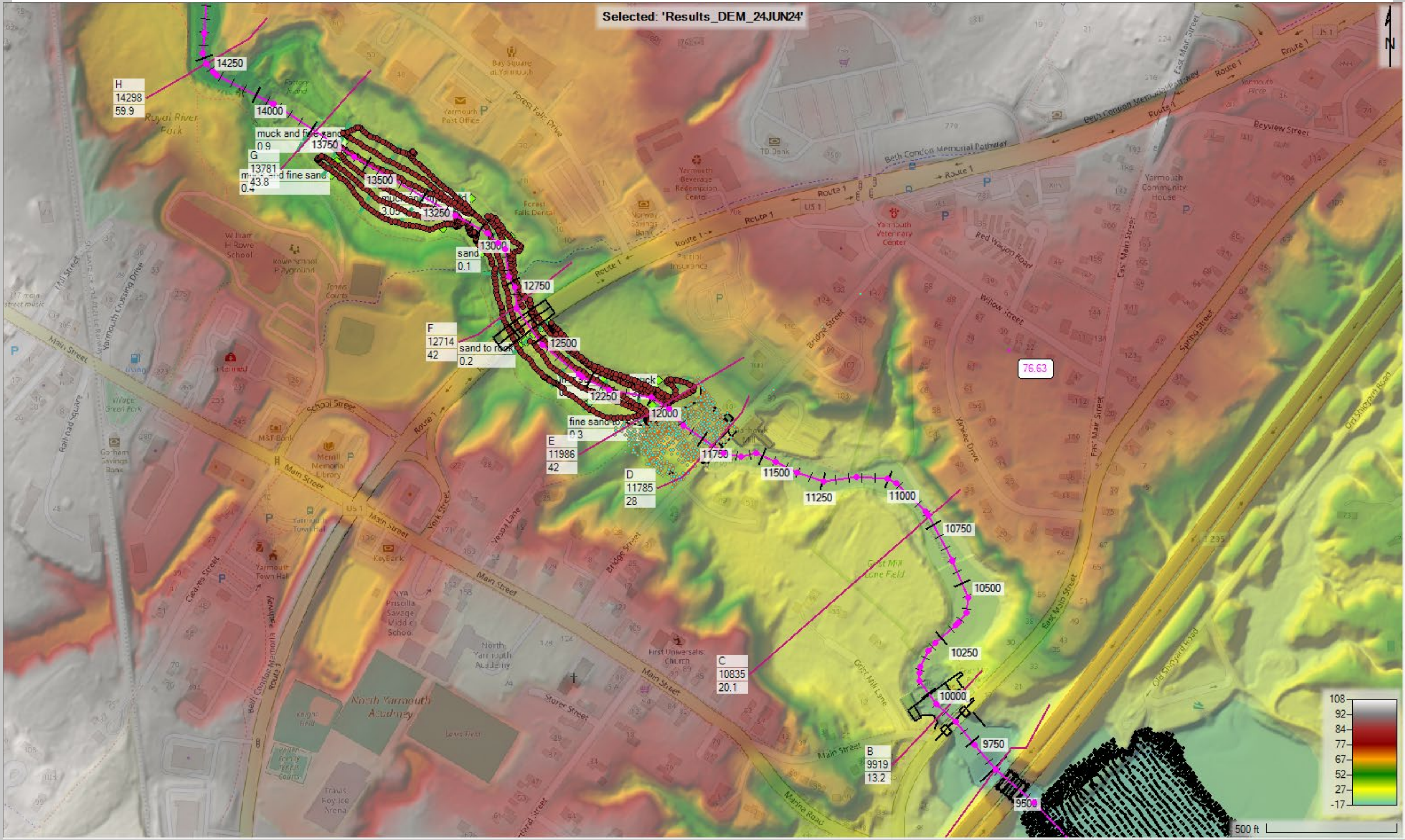


ROYAL RIVER - TERRAIN MODEL
LOWER FALLS

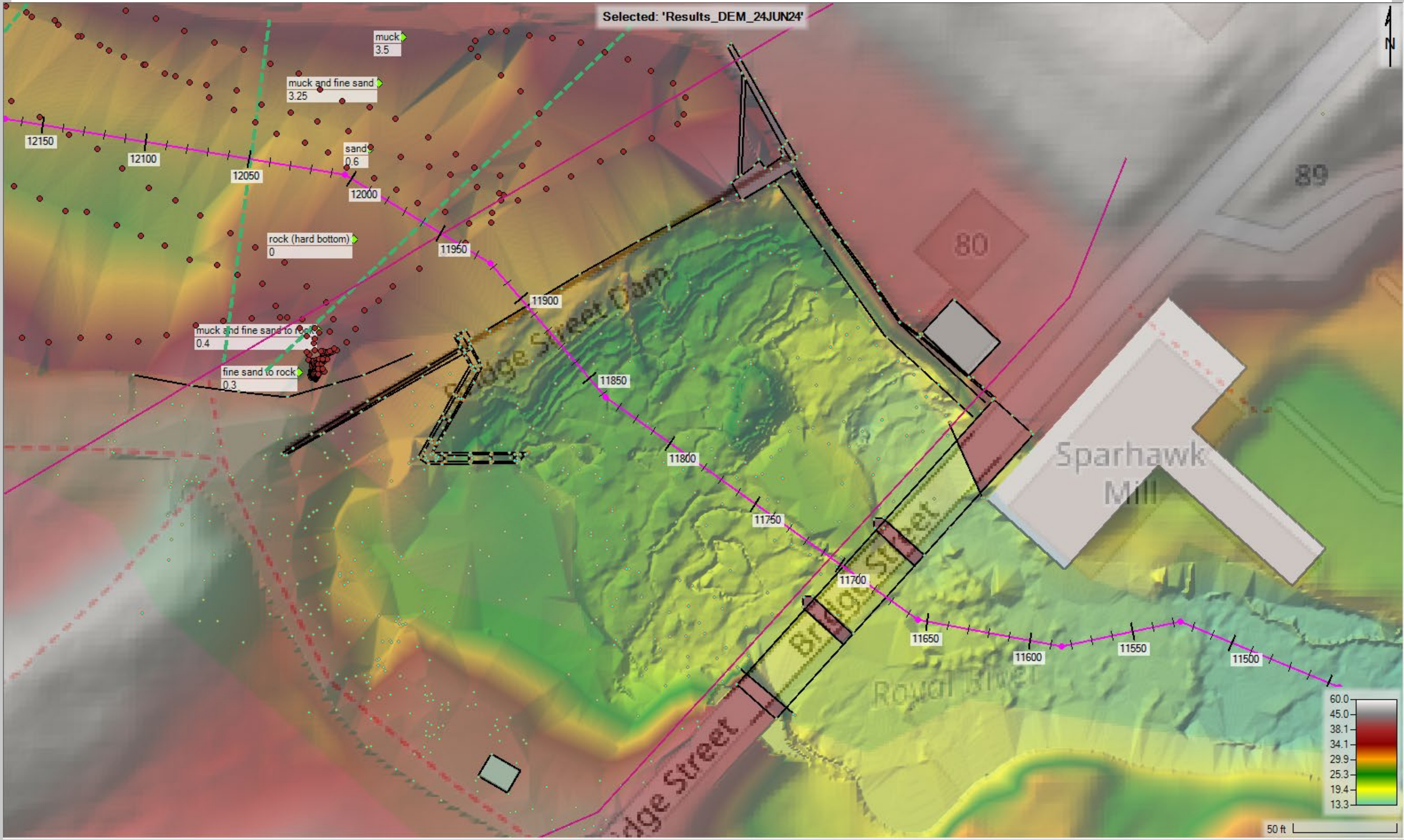


ROYAL RIVER - TERRAIN MODEL

LOWER FALLS TO MIDDLE FALLS OVERVIEW

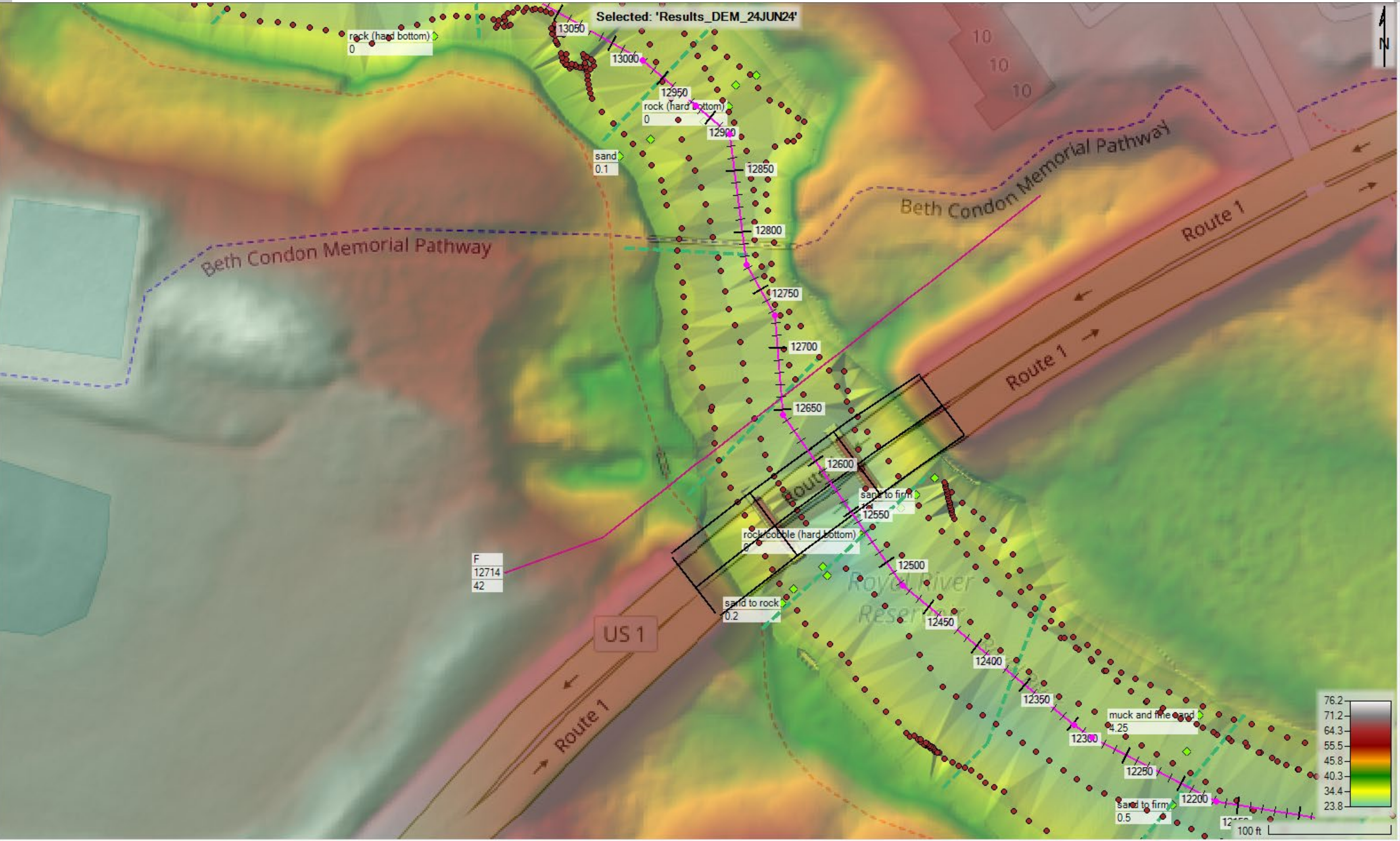


ROYAL RIVER - TERRAIN MODEL
BRIDGE STREET DAM

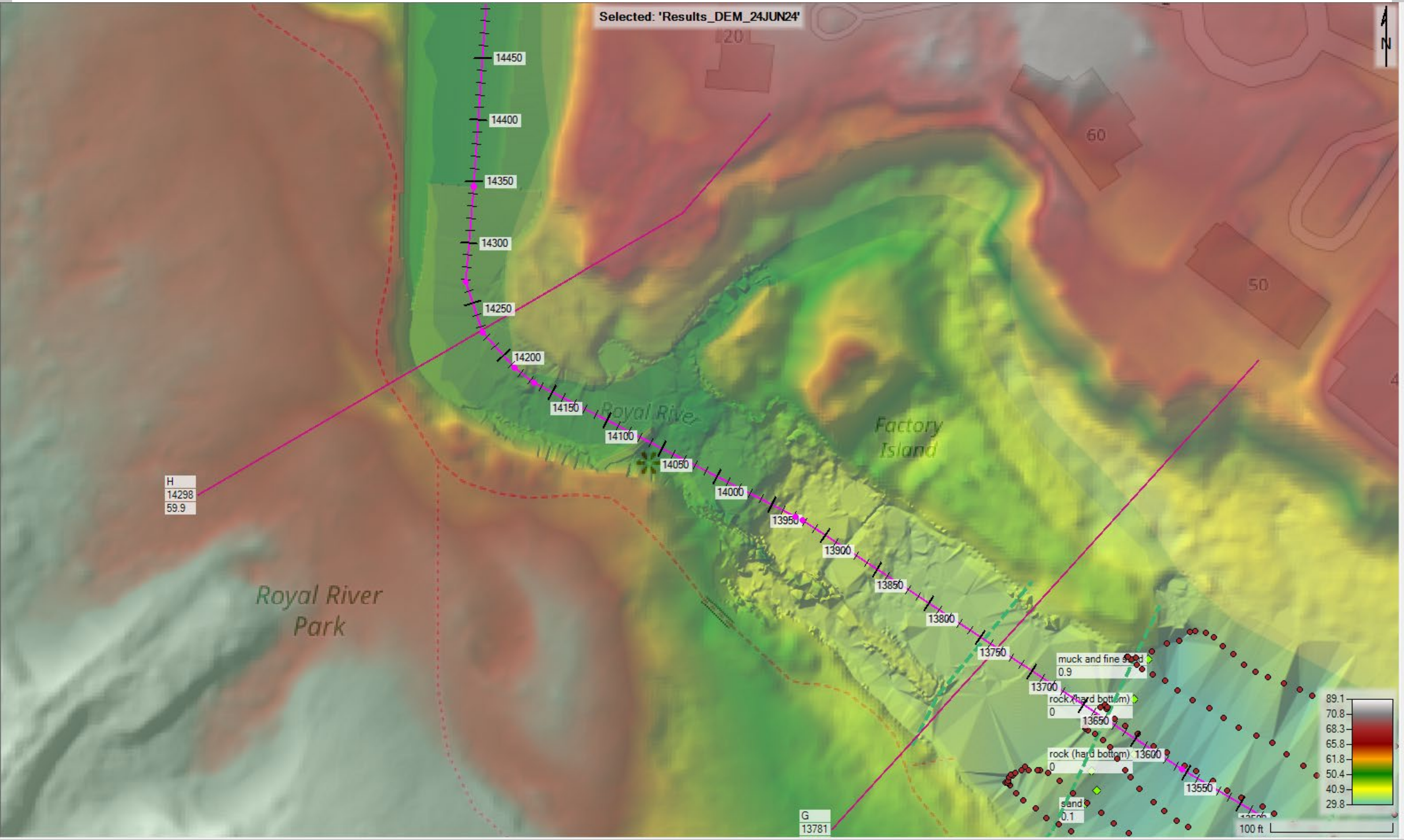


ROYAL RIVER - TERRAIN MODEL

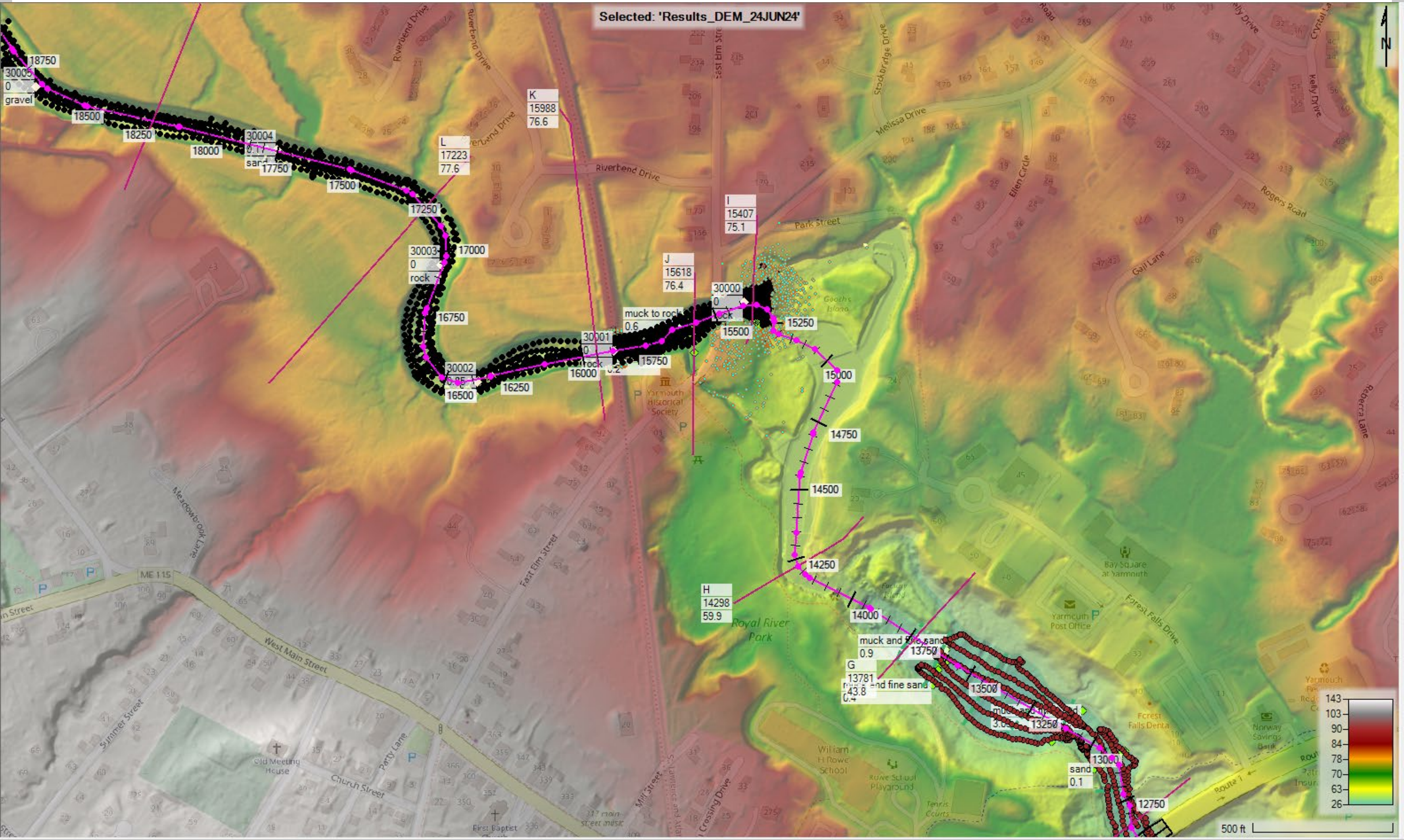
US ROUTE 1 & BETH CONDON FOOTBRIDGE



ROYAL RIVER - TERRAIN MODEL
MIDDLE FALLS

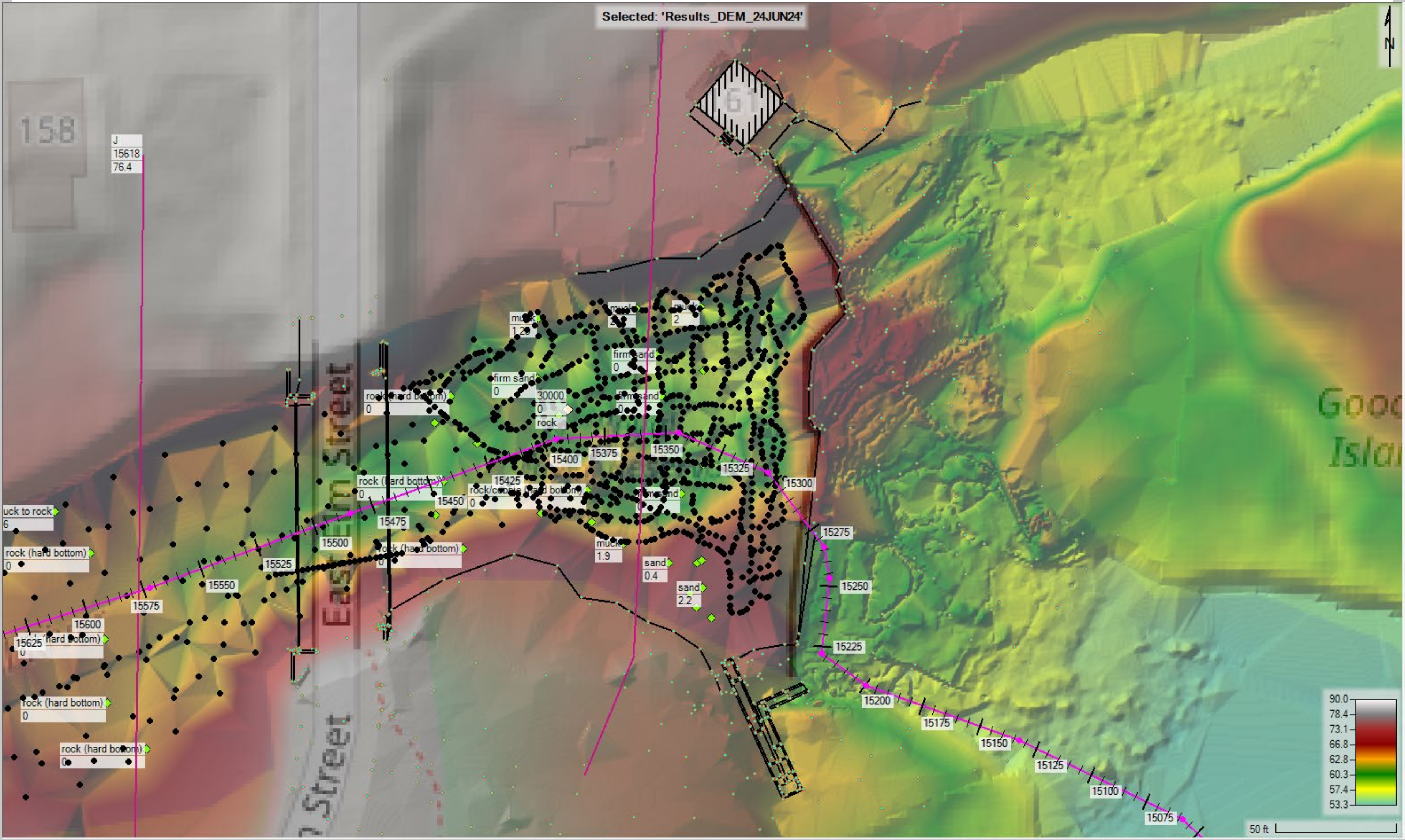


ROYAL RIVER - TERRAIN MODEL
ELM STREET DAM OVERVIEW



ROYAL RIVER - TERRAIN MODEL

ELM STREET DAM



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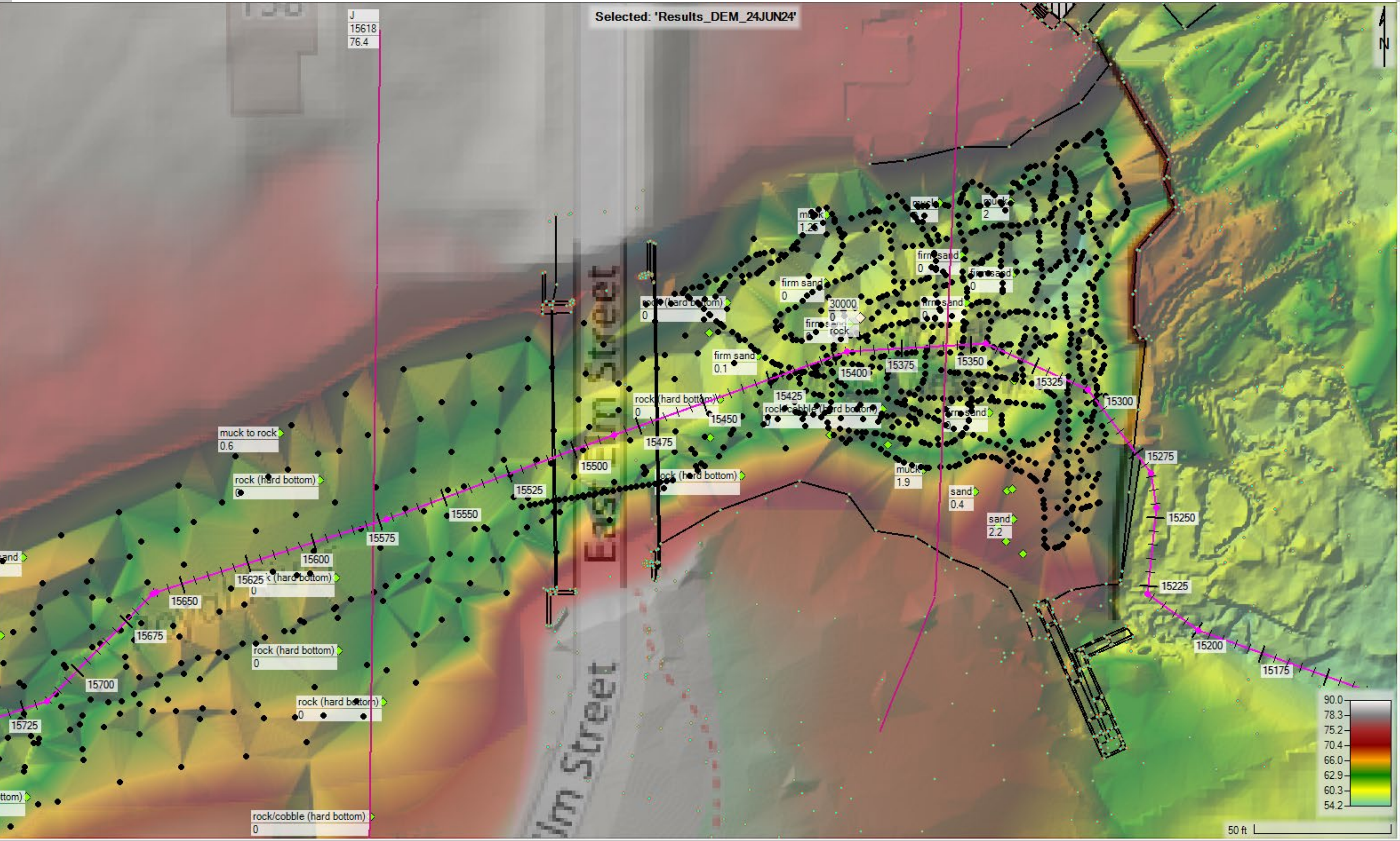
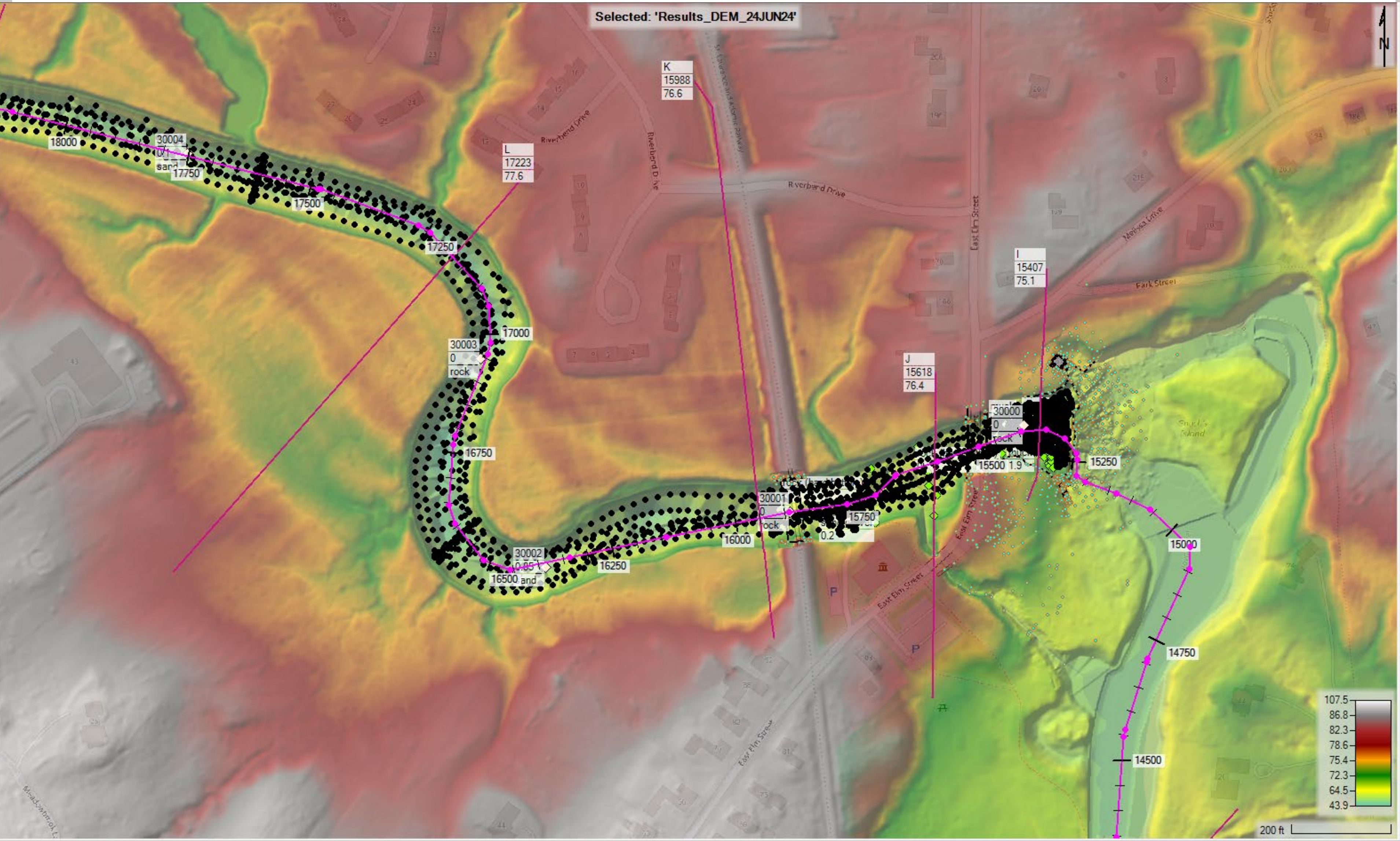
ROYAL RIVER - TERRAIN MODEL
EAST ELM STREET

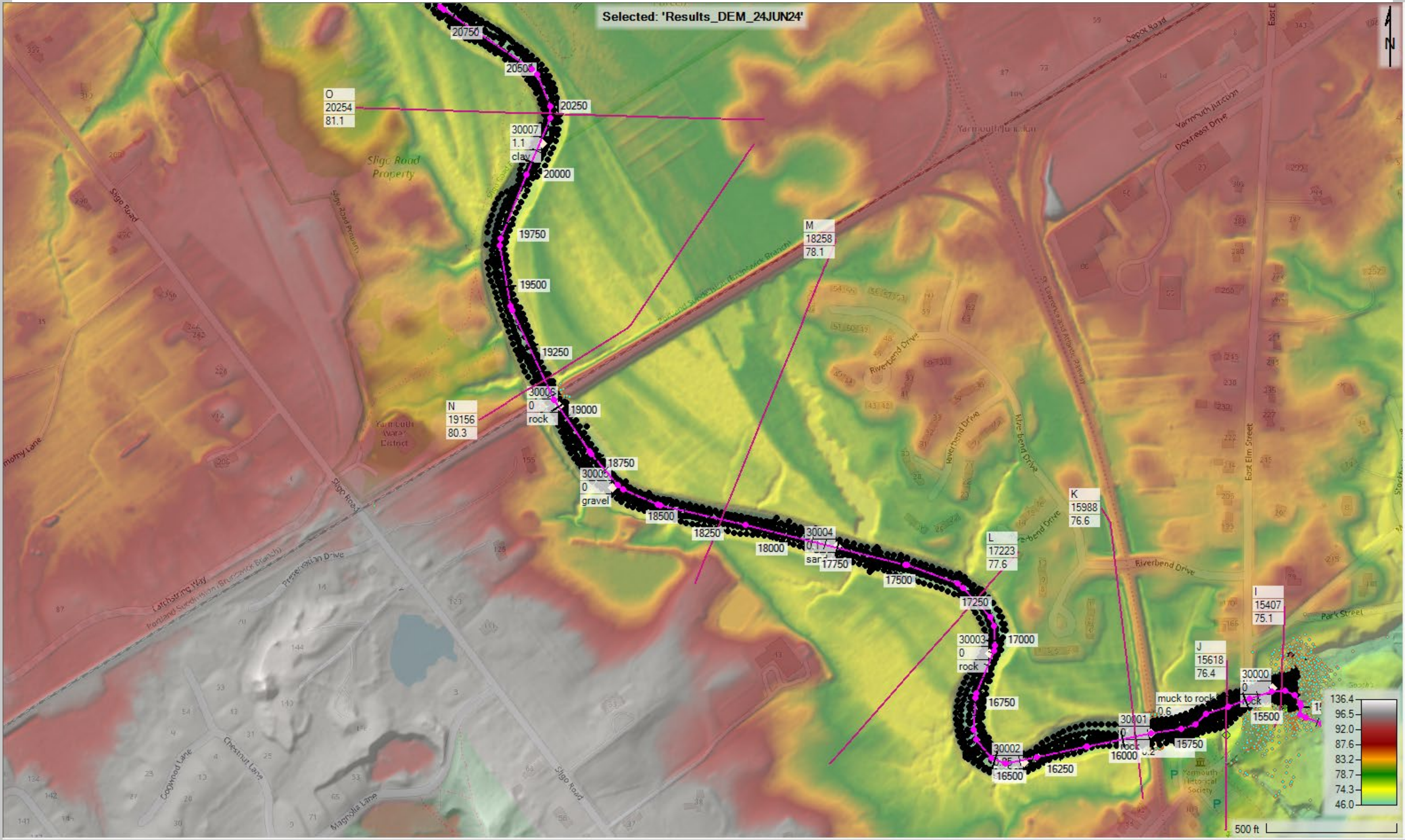


ROYAL RIVER - TERRAIN MODEL
GRAND TRUNK RR



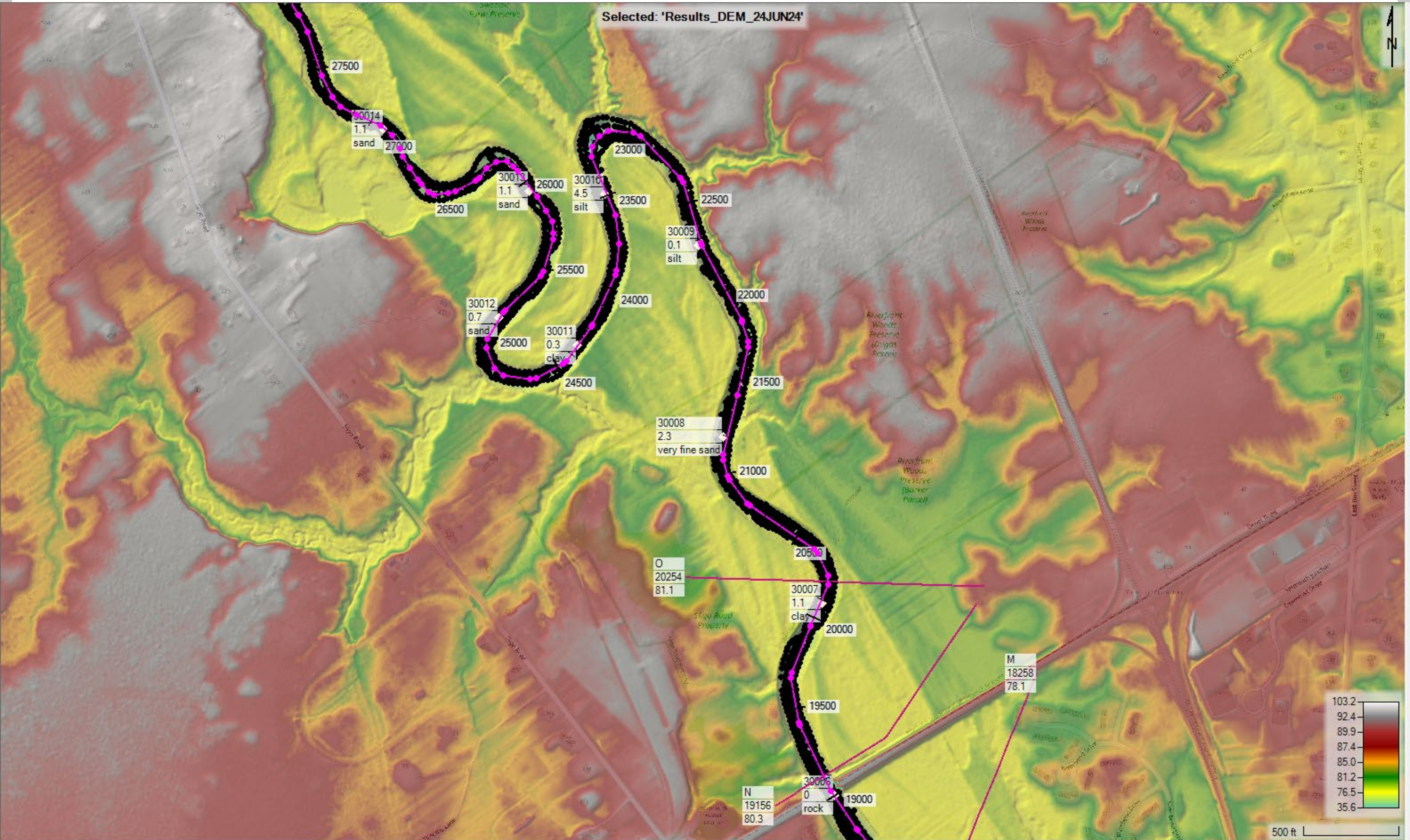
ROYAL RIVER - TERRAIN MODEL

MAINE CENTRAL RR

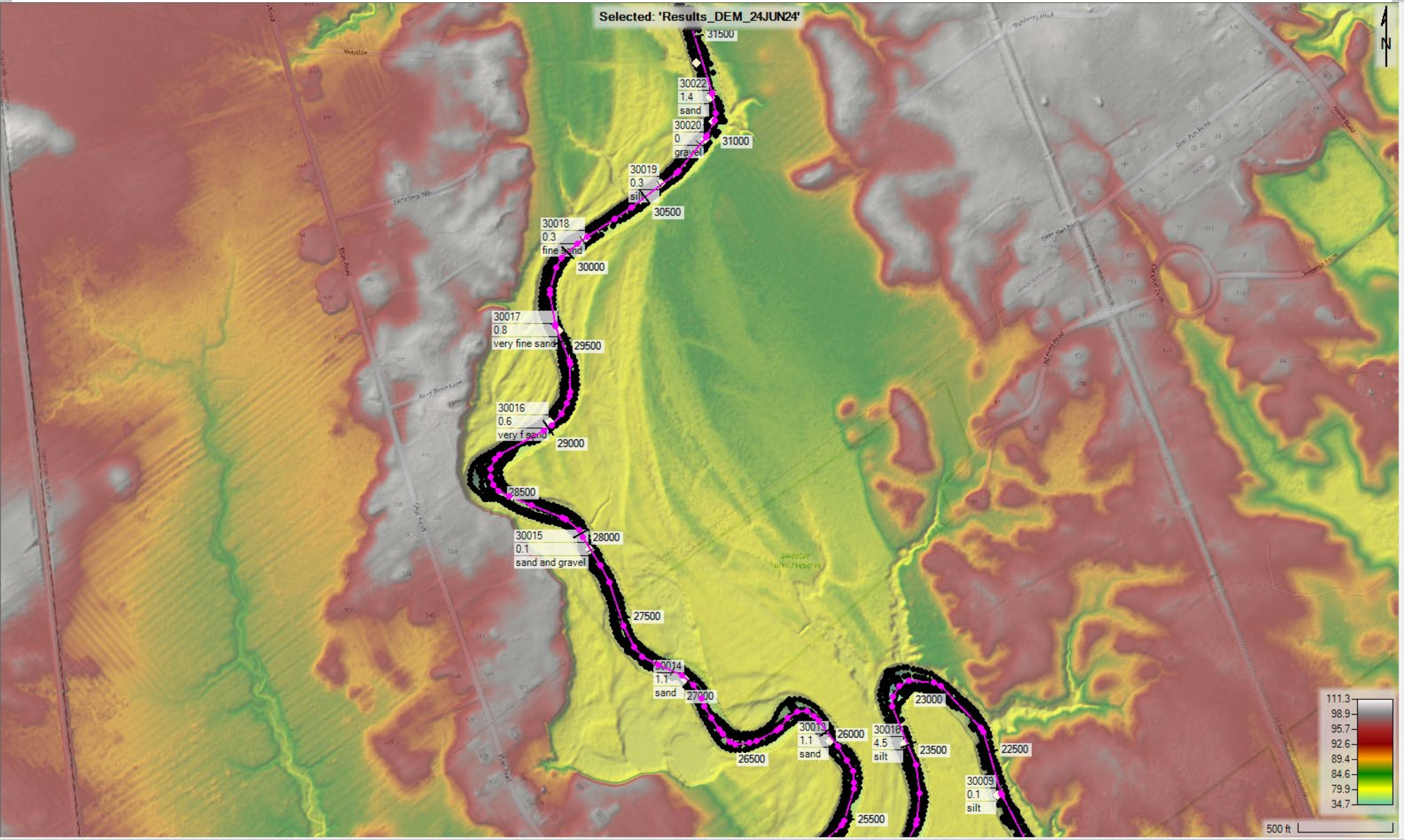


ROYAL RIVER - TERRAIN MODEL

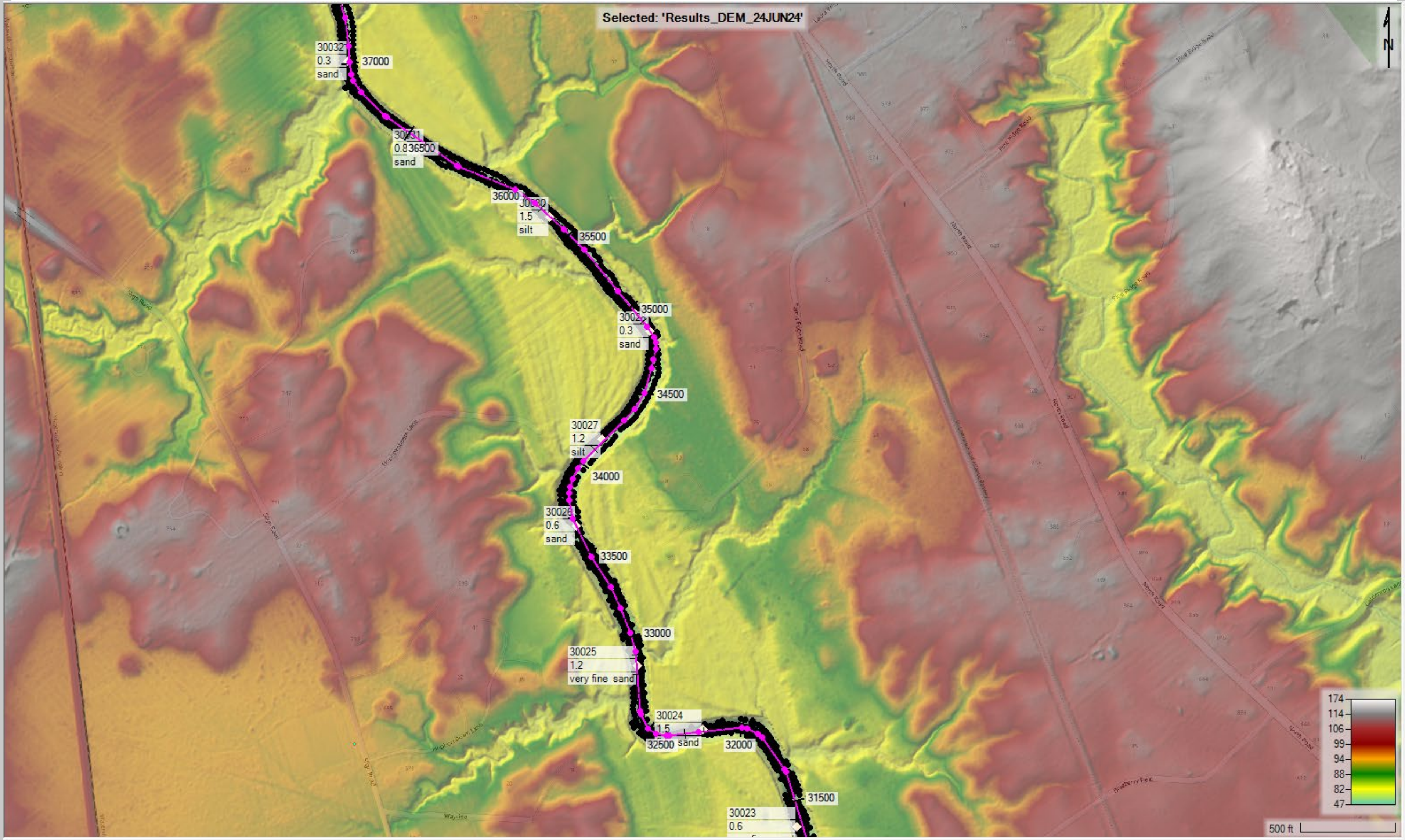
UPSTREAM OF MAINE CENTRAL RR (1)



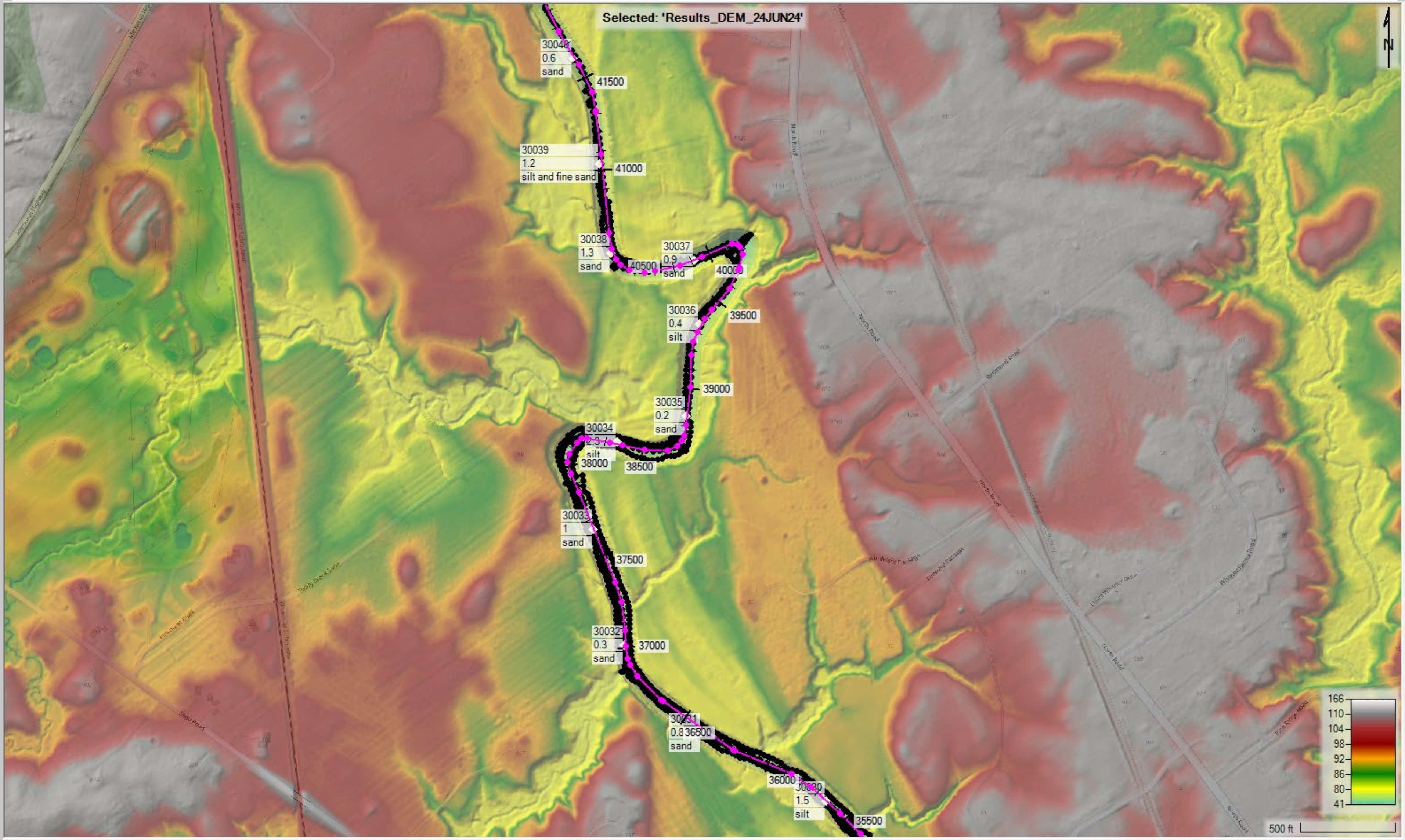
ROYAL RIVER - TERRAIN MODEL
UPSTREAM OF MAINE CENTRAL RR (2)



ROYAL RIVER - TERRAIN MODEL
UPSTREAM OF MAINE CENTRAL RR (3)



ROYAL RIVER - TERRAIN MODEL
NEAR TODDY BROOK



ROYAL RIVER - TERRAIN MODEL

BASTON PARK / US ROUTE 9