HYDROLOGY REPORT

The flow is split between the highway bridge and the town culvert. The summary provided below is the for the bridge. Please see Appendix C for the full Hydrology Data.

SUMMARY

Drainage Area	49.4	mi^2
Q1.1	104	ft^3/s
Q10	523	ft^3/s
Q25	635	ft^3/s
Q50	716	ft^3/s
Q100	786	ft^3/s
Q500	1150	ft^3/s

Reported by: Oskar O'Hara
Date: October 30, 2024

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

HYDRAULIC REPORT

In summary, the bridge span was lengthened by 21’ due to placing the proposed abutments behind existing. The existing bridge meets the 2’ freeboard suggested in the Bridge Design Guide at the Q50 water elevations and provides 2.9’ at Q100. The proposed changes in the vertical profile and structure depth are offset by the increased span. The proposed structure provides adequate hydraulic clearances.

SUMMARY

		Existing Structure	Recommended Structure 46' Single Span Precast NEXT F	
		25' Single Span Concrete Slab	Upstream	Downstream
Total Area of Waterway Opening	ft^2	288	315	315
Headwater Elevation @ $Q_{1.1}$	ft	61.2	60.3	59.9
Headwater Elevation @ Q_{10}	ft	64.9	62.5	61.3
Headwater Elevation @ Q_{25}	ft	65.6	62.9	61.5
Headwater Elevation @ Q_{50}	ft	66.0	63.2	61.8
Headwater Elevation @ Q_{100}	ft	66.6	63.5	62.0
Headwater Elevation @ Q_{500}	ft	68.7	64.7	62.6
Freeboard @ Q_{50}	ft	3.4	4.5	4.4
Freeboard @ Q_{100}	ft	2.9	4.2	4.2
Outlet Velocity @ $Q_{1.1}$	ft/s	5.2	N/A	3.7
Outlet Velocity @ Q_{10}	ft/s	9.6	N/A	6.8
Outlet Velocity @ Q_{25}	ft/s	10.0	N/A	7.3
Outlet Velocity @ Q_{50}	ft/s	10.9	N/A	7.4
Outlet Velocity @ Q_{100}	ft/s	11.0	N/A	7.5
Outlet Velocity @ Q_{500}	ft/s	12.5	N/A	8.8

Reported by: Oskar O’Hara
Date: October 30, 2024

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

APPENDIX C

Hydraulics Report

Hydrology and Hydraulics Report

Chase Mills Bridge Over Gardner Lake Outlet

Bridge Number 5465

October 30, 2024

Prepared for:

Maine Department of Transportation

Prepared by:

Stantec Consulting Services Inc.
136 West Street, Suite 203
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HYDROLOGY AND HYDRAULICS REPORT

Revision	Description	Author		Quality Check		Independent Review	
0	Final for Preliminary Design Report	OO	2024.10.25	GEC	2024.10.30	MRC	2024.10.16

HYDROLOGY AND HYDRAULICS REPORT

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STATE OF MAINE
10/30/2024
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Independent Review by ______________________
(signature)

Michael Chelminski. P.E.

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1.0 INTRODUCTION

The Maine Department of Transportation (MEDOT) proposes replacement of Chase Mills Bridge (Bridge Number 5465) over Gardner Lake Outlet[1] on Chases Mill Road in East Machias, Maine (Project). The location of Chase Mills Bridge is shown at Latitude: 44° 45' 22.0" N, Longitude: 67° 21' 37.9" W in Figure 1. Stantec Consulting Services Inc. (Stantec) is contracted with MEDOT to provide preliminary bridge design services, including a study of the hydrology and hydraulics at the Site.

1.1 PURPOSE

The purpose of this report is to present the methods and results of a hydrologic and hydraulic study (Study) for the preliminary proposed bridge replacement design. The objective of the Study is to evaluate the hydraulic performance of the proposed bridge. Scour and stable material sizing analyses were not required due to the presence of bedrock at the proposed bridge location.

This report includes a description of relevant Project elements, engineering methods, results, and conclusions and recommendations. Appendix A includes details related to the hydrological analysis used as part of the Study.

[1] For the purposes of this report, “Gardner Lake Outlet” is referred to as “Chase Mills Stream” and represents the channel that conveys Gardner Lake discharge from the Chase Mill Dam spillway. For additional clarity, reference Section 2.1 for information related the origin and definition of “Gardner Lake Outlet”, Section 2.2 for information related to Chase Mill Dam and an adjacent culvert to the west, and Section 2.3 for information related to Gardner Lake and Chase Mills Stream.

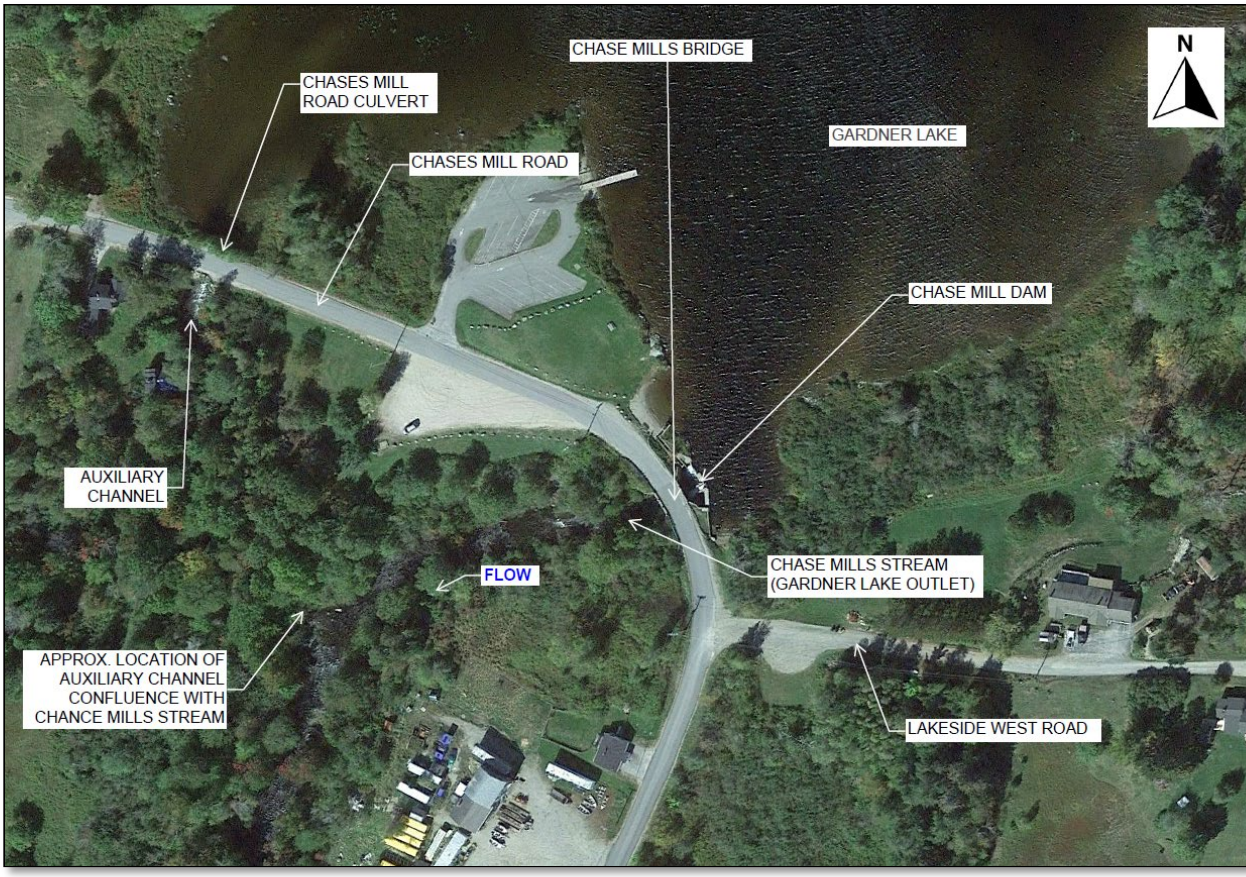


Figure 1. Location of Chase Mills Bridge over Chase Mills Stream (Gardner Lake Outlet) and overview of surrounding features; satellite imagery is from Google Earth and dated September 28, 2019

1.2 SCOPE

The scope of the Study included: (1) review of existing information; (2) a site visit; (3) development of a two-dimensional, depth-averaged numerical hydraulic model for existing and proposed conditions; (4) evaluation and comparison of the hydraulic model results for existing and proposed conditions; and (5) calculation of the flow split between the Chase Mills Bridge and the Chases Mill Road culvert.

1.3 DATUMS AND COORDINATE REFERENCE SYSTEMS

The horizontal coordinate reference system used for the hydraulic model is the Maine 2000 East State Plane Projection, which is based on the North American Datum of 1983 (NAD83). The vertical datum used for the hydraulic model is the North American Vertical Datum of 1988 (NAVD88). Both the horizontal and vertical coordinate systems use US survey feet (ft) as linear units. Elevations provided in this report are based on the NAVD88 unless indicated otherwise.

1.4 REFERENCES

The following data sources, references, and reports pertinent to Chase Mills Bridge were available and were used as part of the Study:

1. Bridge file information provided by MEDOT including the 1952 bridge survey; 2019, 2021, and 2022 bridge inspection reports; and photographs.
2. Information provided by MEDOT from the United States Geological Survey (USGS) regression equations and the USGS StreamStats online software tool (April 2022).
3. Department of the Army: New England Division, Corps of Engineers [USACE]. (1979). *Chase Mill Dam (ME-00335) Phase I Inspection Report.* Prepared by the USACE as part of the National Dam Inspection Program and dated May 1979.
4. National Oceanic and Atmospheric Administration Office for Coastal Management [NOAA/OCM] (January 5, 2022). *2021 – 2022 USGS Lidar: Midcoast Maine.* (2021 LiDAR Data).
5. Topographic and bathymetric survey data collected by MEDOT and provided to Stantec by MEDOT in September 2023. (MEDOT 2023 Survey Data).
6. Federal Emergency Management Agency [FEMA]. (July 18, 2017). *Flood Insurance Rate Map 23029C1415E.* Town of East Machias, Maine, Washington County.
7. Federal Emergency Management Agency. (July 18, 2017). *Flood Insurance Study 23029CV000A.* Washington County, Maine.
8. Maine Department of Transportation. (August 2003). *Bridge Design Guide.*

1.5 SITE VISIT

Michael Chelminski, P.E., and Oskar O'Hara of Stantec conducted a site visit on October 16, 2023. The purpose of the site visit was to inform the Study — primarily the development of the hydraulic model. The site visit included reviewing the MEDOT 2023 Survey Data, taking measurements of relevant features for the Study, and making observations on existing hydraulic structures and conditions.

2.0 PROJECT BACKGROUND

The following sections present background information related to the Project including descriptions of the existing Chase Mills Bridge, adjacent infrastructure and land, hydrologic features, and the proposed bridge replacement design.

2.1 CHASE MILLS BRIDGE

The existing Chase Mills Bridge (Bridge Number 5465) was built in 1952, is a reinforced concrete slab bridge with a bituminous wearing surface and has a 27.75-ft structural span with a 25-ft clear span. Chase Mills Bridge carries Chases Mill Road (reference Section 2.2.1) over Chase Mills Stream (reference Section 2.3.2) and is downstream of Chase Mill Dam (reference Section 2.2.2) and Gardner Lake (reference Section 2.3.1). The bridge is orientated perpendicular to the stream and carries two 12-foot traffic lanes. The substructure consists of concrete gravity abutments on bedrock that were noted as stable for scour conditions in the 2022 bridge inspection report. Maintenance records indicate no significant repairs have been made to the bridge.

Information about Chase Mills Bridge and relevant to the Study obtained from the 1952 bridge survey includes:

1. The curb is 9 inches above the finished grade of the deck.
2. The guardrail is 2 ft above the curb.
3. The low chord is 18.5 inches below the finished grade of the deck.
4. There are drains between the deck and the curb.
5. The bridge has a 25-ft clear span from abutment to abutment.
6. The bridge has a length of 27.5 ft measured parallel to the channel alignment.

From analysis of the MEDOT 2023 Survey Data, the Chase Mills Bridge deck has finished grades of approximately 71.5 ft on the upstream side and 70.5 ft on the downstream side due to superelevation. Therefore, the low chords have elevations of approximately 69.46 ft on the upstream side of the bridge and 68.46 ft on the downstream side of the bridge. Since the streambed has an approximate surveyed elevation of 59 ft beneath the bridge, the opening under the bridge is approximately 11 ft high on the upstream side and 10 ft high on the downstream side.

Note that the bridge inspection reports refer to the feature intersected by the bridge as “Gardiner Lake Outlet” (sic), and the 1952 bridge survey refers to the intersected feature as “Gardner Lake Outlet”. Gardner Lake Outlet is presumed to refer to the channel that conveys Gardner Lake discharge from the Chase Mill Dam spillway. For the purposes of this report, this channel is referred to as Chase Mills Stream for clarity.

2.2 ADJACENT INFRASTRUCTURE AND LAND

The following subsections present information on adjacent infrastructure and land relevant to the Study.

2.2.1 Chases Mill Road

Chases Mill Road is an approximately 23- to 24-ft wide roadway with a bituminous wearing surface. Chases Mill Road crosses over Chase Mills Stream at Chase Mills Bridge (subject bridge; reference Section 2.1) and over an auxiliary channel at Chases Mill Road Culvert (reference Section 2.2.3) within the vicinity of the Project.

2.2.2 Chase Mill Dam

Chase Mill Dam is a concrete dam located approximately 25 ft upstream from Chase Mills Bridge and is the primary water control structure for Gardner Lake. The dam has three spillway sections and two stoplog bays.

The left[2] dam abutment features a concrete wall with an elevation of approximately 69.4 ft that functions as a retaining wall for the roadway embankment, a headwall for the waterway, and a spillway training wall. The right dam abutment has an elevation of approximately 69.7 ft and abuts bedrock downstream. The plunge pool downstream of the dam has a channel bottom elevation of approximately 58.3 ft. Therefore, the dam has a structural height of approximately 11.4 ft.

A Denil fishway is located on the right side of the dam. The fishway entrance (hydraulic outlet) extends into the dam plunge pool from the bedrock along the right bank. Along the centerline, the fishway extends from the fishway entrance parallel to the road for approximately 40 ft before making an approximately 90-degree turn towards the lake and extending another approximately 19 ft to the location of the fishway exit (hydraulic inlet). There is a gate at the fishway exit that was raised (water was flowing into the fishway unobstructed) during the site visit.

2.2.3 Culverts

Chases Mill Road Culvert is a 4-ft-diameter CMP culvert that discharges water from Gardner Lake under Chases Mill Road to an auxiliary channel. Chases Road Mill Culvert is located approximately 500 ft west of Chase Mills Bridge. According to the MEDOT 2023 Survey Data, Chases Mill Road Culvert has an inlet invert of approximately 62.3 ft and an outlet invert of approximately 62.0 ft. The culvert has a stone headwall and wingwalls flush with the headwall. Chases Mill Road Culvert protrudes out of the riprap road embankment on the downstream side. There is large scour pool downstream of the culvert. Note that Chases Mill Road Culvert was included in the Study hydraulic model.

Note that the USACE 1979 dam inspection report identifies two 4-ft diameter culverts under Chases Mill Road located approximately 300 ft and 600 ft west of the dam, both distances of which do not correspond to the MEDOT 2023 Survey Data, which extended approximately 700 ft west of the dam. Based on Stantec's review of the 2021 LiDAR Data, it is possible that an additional culvert may be located under Chases Mill Road approximately 1000 ft west of the dam. This additional culvert was not identified in the MEDOT 2023 Survey Data nor during the site visit, and therefore was not included in the Study hydraulic model. It was

[2] Directionals "left" and "right" reference an observer facing in the downstream direction.

assumed that conveyance through this culvert is likely not significant compared to the flow conveyed over Chase Mill Dam and the Chases Mill Road Culvert, and therefore not including this additional culvert in the hydraulic model results in a conservative assessment of water surface elevation in Gardner Lake and discharge through Chase Mills Bridge as part of the Study (reference Section 2.2.4 for additional discussion).

2.2.4 Adjacent Land

A peninsula of high ground extends northward from Chases Mill Road into Gardner Lake between Chase Mill Dam and Chases Mill Road Culvert, which includes a public boat launch and parking lot.

There are also areas of high ground located north of Chase Mill Road between Chase Mill Road Culvert and a low point in the roadway approximately 1,000 west of Chase Mills Bridge. Based on Stantec's review of the 2021 LiDAR Data, it is likely that during higher water surface levels in Gardner Lake (e.g., 100-year peak water levels), flow overtops this area of high ground and then is conveyed in south direction towards Chases Mill Road and through the additional culvert that was not included in the Study hydraulic model (reference Section 2.2.3). The exclusion of these areas of high ground as part of the Study hydraulic model are based on Stantec's opinion that (1) flows are likely to be relatively insignificant (small) compared to flows conveyed through Chase Mill Dam and Chases Mill Road Culvert during these higher peak water elevations in Gardner Lake, and (2) any small increases in peak water surface levels in Gardner Lake would represent a more conservative analysis of discharge at Chase Mills Bridge.

2.3 HYDROLOGIC FEATURES

The following subsections present an overview of hydrologic features relevant to the Study including Gardner Lake and its contributing watershed, Chase Mills Stream, and an auxiliary channel flowing from Gardner Lake within the vicinity of the Project.

2.3.1 Gardner Lake

Gardner Lake is impounded by Chase Mill Dam, Chases Mill Road at the location of Chases Mill Road Culvert, and areas of high ground north of Chases Mill Road. Gardner Lake connects in the north to Second Lake. Two of the major tributaries to Gardner Lake and Second Lake are Clifford Stream and Patrick Brook, which drains Patrick Lake. According to the USGS StreamStats online tool (version 4.6.2), the tributary drainage area of Chase Mills Stream at the approximate location of Chase Mills Bridge is 49.4 square miles. Figure 2 presents this drainage area and was created using USGS StreamStats (version 4.19.2).

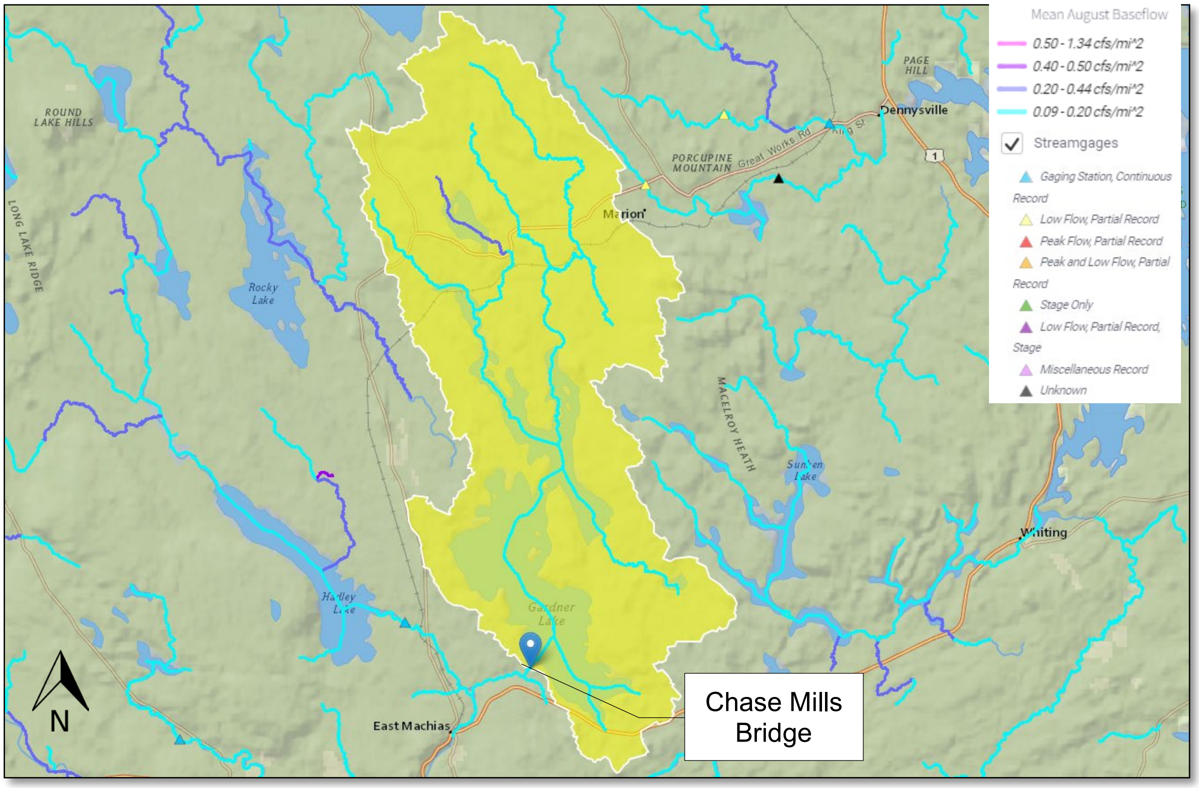


Figure 2. Approximate drainage area depicted in yellow as delineated using USGS StreamStats

2.3.2 Chase Mills Stream

Chase Mills Stream originates from the discharge at Chase Mill Dam (Gardner Lake Outlet) and flows under Chase Mills Bridge. Chase Mills Stream has a bankfull width of approximately 60 ft and a slope of approximately 2%. Substrate in the channel is dominated by cobble, except under Chase Mills Bridge, where bedrock is exposed. Observations during the site visit identified what appeared to be a concrete apron in the channel approximately 100 ft downstream from the bridge. Reinforced concrete rubble along the right bank adjacent to the apparent concrete apron suggests that the apron may have been part of a former dam. A confluence with an auxiliary channel is located approximately 400 ft downstream from Chase Mills Bridge (reference Section 2.3.3).

2.3.3 Auxiliary Channel

An auxiliary channel originates from the Chases Mill Road Culvert outlet and flows south to the confluence with Chase Mills Stream approximately 400 ft downstream from the Chases Mill Road Culvert. The auxiliary channel has a bankfull width of approximately 20 ft and a slope of approximately 3%. Though the bottom of the auxiliary channel was partially obscured by high flows during the site visit, cobble and boulders were observed in the channel and along the banks. The banks are well-defined except for a low-lying section of right bank hallway along the length of the auxiliary channel. Beyond the low-lying section of right bank, there is another manmade earthen feature that crosses what appears to be a former channel. A CMP inlet was observed by the MEDOT survey team (but not by the Stantec site visit team) in this manmade earthen feature. There is a steep cascade with a height of approximately 2 ft in the auxiliary channel at its confluence with Chase Mills Stream.

2.4 PROPOSED DESIGN

The proposed bridge is a single-span bridge with a clear span length of 44 ft. The cross-sectional geometry inside the bridge assumed that the existing abutments would be completely removed and the proposed abutments would be vertical and founded on the existing bedrock. There is no skew in the proposed bridge. The low chord elevation is 67.7 ft upstream and 66.2 ft downstream. For additional details of the proposed replacement bridge, reference the 2024 Preliminary Design Report for Chase Mills Bridge.

3.0 ENGINEERING METHODS

Hydrologic and hydraulic analyses were conducted to estimate hydraulic characteristics, including water surface elevation levels (WSELs) and flow speeds, at the bridge location for existing and proposed conditions. The following sections describe the hydrologic and hydraulic analysis methods.

3.1 HYDROLOGIC ANALYSIS

MEDOT provided Stantec with peak flow and flow duration statistics for the Study in 2023. Note that the flows provided represent the combined discharges from Gardner Lake including those conveyed by Chase Mills Stream (Gardner Lake Outlet) and the auxiliary channel. The discharge statistics provided by MEDOT were based on USGS regression equations for the state of Maine[3]. As part of the hydraulic analysis (reference Section 3.2), an evaluation of the flow split between Chase Mill Dam and Chases Mill Road Culvert (i.e., the percentages of the total flow conveyed by the dam and the culvert) was performed. Peak flows estimated by MEDOT are presented in Table 1 in cubic ft per second (cfs).

Table 1. Chase Mills Stream return period peak flows

Return Period	Annual Exceedance Probability	Peak Flows (cfs) Provided by MEDOT
1.1-year	90%	195
2-year	50%	360
5-year	20%	520
10-year	10%	615
25-year	4%	730
50-year	2%	820
100-year	1%	900
200-year	0.5%	1,165
500-year	0.2%	1,330

According to USGS StreamStats as provided by MEDOT, the percentage of storage (i.e., the percent of the area of combined waterbodies and wetlands within the drainage area), is approximately 30%. The surface

[3] Dudley, 2004. Estimating Monthly Stream Flows…, SIR 2004-5026.

Dudley, 2013. FY2013 Progress Report – Phase 1…, USFWS QRP Project.

Dudley, 2015. Regression Equations for Monthly and Annual Mean…, USGS, SIR 2015-5151.

Hodgkins, G.A., 1999. Estimating the magnitude of peak flows for streams in Maine for Selected Recurrence Intervals, WRIR 99-4008, USGS, Augusta, ME.

Lombard and Hodgkins, 2015. Peak flow regression equations for small, ungagged streams in Maine: Comparing Map-Based to Field-Based Variables. SIR 2015-4059, USGS, Augusta, ME.

Lombard and Hodgkins, 2021. Estimating Flood Magnitude and Frequency on Gaged and Ungaged Streams in Maine. SIR 2021-xxxx, USGS, Augusta, ME.

area of Gardner Lake and Second Lake together is approximately 8.2 square miles, which is approximately 17% of the drainage area. Considering the relatively large percentage of storage, in particular the relatively large area of Gardner Lake and Second Lake compared with the total drainage area, it is expected that peak flows from Gardner Lake to Chase Mills Stream are likely attenuated. Therefore, the flows provided in Table 1 are expected to be conservative (i.e., high).

As part of the Project, Stantec reviewed the FEMA Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) for data on Gardner Lake and Chase Mills Stream. The areas upstream and downstream of the bridge are designated by FEMA as "Special Flood Hazard Areas Without Base Flood Elevation".

Per the MEDOT Bridge Design Guide (August 2003), the design flow for Chase Mills Bridge is the 50-year return period flow.

Supporting information on the estimates of hydrology for the Study, as provided by MEDOT, are provided in Appendix A.

3.2 HYDRAULIC ANALYSIS

The United States Army Corps of Engineers HEC-RAS software (version 6.4.1) was used to develop a two-dimensional, depth-averaged numerical hydraulic model (Model). The Model was used to simulate WSELs and flow speeds for a range of lake WSELs for both existing and proposed conditions.

The spatial extents of the Model are from approximately 400 ft north of Chases Mill Road in Gardner Lake to approximately 700 ft downstream of Chase Mill Bridge (i.e., about 250 ft downstream of the confluence of Chase Mills Stream and the auxiliary channel). The terrain was developed from the MEDOT 2023 Survey Data and the 2021 LiDAR Data. Terrain modifications were also made in HEC-RAS to the combined digital elevation model composited from the survey and 2021 LiDAR Data. The two-dimensional computational mesh has a maximum point spacing of 10 ft across the domain. Computational mesh point spacings of 2 ft and 5 ft were used in the vicinity of the bridge and in the stream channels, respectively, to increase numerical stability and accuracy in these regions. Breaklines were added along the stream channels and structures to align cells with the flow direction.

Chases Mill Road Culvert was modelled as a 46.6-ft long, 4-ft diameter barrel with the invert elevations provided in Subsection 2.2.3. Chase Mill Dam was modelled as a "weir" with elevations taken from the MEDOT 2023 Survey Data and observations by Stantec during the site visit. Flows through the Denil fishway were modeled using a "gate" with a user defined rating curve. The rating curve was developed from an empirical equation for flows through Denil fishways with input parameters based on the survey data and field observations and measurements[4].

[4] Odeh, Mufeed, "Discharge Rating Equation and Hydraulic Characteristics of Standard Denil Fishways" *Journal of Hydraulic Engineering*, Vol. 129, No. 5 (May 1, 2003).

Manning's roughness coefficients were assigned based on field observations, review of aerial photography, and professional judgement. Selected Manning's roughness coefficients are as follows: 0.035 for channels and the lake, 0.05 for lawns and roads, and 0.1 for forested and overgrown areas.

The upstream boundary condition for the Model was defined as a stage hydrograph. The downstream boundary condition was defined as a normal depth slope of 0.016, equivalent to the approximate slope of the channel at the downstream end of the Model domain. Model simulations were run in an unsteady state with the original shallow water equations (the Eulerian-Lagrangian Method) and (non-conservative) turbulence modelling.

To determine the lake level stages associated with peak discharges (presented in Table 1), a multi-phased modeling approach was used. The first phase (Phase 1) of modeling included estimating the discharges from the two lake outlets (i.e., the flow split between Chase Mill Dam and Chases Mill Road Culvert) with the purpose of creating a stage-discharge relationship for each structure. The second phase (Phase 2) of modeling used the stage-discharge relationship developed as part of the first phase to simulate lake WSELs associated with the peak flows presented in Table 1 for existing conditions. The third phase (Phase 3) included modifying the existing conditions geometry to include the proposed bridge replacement configuration (reference Section 2.4), running the different water levels used in Phase 1 to (1) confirm that the flow split hydraulics are similar between existing and proposed conditions, and (2) develop appropriate HEC-RAS restart files for the proposed conditions peak flow simulations.

For Phase 1, lake WSELs were modeled at constant values and discharges at the dam and primary culvert were calculated. A series of simulations were performed using upstream boundary conditions that feature stage hydrographs plateauing at integer elevation values from 66 to 70 ft. The simulation for a WSEL of 66 ft was initiated with the lake WSEL equal to the modified lakebed (58 ft) and increased the lake WSEL at a rate of 1 ft every 4 minutes. The simulations for WSELS of 67 ft through 70 ft used restart files from the final time step of the previous simulation and increased the WSEL to the desired elevation at the same rate. Flows were extracted near the downstream extent of the Model for each of the integer elevation simulations, and the flows were plotted against the lake WSELs. A logarithmic curve was fitted to the data to represent a relationship between the lake stage and lake discharge simulated data.

For Phase 2, the logarithmic curve equation developed as part of Phase 1 was used to estimate the approximate lake WSELs for the peak flow data presented in Table 1. Model simulations were then performed using the calculated Gardner Lake WSELs that correspond to the design peak flows for the Project. Restart files were used based on the Phase 1 simulations. Hydraulic characteristics of interest (i.e., flow speed and WSEL) were then estimated at the Project bridge for existing conditions.

For Phase 3, the existing conditions geometry was modified at the location of Chase Mills Bridge to represent the proposed bridge configuration. Breaklines were added to add additional refinement to the computational mesh within the Chase Mills Stream channel underneath the proposed bridge. With the exception of the additional mesh refinement within the vicinity of the proposed bridge, no other additional changes were made to the proposed geometry compared to the existing conditions geometry. The same WSELs assessed in Phase 1 were simulated and compared to the existing conditions simulation results for assessing potential changes in the flow split between Chase Mill Dam and Chases Mill Road Culvert and to provide suitable HEC-RAS restart files for the peak flow simulations. Peak flow simulations were performed and hydraulic characteristics of interest (i.e., flow speed and WSEL) were then estimated at the Project bridge for proposed conditions.

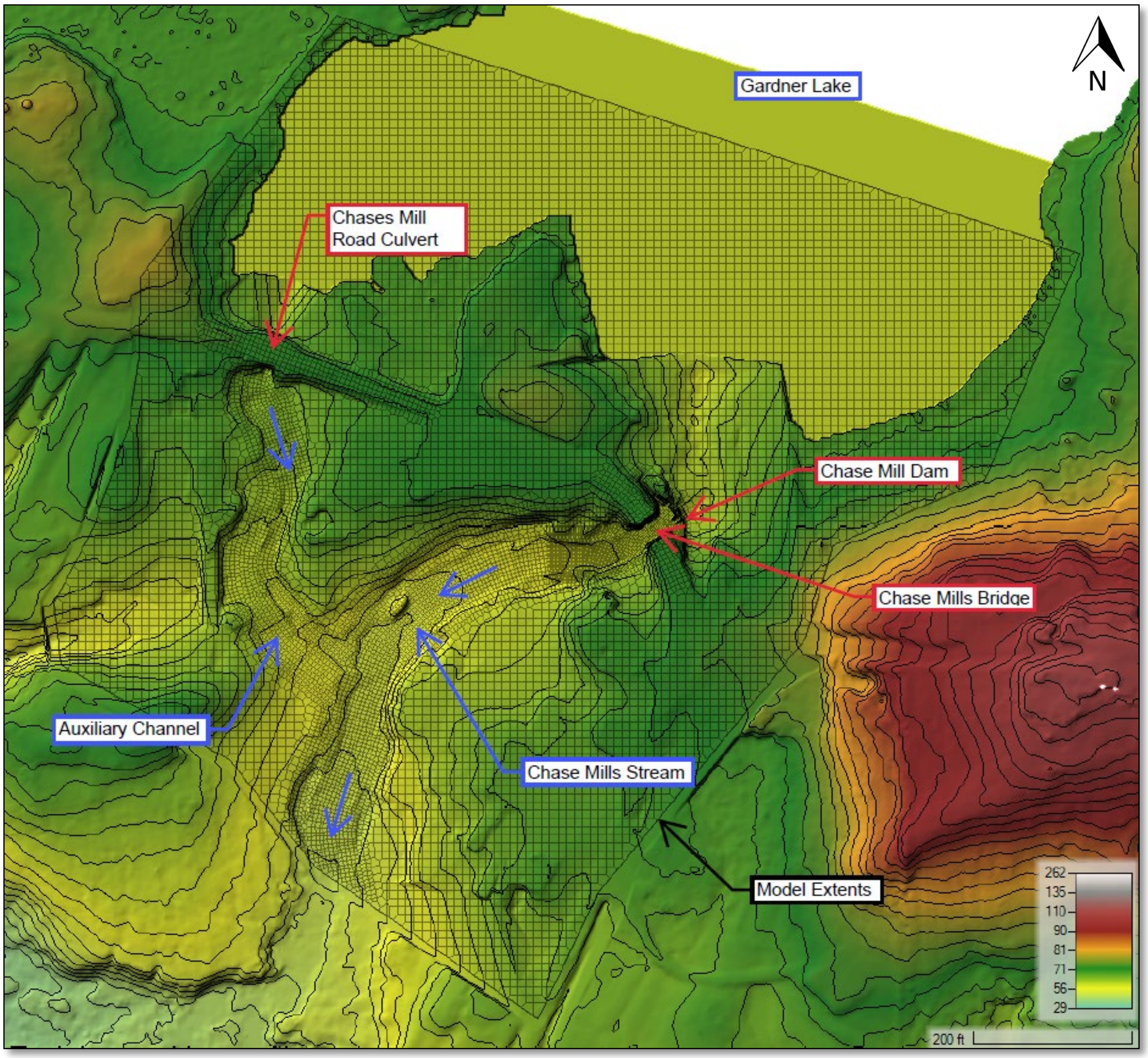


Figure 3. Existing conditions Model terrain (with 2-ft contours) and computational mesh

3.3 SCOUR ANALYSIS

A scour analysis was not conducted for the Project since the existing abutments are founded on bedrock and the proposed replacement abutments are also founded on bedrock.

3.4 STABLE MATERIAL SIZING

Stable material sizing was not conducted for the Project since the channel upstream and downstream of the bridge is primarily bedrock and scour countermeasures are not required as part of the proposed bridge replacement design.

4.0 RESULTS AND DISCUSSION

For Phase 1, simulated flows were extracted at three locations: (1) Chase Mills Stream downstream from Chase Mills Bridge, (2) the auxiliary channels downstream of Chases Mill Road Culvert, and (3) downstream of the confluence of Chase Mills Stream and the auxiliary channel representing combined discharges of Chase Mills Stream and the auxiliary channel. Simulations included a series of integer lake WSELs that ranged from 66 ft to 70 ft as defined by the upstream boundary condition to bound the range of expected WSELs in Gardner Lake for the return storms presented in Table 1. The flow spit discharges between Chase Mill Dam and Chases Mill Road Culvert were estimated by the Model. Results from the Phase 1 assessment of the flow split discharges are presented in Table 2. A logarithmic curve was fitted to the data to represent a relationship between the lake stage and the total discharge in Chase Mills Stream, which is presented in Figure 4.

Table 2. Summary of the Model results for the simulations for integer Gardner Lake WSELs with the flow split between Chase Mills Bridge and the Chases Mill Road primary culvert

Lake WSEL (ft)	Flow (cfs) Downstream			Flow as a Percentage of the Total	
	Culvert	Bridge	Total	Culvert	Bridge
66	57	27	84	68%	32%
67	81	77	158	51%	49%
68	98	247	344	28%	72%
69	113	546	660	17%	83%
70	127	1,095	1,222	10%	90%

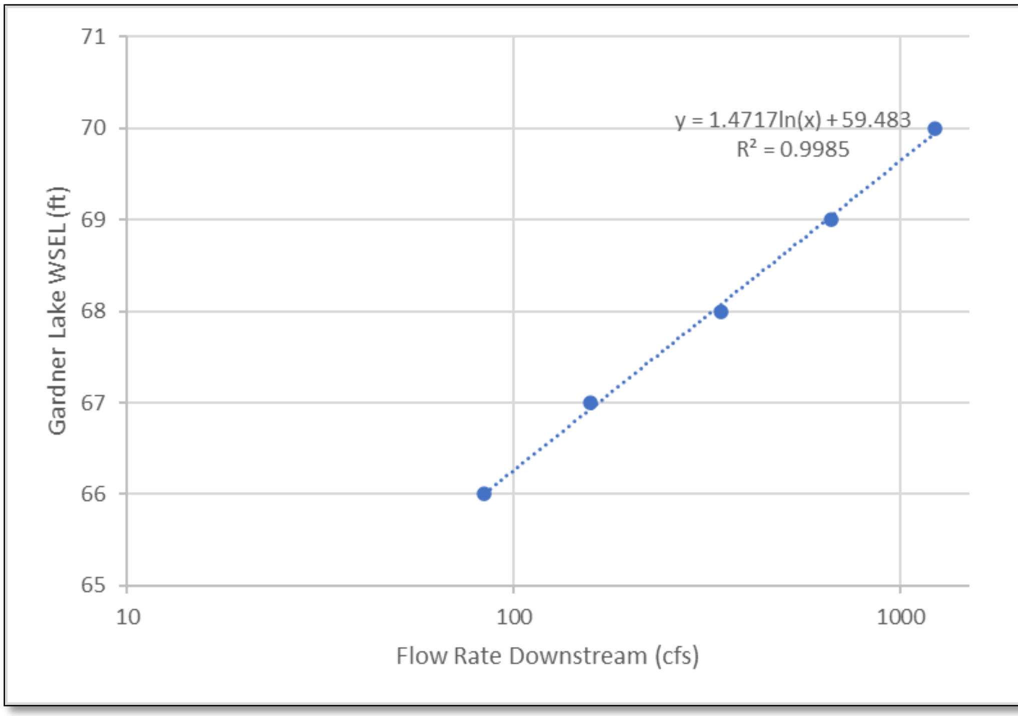


Figure 4. Gardner Lake WSEL plotted against flow near the downstream Model extent with a fitted trendline

For Phase 2, the WSELs in Gardner Lake were estimated for the peak flows in Table 1 using the regression equation of the fitted curve in Figure 4, which defined the upstream stage boundary condition for the existing conditions model simulations. Flows were once again extracted near the downstream Model extent to calculate the difference between the targeted peak flows (Table 1) and the resulting simulation flows. A summary of the target flows versus the simulated flows are presented in Table 3.

A summary of the existing conditions Model results for the peak flows as part of Phase 2 are presented in Table 4. The WSELs presented in Table 4 are located on the upstream and downstream ends of the bridge (i.e., upstream and downstream cross-sections). The WSELs reported are the estimated maxima at these cross-sections. Freeboard was calculated as the vertical distance between the simulated WSELs and the low chord elevations for both upstream and downstream. The maximum flow speeds taken from the upstream and downstream cross-sections are also presented in Table 4. Note that the flow speeds downstream of the bridge were approximately double the flow speeds upstream of the bridge across the simulated flows due to an abrupt change in the channel slope immediately downstream of the bridge. Graphical depictions of simulated WSELs and flow speeds are presented in Figures 5, 6, 7, and 8 for the 2- and 50-year return peak flows.

For Phase 3, the WSELs simulated as part of Phase 1 were simulated again for proposed conditions. A summary of the target flows versus the simulated flows for proposed conditions are presented in Table 3. The Model results comparing existing and proposed conditions for these Phase 1 WSELs do not result in significant changes in the flow-split discharges between the Chase Mill Dam and the Chases Mill Road

Culvert. This result is consistent with expected conditions given that supercritical flow occurs at the dam and in/adjacent to the culvert during the simulated conditions (i.e., these structures are the hydraulic controls for the range of flows evaluated and are independent of downstream changes).

Since the flow split characteristics were similar compared to existing conditions, simulations of the peak flows for proposed conditions were performed using the same WSELs in Gardner Lake estimated for existing conditions as part of Phase 2. A summary of the proposed conditions Model results for the peak flows are presented in Table 5. Freeboard and maximum flow speeds in Table 5 were calculated for both the upstream and downstream ends of the proposed bridge.

Graphical depictions of simulated WSELs and flow speeds are presented in Figures 5, 6, 7, and 8 for the 2- and 50-year return peak flows. Note that water surface elevations are higher under proposed conditions compared to existing conditions within the area immediate downstream of the hydraulic influence of the proposed bridge, which is depicted in Figure 9. Under existing conditions, the area just downstream of the bridge has critical flow (i.e., Froude numbers greater than 1) and high flow speeds, which are due to the hydraulic contraction at the bridge. Under proposed conditions, the contraction through the larger clear-span bridge opening has significantly less hydraulic influence, resulting in a smaller hydraulic head differential through the bridge and subsequently lower flow speeds downstream of the bridge. Since the discharge through Chase Mills Stream for existing and proposed conditions is the same (i.e., mass is conserved), a greater cross-sectional area, and therefore higher WSEL, is required in the proposed conditions model to convey the same amount of flow with subsequent lower flow speeds compared to existing conditions. The WSELs outside of this local hydraulic influence within the vicinity of the bridge are the same for both existing and proposed conditions.

Table 3. Summary of Gardner Lake WSELs estimated for return periods based on the Phase 1 flow split assessment and used for the Phase 2 and Phase 3 upstream stage boundary conditions

Return Period	Peak Flow (cfs)	Gardner Lake WSEL (ft)	Simulation Flow (cfs)		Difference in Flows (cfs)	
			Existing Conditions	Proposed Conditions	Existing Conditions	Proposed Conditions
1.1-year	195	67.24	190	189	-5	-6
2-year	360	68.15	385	384	25	24
5-year	520	68.69	546	546	26	26
10-year	615	68.93	634	636	19	21
25-year	730	69.19	751	751	21	21
50-year	820	69.36	835	837	15	17
100-year	900	69.49	906	908	6	8
200-year	1,165	69.87	1,145	1136	-20	-29
500-year	1,330	70.07	1,261	1270	-69	-60

Table 4. Summary of the Model results for the existing conditions simulations for WSELs, freeboard, and maximum flow speeds upstream (U/S) and downstream (D/S) of the bridge

Return Period	WSEL U/S (ft)	WSEL D/S (ft)	Freeboard U/S (ft)	Freeboard D/S (ft)	Max. Flow Speed U/S (ft/s)	Max. Flow Speed D/S (ft/s)
1.1-year	61.21	60.16	8.25	8.30	2.86	5.19
2-year	63.15	61.01	6.31	7.45	3.85	7.63
5-year	64.16	61.55	5.30	6.91	4.68	9.30
10-year	64.89	61.79	4.57	6.67	4.82	9.60
25-year	65.58	62.08	3.88	6.38	5.06	10.03
50-year	66.00	62.42	3.46	6.04	5.41	10.87
100-year	66.58	62.39	2.88	6.07	5.07	11.03
200-year	68.04	63.06	1.42	5.40	5.11	11.87
500-year	68.69	63.31	0.77	5.15	5.37	12.52

Table 5. Summary of the Model results for the proposed conditions simulations for WSELs, freeboard, and maximum flow speeds upstream (U/S) and downstream (D/S) of the bridge

Return Period	WSEL U/S (ft)	WSEL D/S (ft)	Freeboard U/S (ft)	Freeboard D/S (ft)	Max. Flow Speed U/S (ft/s)	Max. Flow Speed D/S (ft/s)
1.1-year	60.27	59.90	7.43	6.30	4.03	3.66
2-year	61.38	60.58	6.32	5.62	4.31	5.03
5-year	62.04	61.04	5.66	5.16	5.77	6.18
10-year	62.46	61.29	5.24	4.91	6.10	6.77
25-year	62.85	61.53	4.85	4.67	6.53	7.33
50-year	63.24	61.78	4.46	4.42	6.60	7.41
100-year	63.48	61.96	4.22	4.24	6.81	7.47
200-year	64.26	62.25	3.44	3.95	7.27	8.88
500-year	64.66	62.57	3.04	3.63	6.75	8.81

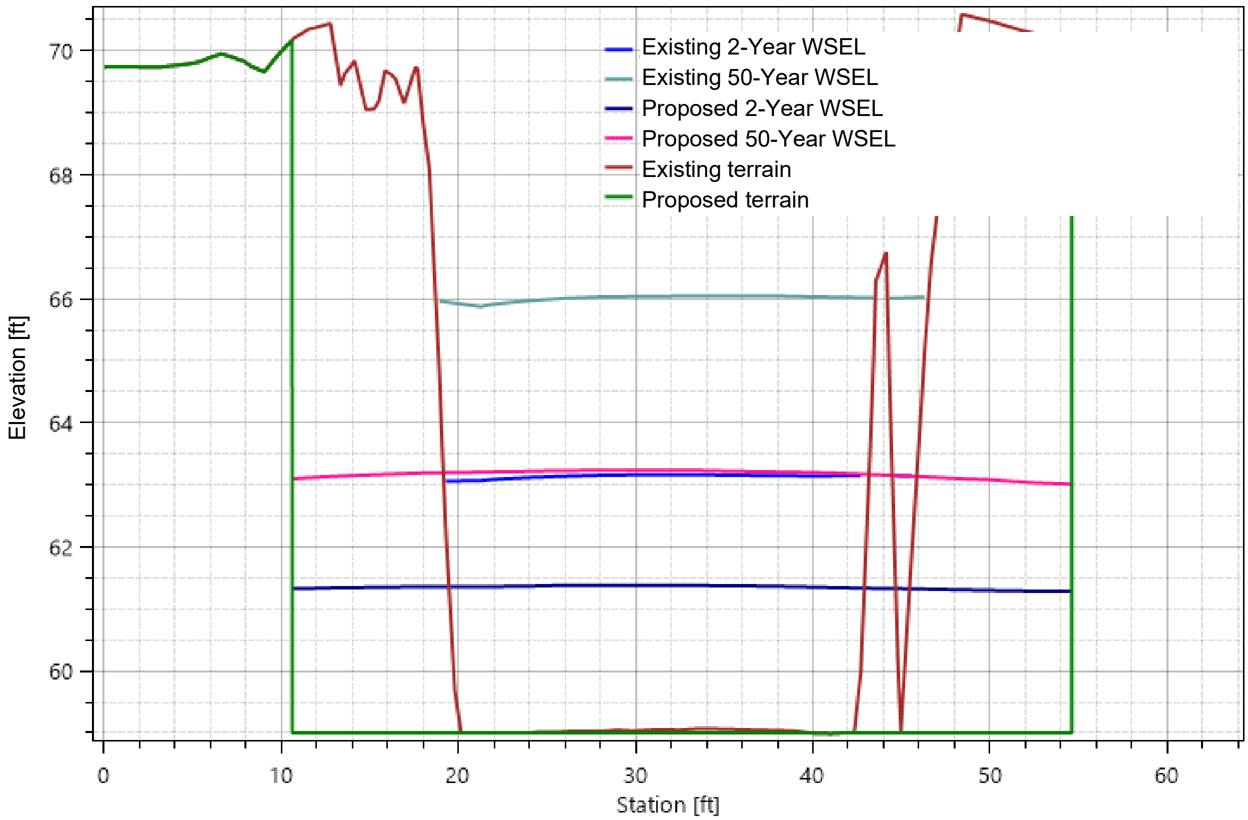


Figure 5. Simulated WSELs at the upstream cross-section for the 2- and 50-year return period flows for existing and proposed conditions

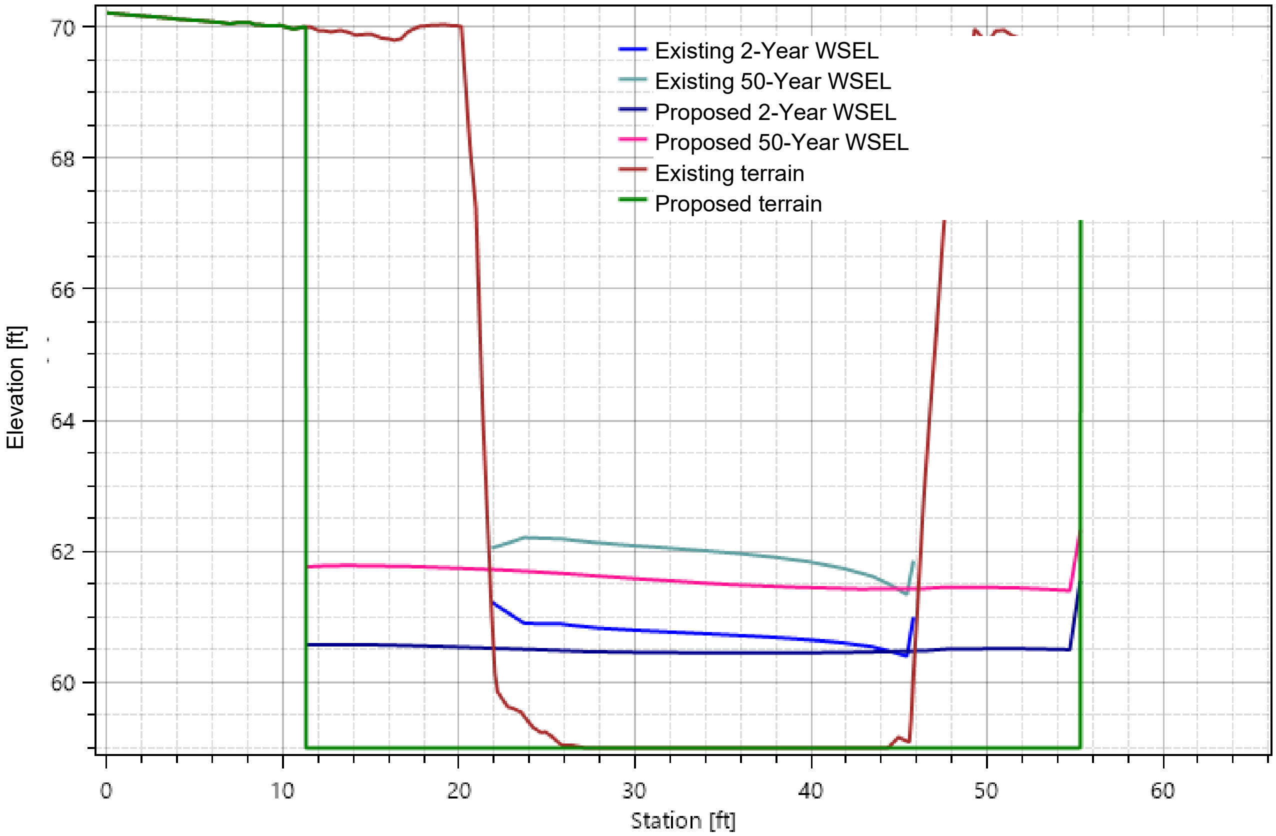


Figure 6. Simulated WSELs at the downstream cross-section for the 2- and 50-year return period flows for existing and proposed conditions

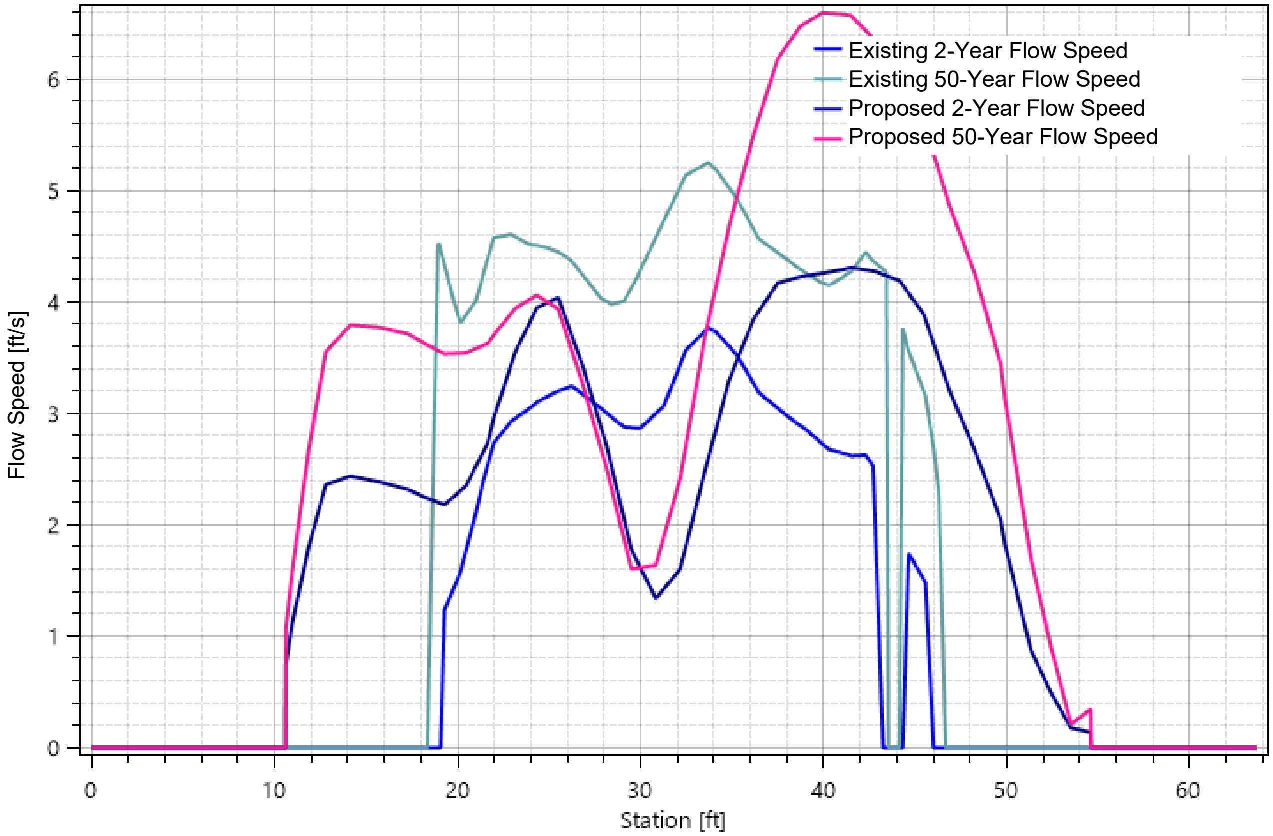


Figure 7. Simulated flow speeds at the upstream cross-section for the 2- and 50-year return period flows for existing and proposed conditions

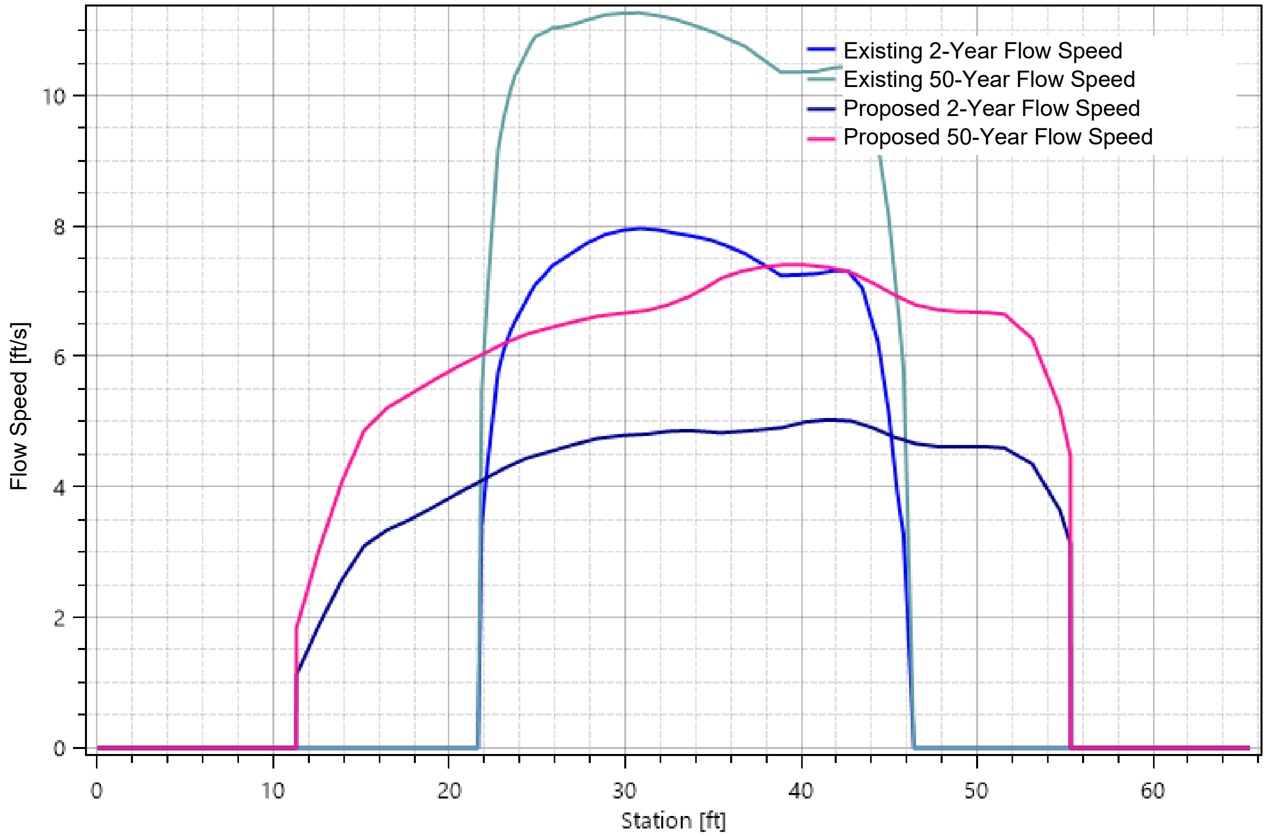


Figure 8. Simulated flow speeds at the downstream cross-section for the 2- and 50-year return period flows for existing and proposed conditions

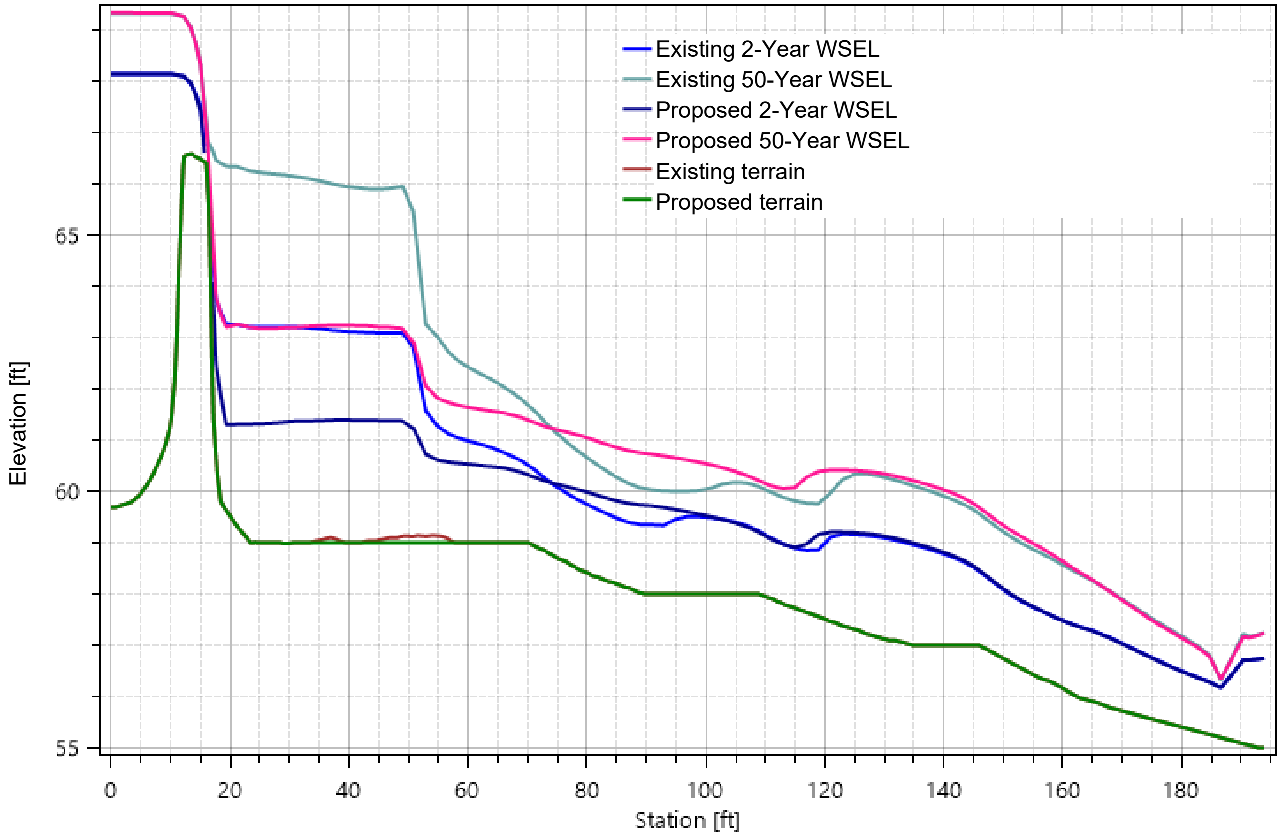


Figure 9. Simulated WSELs along the Chase Mills Stream alignment for the 50- and 100-year return period flows for existing and proposed conditions

5.0 CONCLUSIONS AND RECOMMENDATIONS

Model simulation results indicate that replacement of the existing Chase Mills Bridge with the proposed bridge geometry will not increase WSELs in Garder Lake, downstream of the influence hydraulic influence of the bridge in Chase Mills Stream, or in the auxiliary channel for the simulated flows. Note that there is a small increase in WSEL under proposed conditions immediately downstream of the bridge due to the greater flow conveyance achieved through the proposed bridge geometry compared to existing conditions, which results in a reduction of the "firehose" effect (i.e., high flow speeds downstream due to high hydraulic head differentials through the bridge opening) apparent in the existing conditions simulations. The simulation results also indicate that the proposed bridge will not change the flow-split between the dam and the primary culvert under Chases Mill Road.

The increased span of the proposed bridge will result in lower WSELs under the bridge and lower flow speeds. These findings are consistent with improved hydraulic conveyance provided by the increased bridge span. Chase Mills Stream is relatively steep downstream from the bridge and supercritical flow occurs for existing and proposed conditions. WSELs for existing and proposed conditions converge a short distance downstream from the location of the bridge and the spatial extent of hydraulic changes associated with the proposed bridge (e.g., WSEL rise) are therefore limited.

The proposed bridge abutments will be founded on bedrock and scour at the bridge is not anticipated. Stable material sizing for scour countermeasure design is therefore also not required as part of the Study.

Based upon the findings described in this memo, we recommend the design of the proposed bridge continue to be advanced. Bridge openings and structural components should remain as presented herein, or if revised, should be re-evaluated for hydraulic considerations.

Appendix A HYDROLOGIC STATISTICS

WIN:	25529.00	**Project Name:**	East Machias, Chase Mills Bridge #5465
Town:	East Machias	**Stream Name:**	Chase Mills Stream
Route No.	Chase Mill Rd	**Bridge Name:**	Chase Mills
Asset ID:	5465	**Analysis by:**	csh
Lat:	44.75660 **Long:** -67.35990	**Date:**	11/2/2021

Peak Flow Calculations by USGS Regression Equations (Lombard/Hodgkins, 2021; Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

ver. 2021 Jan 01

	km^2	mi^2	ac	*Enter data in [mi^2]*
A	127.95	49.40	31616.0	Watershed Area *DRNAREA*
W	36.18	14.0	8941.0	Wetlands area (by NWI)
P_c	629832	4965606		watershed centroid (E, N; UTM 19N; meters)
County	Washington			*choose county from drop-down menu*

Worksheet prepared by:
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov

Watershed Characteristics from StreamStats

STORNWI	28.28	NWI Wetlands %
STORAGE	28.28	% of area of storage (lakes ponds reservoirs wetlands)
SANDGRAVF	0.012	sand & gravel aquifer as decimal fraction of watershed A
ELEV	129.3	mean basin elevation (ft)
BSLDEM10M	4.11	mean basin slope (%)
COASTDIST	33.00	distance from the coast (mi)
ELEVMAX	433.9	maximum basin elevation (ft)
LC06WATER	17.62	percent of drainage basin land cover as open water
PRECIP	48.3	mean annual precipitation
STATSGOA	8.3	mean basin percentage of hydrological soil group A

References:

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine
for Selected Recurrence Intervals
WRIR 99-4008, USGS Augusta, ME

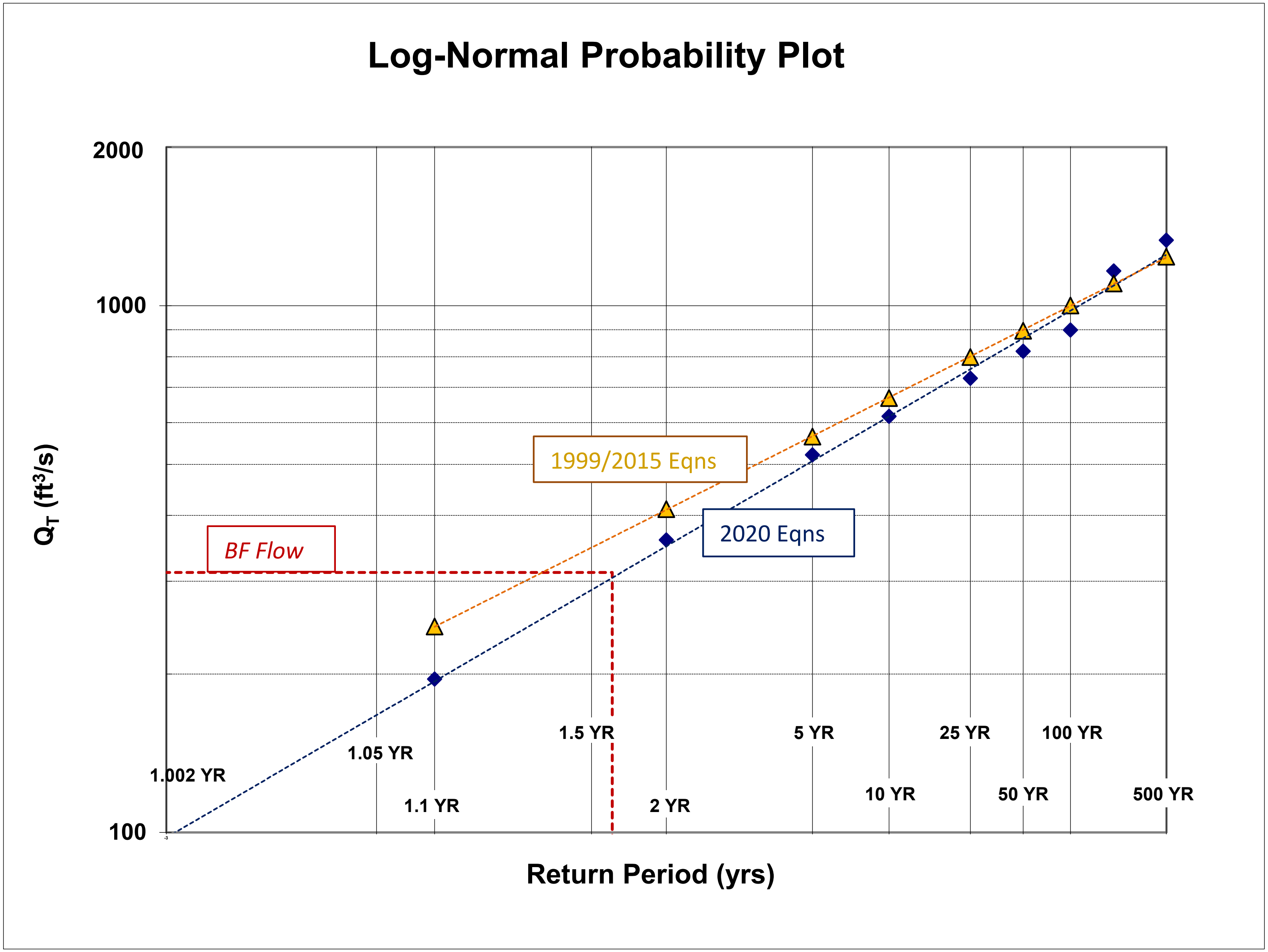
Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams:
in Maine: Comparing Map-Based to Field-Based Variables
SIR 2015-4059, USGS, Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2021.
Estimating Flood Magnitude and Frequency on Gaged and
Ungaged Streams in Maine
SIR 2021-xxxx, USGS, Augusta, ME.

Ret Pd T (yr)	I24	Q_T (ft^3/s) *1999 / 2015*	Q_T (ft^3/s) *2021*	Q_T (ft^3/s) *Design*
1.1		246	196	***195***
2	1.92	411	359	***360***
5	2.48	564	521	***520***
10	2.84	668	617	***615***
25	3.30	799	728	***730***
50	3.65	896	820	***820***
100	3.99	1002	899	***900***
200	5.26	1103	1164	***1165***
500	5.95	1239	1332	***1330***

Instructions:
Enter values in blue cells only, watershed & I24 data from StreamStats

Use results under "Design"
Check against gage data and FEMA studies if available
Questions? Check with ENV / Hydrology Section



Log-Normal Probability Plot
2000
1000
100
Q_T (ft³/s)
Return Period (yrs)
1999/2015 Eqns
2020 Eqns
BF Flow
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR

WIN:	25529.00	**Project Name:**	East Machias, Chase Mills Bridge #5465
Town:	East Machias	**Stream Name:**	Chase Mills Stream
Route No.	Chase Mill Rd	**Bridge Name:**	Chase Mills
Asset ID:	5465	**Analysis by:**	csh
Lat:	44.75660 **Long:** -67.35990	**Date:**	11/2/2021

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

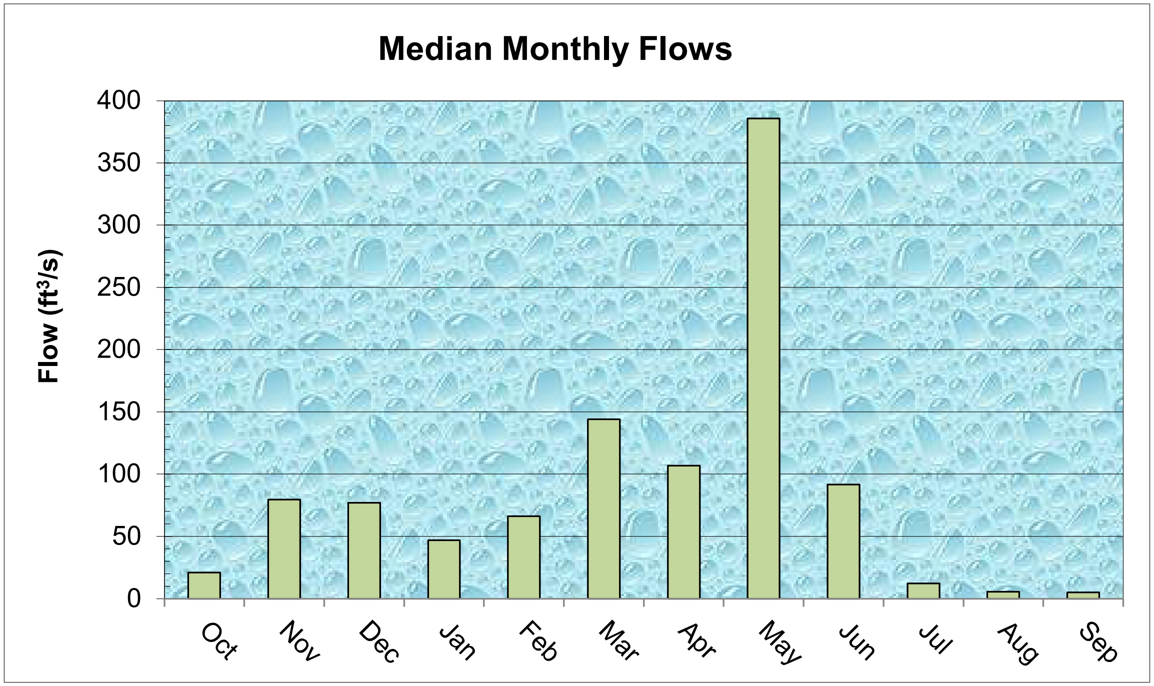
MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004, 2013, 2015)

	Value	Variable	Explanation
	49.40	*A*	Area (mi^2)
629832	4965606	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	32.63	*DIST*	Distance from Coastal reference line (mi)
	48.3	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**46.85**	1.3277
Feb	**66.08**	1.8728
Mar	**144.14**	4.0847
Apr	**106.86**	3.0282
May	**385.58**	10.9267
Jun	**91.72**	2.5991
Jul	**12.20**	0.3457
Aug	**5.46**	0.1546
Sep	**4.94**	0.1400
Oct	**21.08**	0.5975
Nov	**79.44**	2.2514
Dec	**76.92**	2.1799

Q_{bf}	**311.6**	
ann avg	**95.5**	
ann med	**43.2**	
$Q_{1.002}$	**96.8**	
$Q_{1.01}$	**124.5**	
$Q_{1.05}$	**168.0**	
Q_{bf}	**506.4**	assume v = 4ft/s

W_{bf}	**56.6**	estimated bankfull width (ft)
d_{bf}	**2.2**	estimated bankfull depth (ft)
A_{bf}	**130.2**	estimated bankfull flow area (ft^2)

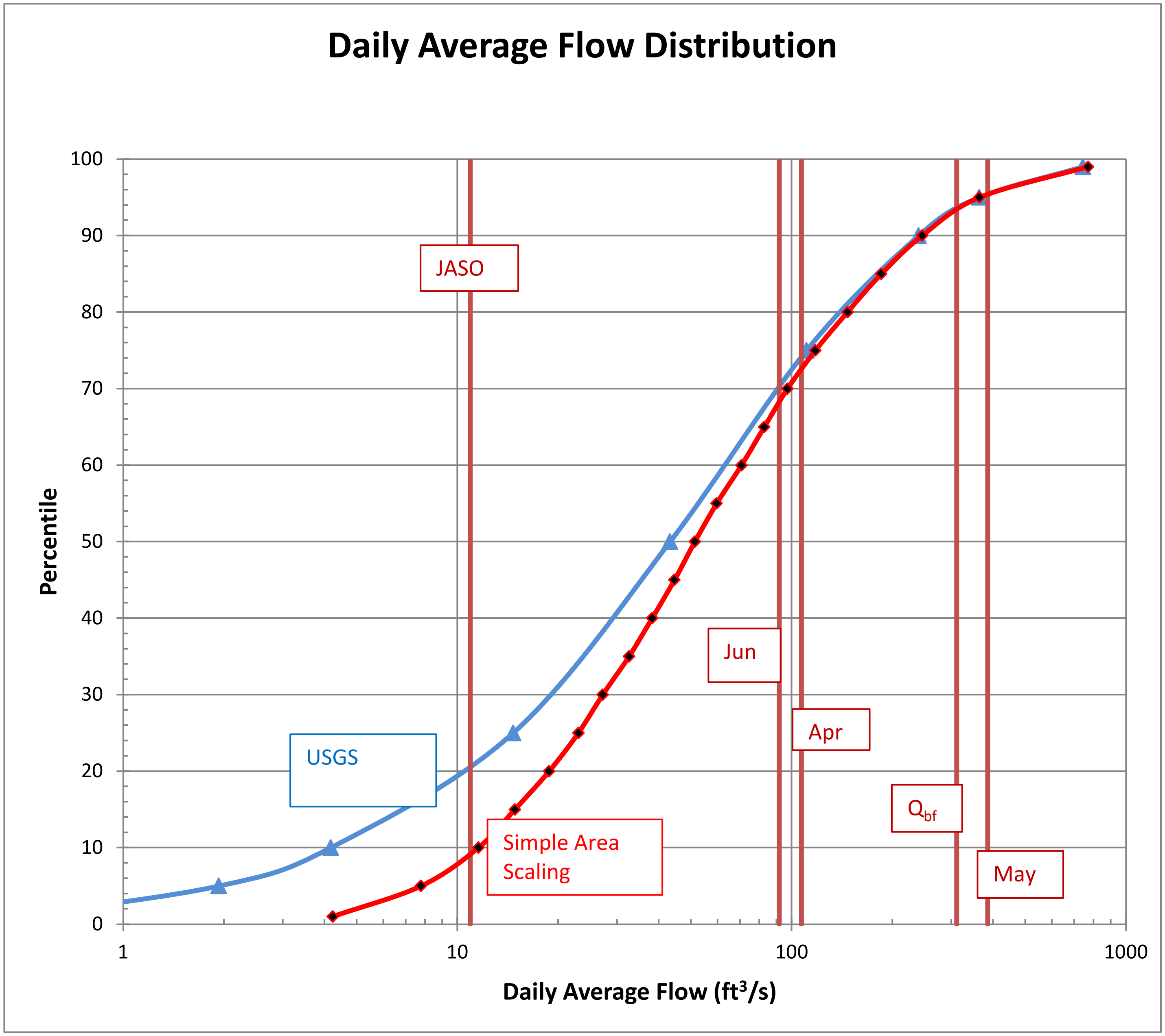


References

Dudley, 2013. FY2013 Progress Report - Phase 1 …, USFWS QRP Project

Dudley, 2004. Estimating Monthly Streamflows … , SIR 2004-5026

Dudley, 2015. Regression Equations for Monthly & Annual Mean..., USGS SIR 2015-5151



Daily Avg Flow Dist

A_{ws} = (mi^2) 49.4

Q (ft^3/s)

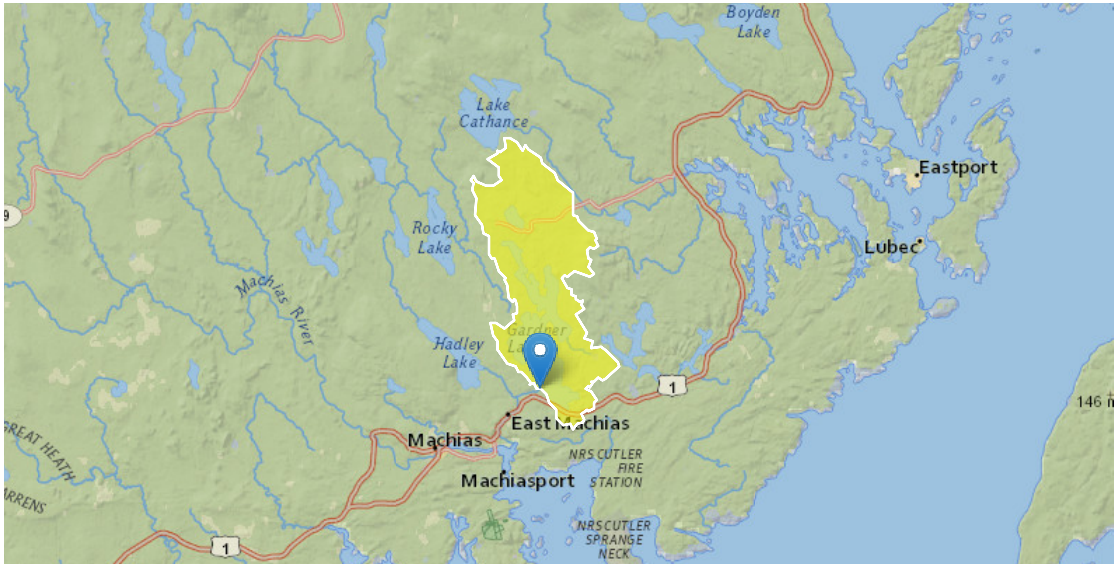
Pctl	Median	84th pctl
1	4.23	7.50
5	7.78	12.51
10	11.55	17.37
15	14.85	21.68
20	18.80	26.30
25	23.00	30.83
30	27.22	35.11
35	32.61	40.13
40	38.24	46.15
45	44.57	52.18
50	51.31	61.60
55	59.59	71.69
60	70.77	84.16
65	82.80	98.05
70	97.12	114.39
75	117.73	137.56
80	146.83	164.24
85	185.26	210.47
90	245.41	282.62
95	364.21	439.49
99	770.18	1013.97

Q_{bf}	311.6
$Q_{1.002}$	96.8
$Q_{1.1}$	195.5
Q_2	359.1

3000

East Machias 25529 Chase Mills Br #5465 Gardner Lk Outlet

Region ID:	ME
Workspace ID:	ME20211103193201777000
Clicked Point (Latitude, Longitude):	44.75664, -67.35990
Time:	2021-11-03 15:32:30 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	49.36	square miles
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.26	inches
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	30.425	percent
I24H5Y	Maximum 24-hour precipitation that occurs on average once in 5 years	3.99	inches
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.59	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.43	inches
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.07	inches
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	6.72	inches
I24H200Y	Maximum 24-hour precipitation that occurs on average once in 200 years	7.44	inches
I24H500Y	Maximum 24-hour precipitation that occurs on average once in 500 years	8.46	inches

Parameter Code	Parameter Description	Value	Unit
SANDGRAVAF	Fraction of land surface underlain by sand and gravel aquifers	0.012	dimensionless
ELEV	Mean Basin Elevation	129.3	feet
BSLDEM10M	Mean basin slope computed from 10 m DEM	4.11	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	629831.98	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	4965605.59	meters
COASTDIST	Shortest distance from the coastline to the basin centroid	33	miles
ELEVMAX	Maximum basin elevation	433.9	feet
LC06WATER	Percent of open water, class 11, from NLCD 2006	17.62	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	1.2	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	0.21	percent
PRDECFEB90	Basin average mean precipitation for December to February from PRISM 1961-1990	12.5	inches
PRECIP	Mean Annual Precipitation	48.3	inches
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	1.22	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	8.3	percent
STORNWI	Percentage of strorage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	28.28	percent

Peak-Flow Statistics Parameters [Statewide multiparameter peakflows SIR 2020 5092]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	0.26	5680
I24H2Y	24 Hour 2 Year Precipitation	3.26	inches	1.92	4.17
STORAGE	Percent Storage	30.425	percent	0	29.4
I24H5Y	24 Hour 5 Year Precipitation	3.99	inches	2.48	5.38
I24H10Y	24 Hour 10 Year Precipitation	4.59	inches	2.84	6.38
I24H25Y	24 Hour 25 Year Precipitation	5.43	inches	3.3	7.75
I24H50Y	24 Hour 50 Year Precipitation	6.07	inches	3.65	8.79
I24H100Y	24 Hour 100 Year Precipitation	6.72	inches	3.99	9.88
I24H200Y	24 Hour 200 YearPrecipitation	7.44	inches	5.26	11.1
I24H500Y	24 Hour 500 Year Precipitation	8.46	inches	5.95	13.1

Peak-Flow Statistics Disclaimers [Statewide multiparameter peakflows SIR 2020 5092]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report [Statewide multiparameter peakflows SIR 2020 5092]

Statistic	Value	Unit
50-percent AEP flood	552	ft^3/s
20-percent AEP flood	744	ft^3/s
10-percent AEP flood	875	ft^3/s
4-percent AEP flood	1040	ft^3/s
2-percent AEP flood	1170	ft^3/s
1-percent AEP flood	1300	ft^3/s
0.5-percent AEP flood	1450	ft^3/s
0.2-percent AEP flood	1600	ft^3/s

Peak-Flow Statistics Citations

Lombard, P.J., and Hodgkins, G.A.,2020, Estimating flood magnitude and frequency on gaged and ungaged streams in Maine: U.S. Geological Survey Scientific Investigations Report 2020–5092, 56 p. (https://doi.org/10.3133/sir20205092)

Flow-Duration Statistics Parameters [Statewide Annual SIR 2015 5151]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	14.9	1419
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.012	dimensionless	0	0.212
ELEV	Mean Basin Elevation	129.3	feet	239	2120

Flow-Duration Statistics Disclaimers [Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report [Statewide Annual SIR 2015 5151]

Statistic	Value	Unit
1 Percent Duration	0.486	ft^3/s
5 Percent Duration	1.93	ft^3/s
10 Percent Duration	4.17	ft^3/s
25 Percent Duration	14.7	ft^3/s
50 Percent Duration	43.2	ft^3/s
75 Percent Duration	111	ft^3/s
90 Percent Duration	239	ft^3/s
95 Percent Duration	364	ft^3/s

Statistic	Value	Unit
99 Percent Duration	743	ft^3/s

Flow-Duration Statistics Citations

Dudley, R.W.,2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p. (http://dx.doi.org/10.3133/sir20155151)

Annual Flow Statistics Parameters [Statewide Annual SIR 2015 5151]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	14.9	1419
SANDGRAVAF	Fraction of Sand and Gravel Aquifers	0.012	dimensionless	0	0.212
ELEV	Mean Basin Elevation	129.3	feet	239	2120

Annual Flow Statistics Disclaimers [Statewide Annual SIR 2015 5151]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Annual Flow Statistics Flow Report [Statewide Annual SIR 2015 5151]

Statistic	Value	Unit
Mean Annual Flow	95.4	ft^3/s

Annual Flow Statistics Citations

Dudley, R.W.,2015, Regression equations for monthly and annual mean and selected percentile streamflows for ungaged rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2015–5151, 35 p. (http://dx.doi.org/10.3133/sir20155151)

Bankfull Statistics Parameters [Central and Coastal Bankfull 2004 5042]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	2.92	298

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	49.36	square miles	0.07722	59927.7393

Bankfull Statistics Flow Report [Central and Coastal Bankfull 2004 5042]

Statistic	Value	Unit
Bankfull Streamflow	311	ft^3/s
Bankfull Width	58.3	ft
Bankfull Depth	2.24	ft
Bankfull Area	130	ft^2

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	76.6	ft
Bieger_D_channel_depth	3.43	ft
Bieger_D_channel_cross_sectional_area	268	ft^2

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	75.3	ft
Bieger_P_channel_depth	3.24	ft
Bieger_P_channel_cross_sectional_area	253	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	48.9	ft
Bieger_USA_channel_depth	2.77	ft
Bieger_USA_channel_cross_sectional_area	140	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bankfull Streamflow	311	ft^3/s

Statistic	Value	Unit
Bankfull Width	58.3	ft
Bankfull Depth	2.24	ft
Bankfull Area	130	ft^2
Bieger_D_channel_width	76.6	ft
Bieger_D_channel_depth	3.43	ft
Bieger_D_channel_cross_sectional_area	268	ft^2
Bieger_P_channel_width	75.3	ft
Bieger_P_channel_depth	3.24	ft
Bieger_P_channel_cross_sectional_area	253	ft^2
Bieger_USA_channel_width	48.9	ft
Bieger_USA_channel_depth	2.77	ft
Bieger_USA_channel_cross_sectional_area	140	ft^2

Bankfull Statistics Citations

Dudley, R.W.,2004, Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042, 30 p (http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf)

Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

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StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2