TOWN OF STODDARD, NH
KING'S HIGHWAY CULVERT REPLACMENT
OVER KENNEDY BROOK
D&K Project No. 325288

ADDENDUM NO. 1

December 7, 2020

TO: PROSPECTIVE BIDDERS

FROM: DuBois & King, Inc.
15 Constitution Drive, Suite 1L
Bedford, NH 03110

This Addendum forms part of the Contract Documents and modifies the original Bidding Documents dated November 20, 2020. **NOTE: Contractor to Acknowledge receipt of this Addendum in the space provided on Page 1 of the Bid Form (Section 00410, Page 00410-1). Failure to do so may subject the Bidder to disqualification.**

I. CONTRACT DOCUMENTS (SPECIFICATIONS) CHANGES

A. SECTION 111 – ADVERTISEMENT FOR BIDS

1. **Insert** the following sentence at the end of the second paragraph as follows:

   … "NHDOT has posted the existing bridge for 10 tons."

B. SECTION 410 – BID FORM, ARTICLE 5 – BASIS OF BID, Paragraph 5.01:

1. Page 5 **Insert** the following new Bid Item

   504.2 Rock Bridge Excavation, per cubic yard;

   ________________________________Dollars and 50 C.Y.
   ___________________ Cents ($________________) $__________________

2. Page 9 **Insert** the following new Bid Item:

   1008.11 Alterations and Additions as Needed – Unanticipated Work, per allowance;

   ______Ten Thousand______________Dollars and 1 Allowance
   ___________________ Cents ($________________) $_____10,000.00_____

3. **Delete** Section 00410 – Bid Form in its entirety (10 pages). **Replace** with Bid Form, Revised 12/7/20 (11 pages), attached.

C. SECTION 850 – SPECIAL CONDITIONS

1. PARAGRAPH 1.08 UTILITIES, **insert** new subparagraph – C as follows:

   C. Temporary power shutdowns will not be permitted. Any anticipated work (temporary pole relocations, site review with field technician, etc.) shall be coordinated with:

Eversource
Builders & Contractors Phone#: 603-536-8621

D. APPENDIX

1. **Insert** the Hydrologic &Hydraulic Analysis Report at the end of the Appendix (attached).

II. PLANS (DRAWINGS) CHANGES

A. SHEET NO. 6 – SUMMARY OF QUANTITIES

1. BRIDGE ITEMS (TABLE)

Insert the following new items:

504.2	ROCK BRIDGE EXCAVATION	CY	50

1008.11	ALTERATIONS AND ADDITIONS AS NEEDED - UNANTICIPATED WORK	$	10000

III. ADDITIONAL INFORMATION OR CLARIFICATION

A. The Bid Form has been revised (revised 12/7/20) to address changes to this document in this Addendum No. 1.

1. Revised Bid Form is hereby **reissued** to prospective bidders for use in completing and submitting a Bid for this project. Bid Form, Revised 12/7/20, is attached.

B. Temporary power shutdowns will not be permitted. Any anticipated work (temporary pole relocations, site review with field technician, etc.) shall be coordinated with Eversource. Contact information provided in section 00850 – Special Conditions.

IV. ATTACHMENTS

- Advertisement for Bid, Revised 12/7/20
- Bid Form, Revised 12/7/20
- Appendix – H&H Report

END ADDENDUM

TOWN OF STODDARD, NH
KING'S HIGHWAY CULVERT REPLACEMENT OVER KENNEDY BROOK

ADVERTISEMENT FOR BIDS
REVISED 12/7/20

Sealed bids for the Construction of the King's Highway Culvert Replacement over Kennedy Brook will be received by the Town of Stoddard, at the office of the Selectman's Office, 1450 Route 123 North, Stoddard, NH 03464, until 4:00 PM local time on, Monday, December 14, 2020, at which time the Bids received will be publicly opened and read.

This project consists of total removal of the two existing corrugated metal pipe (CMP) culverts, construction of a cast-in-place 3-sided rigid frame culvert, bridge rail and approach rail, earthwork, drainage, approach gravel roadway work. Traffic shall be maintained for the duration of the project using phased construction. Precast units may be substituted for all cast-in-place units (rigid frame, footings, headwalls, wingwalls, etc.) at no additional cost at the request of the contractor. NHDOT has posted the existing bridge for 10 tons.

Bids will be received for a single prime Contract. Bids shall be on a lump sum and unit price basis as indicated in the Bid Form.

The anticipated project schedule is to start construction on or about December 21, 2020 and complete construction by June 25, 2021.

The Issuing Office for the Bidding Documents is: DuBois & King, Inc., 15 Constitution Drive, Suite 1L, Bedford, NH 03110, Contact: James Hall @ 603-637-1043 Ext. 4411. Prospective Bidders may examine the Bidding Documents at the Issuing Office on Mondays through Fridays between the hours of 8:00 am to 4:30 pm, and may obtain copies of the Bidding Documents from the Issuing Office as described below.

Bidding Documents may also be examined at the office of the following during normal business hours:

1. The Owner:
   Town of Stoddard
   1450 Route 123 North
   Stoddard, NH 03464

2. Construction Summary of New Hampshire
   734 Chestnut Street
   Manchester NH 03104

4. Associated General Contractors of NH
   48 Grandview Road
   Bow NH 03304

5. Works in Progress, Inc.
   20 Farrell Street
   South Burlington VT 05403-6112

6. Reprographics of New England
   450 Weaver Street
   Winooski VT 05404

Copies of Bidding Documents may be obtained at the office of the Engineer, DuBois & King, Inc. (Bedford, NH office), or downloaded online, on or after Friday, November 20, 2020.

Bidding Documents may be downloaded online by registering at www.dubois-king.com/projects-bidding-active for a non-refundable charge of $75.00. Alternatively, PDF on Compact Disc or printed Bidding Documents may be obtained from the Issuing Office either via in-person pick-up or via mail, upon Issuing Office's receipt of payment for Bidding Documents. The non-refundable cost of a Compact Disc or printed Bidding Documents is $75.00 per set including shipping via overnight express service. Make checks payable to "DuBois & King, Inc." The date that the Bidding Documents are transmitted by the Issuing Office will be considered the prospective Bidder's date of receipt of the Bidding Documents. Partial sets of Bidding Documents will not be available from the Issuing Office. Only Bid Documents obtained from the Issuing Office shall be used for submitting a Bid. Neither Owner nor Engineer will be responsible for full or partial sets of Bidding Documents, including Addenda if any, obtained from sources other than the Issuing Office.

A pre-bid conference will be held at the project site at 10:00 am on Friday, December 4, 2020. Attendance at the pre-bid conference is highly encouraged but is not mandatory.

Prequalification: All Bidders (Prime Contractor or Contractor/Subcontractors Teams) must be listed by the New Hampshire Department of Transportation as prequalified for Bridge Construction. See Instructions to Bidders.

Attachments: The documents listed in Article 7 of Section 00410 - Bid Form shall be furnished and submitted with a bid.

Bid Security shall be furnished in accordance with the Instructions to Bidders.

Owner: Ms. Michelle Pong, Town Administrator
Town of Stoddard
1450 Route 123 North
Stoddard, NH 03464
November 20, 2020
Revised: December 7, 2020

END OF ADVERTISEMENT FOR BIDS

BID FORM

REVISED 12/7/20

KING'S HIGHWAY CULVERT REPLACEMENT OVER KENNEDY BROOK

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ARTICLE 1 – BID RECIPIENT

1.01 This Bid is submitted to:

Ms. Michelle Pong, Town Administrator, Town of Stoddard, 1450 Route 123 North, Stoddard, NH 03464

1.02 The undersigned Bidder proposes and agrees, if this Bid is accepted, to enter into an Agreement with Owner in the form included in the Bidding Documents to perform all Work as specified or indicated in the Bidding Documents for the prices and within the times indicated in this Bid and in accordance with the other terms and conditions of the Bidding Documents.

ARTICLE 2 – BIDDER'S ACKNOWLEDGEMENTS

2.01 Bidder accepts all of the terms and conditions of the Instructions to Bidders, including without limitation those dealing with the disposition of Bid security. This Bid will remain subject to acceptance for 60 days after the Bid opening, or for such longer period of time that Bidder may agree to in writing upon request of Owner.

ARTICLE 3 – BIDDER'S REPRESENTATIONS

3.01 In submitting this Bid, Bidder represents that:

A. Bidder has examined and carefully studied the Bidding Documents, and any data and reference items identified in the Bidding Documents, and hereby acknowledges receipt of the following Addenda posted on the Engineer's website:

Addendum No.	Addendum, Date
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

B. Bidder has visited the Site, conducted a thorough, alert visual examination of the Site and adjacent areas, and become familiar with and satisfied itself as to the general, local, and Site conditions that may affect cost, progress, and performance of the Work.

C. Bidder is familiar with and has satisfied itself as to all Laws and Regulations that may affect cost, progress, and performance of the Work.

D. Bidder has carefully studied all: (1) reports of explorations and tests of subsurface conditions at or adjacent to the Site and all drawings of physical conditions relating to existing surface or subsurface structures at the Site that have been identified in the Supplementary Conditions, especially with respect to Technical Data in such reports and drawings, and (2) reports and drawings relating to Hazardous Environmental Conditions, if any, at or adjacent to the Site that have been identified in the Supplementary Conditions, especially with respect to Technical Data in such reports and drawings.

E. Bidder has considered the information known to Bidder itself; information commonly known to contractors doing business in the locality of the Site; information and observations obtained from visits to the Site; the Bidding Documents; and any Site-related reports and drawings identified in the Bidding Documents, with respect to the effect of such information, observations, and documents on (1) the cost, progress, and performance of the Work; (2) the means, methods, techniques, sequences, and procedures of construction to be employed by Bidder; and (3) Bidder's safety precautions and programs.

F. Bidder agrees, based on the information and observations referred to in the preceding paragraph, that no further examinations, investigations, explorations, tests, studies, or data are necessary for the determination of this Bid for performance of the Work at the price bid and within the times required, and in accordance with the other terms and conditions of the Bidding Documents.

G. Bidder is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents.

H. Bidder has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder has discovered in the Bidding Documents, and confirms that the written resolution thereof by Engineer is acceptable to Bidder.

I. The Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for the performance and furnishing of the Work.

J. The submission of this Bid constitutes an incontrovertible representation by Bidder that Bidder has complied with every requirement of this Article, and that without exception the Bid and all prices in the Bid are premised upon performing and furnishing the Work required by the Bidding Documents.

ARTICLE 4 – BIDDER'S CERTIFICATION

4.01 Bidder certifies that:

A. This Bid is genuine and not made in the interest of or on behalf of any undisclosed individual or entity and is not submitted in conformity with any collusive agreement or rules of any group, association, organization, or corporation;

B. Bidder has not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid;

C. Bidder has not solicited or induced any individual or entity to refrain from bidding; and

D. Bidder has not engaged in corrupt, fraudulent, collusive, or coercive practices in competing for the Contract. For the purposes of this Paragraph 4.01.D:

1. "corrupt practice" means the offering, giving, receiving, or soliciting of any thing of value likely to influence the action of a public official in the bidding process;
2. "fraudulent practice" means an intentional misrepresentation of facts made (a) to influence the bidding process to the detriment of Owner, (b) to establish bid prices at artificial non-competitive levels, or (c) to deprive Owner of the benefits of free and open competition;
3. "collusive practice" means a scheme or arrangement between two or more Bidders, with or without the knowledge of Owner, a purpose of which is to establish bid prices at artificial, non-competitive levels; and
4. "coercive practice" means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the bidding process or affect the e execution of the Contract.

ARTICLE 5 – BASIS OF BID

5.01 Bidder will complete the Work in accordance with the Contract Documents for the following price(s):

Item No.	Brief Description - Unit or Lump Sum Price (in both words and numerals)	Estimated Quantity	Total Bid Price (in numerals)
203.1	Common Excavation, per cubic yard; ________________________Dollars and ________________ Cents ($__________)	325 C.Y.	$____________
203.5572	Guardrail EAGRT Offset Platform Alternate, TL 2 – 25', per unit; ________________________Dollars and ________________ Cents ($__________)	4 U	$____________
203.6	Embankment-In-Place, per cubic yard; ________________________Dollars and ________________ Cents ($__________)	290 C.Y.	$____________
207.3	Unclassified Channel Excavation, per cubic yard; ________________________Dollars and ________________ Cents ($__________)	140 C.Y.	$____________

209.201 Granular Backfill (Bridge), per cubic yard;

____Dollars and 250 C.Y.

_____________________________ Cents ($__________________) $____________________

214. Fine Grading, per unit;

____Dollars and 1 U

_____________________________ Cents ($__________________) $____________________

304.3 Crushed Gravel, per cubic yard;

____Dollars and 570 C.Y.

_____________________________ Cents ($__________________) $____________________

304.35 Crushed Gravel for Drives, per cubic yard;

____Dollars and 10 C.Y.

_____________________________ Cents ($__________________) $____________________

503.201 Cofferdams, per unit;

____Dollars and 1 U

_____________________________ Cents ($__________________) $____________________

504.1 Common Bridge Excavation, per cubic yard;

____Dollars and 650 C.Y.

_____________________________ Cents ($__________________) $____________________

504.2 Rock Bridge Excavation, per cubic yard;

____Dollars and 50 C.Y.

__________________________ Cents ($________________) $___________________

520.001 Concrete Class AAA, per cubic yard;

____Dollars and 75 C.Y.

__________________________ Cents ($________________) $___________________

520.1 Concrete Class A, per cubic yard;

____Dollars and 23 C.Y.

__________________________ Cents ($________________) $___________________

520.2 Concrete Class B, per cubic yard;

____Dollars and 60 C.Y.

__________________________ Cents ($________________) $___________________

520.211 Concrete Class B, Footings (On Rock), per cubic yard;

____Dollars and 20 C.Y.

__________________________ Cents ($________________) $___________________

534.3 Water Repellent (Silane/Siloxane), per gallon;

____Dollars and 5 GAL

__________________________ Cents ($________________) $___________________

544.201 Reinforcing Steel – Epoxy Coated, per pound;

____Dollars and 23500 LB

___________________________ Cents ($________________) $___________________

563.3 Bridge Rail T101, per linear foot;

____Dollars and 55 L.F.

___________________________ Cents ($________________) $___________________

585.2 Stone Fill, Class B, per cubic yard;

____Dollars and 145 C.Y.

___________________________ Cents ($________________) $___________________

593.421 Geotextile; Perm Control Cl. 2, Non-Woven, per square yard;

____Dollars and 500 S.Y.

___________________________ Cents ($________________) $___________________

606.12551 Beam Guardrail (Terminal Unit Type EAGRT, TL 2 – 25') (Steel Post), per unit;

____Dollars and 4 U

___________________________ Cents ($________________) $___________________

606.1285 Beam Guardrail (Bridge Approach Unit), per unit;

____Dollars and 4 U

___________________________ Cents ($________________) $___________________

606.18001 31” W-Beam Guardrail With 8” Offset Block (Steel Post), per linear foot;

____Dollars and 262.5 L.F.

___________________________ Cents ($________________) $___________________

615.03 Traffic Sign Type C, per square foot;

____Dollars and 5 S.F.

___________________________ Cents ($________________) $___________________

615.033 Removing Traffic Sign, Type C, per unit;

____Dollars and 2 U

___________________________ Cents ($________________) $___________________

619.1 Maintenance of Traffic, per unit;

____Dollars and 1 U

___________________________ Cents ($________________) $___________________

645.531 Silt Fence, per linear foot;

____Dollars and 410 L.F.

___________________________ Cents ($________________) $___________________

645.7 Storm Water Pollution Prevention Plan, per unit;

____Dollars and 1 U

___________________________ Cents ($________________) $___________________

645.711 Monitoring SWPPP and Erosion and Sediment Controls, per visit;

____Dollars and 16

VISIT

____________________________ Cents ($_________________) $____________________

646.31 Turf Establishment with Mulch and Tackifiers, per square yard;

____Dollars and 475

S.Y.

____________________________ Cents ($_________________) $____________________

647.1 Humus, per cubic yard;

____Dollars and 52

C.Y.

____________________________ Cents ($_________________) $____________________

670.046 Construct and Remove Temporary Widening, per unit;

____Dollars and 1

U

____________________________ Cents ($_________________) $____________________

670.067 Relocate Multiple Mailboxes, per unit;

____Dollars and 1

U

____________________________ Cents ($_________________) $____________________

692. Mobilization, per unit;

____Dollars and 1

U

____________________________ Cents ($_________________) $____________________

699. Miscellaneous Temporary Erosion and Sediment Control, per allowance;

_______Three Thousand____________________Dollars and 1 Allowance

___________________________ Cents ($________________) $______3,000.00______

1008.11 Alterations and Additions as Needed – Unanticipated Work, per allowance;

_______Ten Thousand_____________________Dollars and 1 Allowance

___________________________ Cents ($________________) $______10,000.00_____

* Unit Bid Items and Authorized Addition or Reduction payment items shall be applied to additions or reductions in the scope of work. Indeterminate Quantity assumed for comparison for bids.

Total of All Unit Price Bid Items (BASE BID) ($_________________________)

Notes:

1. Bidder acknowledges that (a) each Bid Unit Price includes an amount considered by Bidder to be adequate to cover Contractor's overhead and profit for each separately identified item, and (b) estimated quantities are not guaranteed, and are solely for the purpose of comparison of Bids, and final payment for all unit price Bid items will be based on actual quantities, determined as provided in the Contract Documents.
2. Unit Prices have been computed in accordance with Paragraph 13.03.B of the General Conditions.
3. In the event that there is a discrepancy between the lump sum or unit prices written in words and figures, the prices written in words shall govern.
4. BIDDERS must bid on each item. All entries in the entire BID must be made clearly and in ink; prices bid must be written in both words and in figures.
5. BIDDERS must insert extended item prices obtained from quantities and unit prices.
6. BIDS shall include all applicable taxes and fees.

ARTICLE 6 – TIME OF COMPLETION

6.01 Bidder agrees that the Work will be substantially complete and will be completed and ready for final payment in accordance with Paragraph 15.06 of the General Conditions on or before the dates or within the number of calendar days indicated in the Agreement.

6.02 Bidder accepts the provisions of the Agreement as to liquidated damages.

ARTICLE 7 – ATTACHMENTS TO THIS BID

7.01 The following documents are submitted with and made a condition of this Bid:

A. Required Bid security;

B. List of Subcontractors;

C. List of Suppliers;

D. Proposed Construction Schedule.

ARTICLE 8 – DEFINED TERMS

8.01 The terms used in this Bid with initial capital letters have the meanings stated in the Instructions to Bidders, the General Conditions, and the Supplementary Conditions.

ARTICLE 9 – BID SUBMITTAL

BIDDER: [Indicate correct name of bidding entity]

____

By:
[Signature] ____

[Printed name] ____
(If Bidder is a corporation, a limited liability company, a partnership, or a joint venture, attach evidence of authority to sign.)

Attest:
[Signature] ____

[Printed name] ____

Title: ____

Submittal Date: ____

Address for giving notices:

____

____

____

Telephone Number: ____

Fax Number: ____

Contact Name and e-mail address: ____________________________________

____

Bidder's License No.: ____
(where applicable)

APPENDIX

H&H REPORT

Hydrologic and Hydraulic Analysis for King's Highway Culvert Replacement

Stoddard, New Hampshire
Cheshire County

Prepared for:

Stoddard
NEW HAMPSHIRE

Town of Stoddard
1450 Route 123 North
Stoddard, NH 03464

Prepared by:

DuBois & King inc.

15 Constitution Drive, Suite 1L
Bedford, NH 03110
Phone: (603) 637-1043

Project No. 325288

September 2020

Hydrologic and Hydraulic Analysis for
King's Highway Culvert Replacement

Stoddard, New Hampshire

Table of Contents

1.0 EXECUTIVE SUMMARY

This report summarizes the techniques used to assess the existing stream crossing and replacement alternatives for the King's Highway crossing on Kennedy Brook in Stoddard, New Hampshire. The hydraulic analysis evaluates the existing crossing and proposed alternatives in reference to applicable design criteria outlined by the New Hampshire Department of Environmental Services (NHDES) and the New Hampshire Department of Transportation (NHDOT) for stream crossing structure replacements.

DuBois and King performed a preliminary visual evaluation of the existing crossing in the spring of 2019 and a subsequent field survey in July 2020, to obtain existing culvert and channel geometries. The existing crossing conveys Kennedy Brook easterly beneath King's Highway via two 54-inch corrugated metal pipe (CMP) culverts for a combined hydraulic opening width of 9-feet. There is approximately 18-inches of separation between the two culverts which brings the combined span of the crossing to 10.5-feet. The existing culverts are in poor condition, exhibiting signs of deterioration along the inverts and section loss along the interior of the pipes. The inlets and outlets of the culverts have headwalls that were constructed with dry-laid stone. The inlet headwall is showing signs of deterioration, leaving the upstream bank unprotected during high flow events. The full summary assessment of the existing crossing is included in **Appendix A**.

Based on this preliminary assessment, the Town of Stoddard requested DuBois & King to evaluate replacement alternatives for the existing crossing. Three alternatives to the existing crossing were designed to meet the following requirements:

- Convey the 50-year (2% AEP) storm event while maintaining 1-foot of freeboard between the water surface elevation (WSE) and the lowest point on the bridge (low chord elevation)
- Comply with NHDES Env-Wt 904 criteria (1.2 x the bankfull width plus 2-feet)
- Convey the 100-year (0.1% AEP) storm event without overtopping the road

Based on the results of the hydrologic and hydraulic analysis for the project, the study reached following conclusions with regards to the King's Highway crossing:

1. The results suggest that the existing structure does not meet the NHDOT design criteria of passing the 50-year (2% AEP) storm event while maintaining 1-foot of freeboard or conveying the 100-year (1% AEP) discharges without overtopping the road. Additionally the existing structure does not meet the NHDES bankfull width design criteria.

2. Several replacement alternatives were selected that partially satisfy the NHDOT and NHDES design criteria. All selected alternatives offer improvement over existing conditions and are described further below:

    a. Alternative A (20-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES bankfull width, 50-year, and 100-year design criteria previously discussed. The results suggest Alternative A does offer improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

b. Alternative B (25-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES 50-year and 100-year design criteria previously discussed. The results suggest that Alternative B can pass the 100-year storm event without overtopping the road. The results suggest Alternative B offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

c. Alternative C (30-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES 50-year, and 100-year design criteria previously discussed. The results suggest that Alternative C can pass the 100-year storm event without overtopping the road. The results suggest Alternative C offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

d. Alternative D (25-foot x 6-foot Box Culvert) meets the NHDOT 50-year and NHDES 100-year storm design criteria. Alternative D does meet the NHDES bankfull width design criteria. The results suggest Alternative D offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

3. The replacement culvert should have a simulated streambed bottom with gradations matching what is observed in the natural channel.

4. The results suggested that none of the replacement alternatives had a more than negligible effect on water surface elevation, velocity, and flood depths observed at the downstream private driveway crossing.

2.0 DESIGN CONSIDERATIONS

2.1 Hydraulic Capacity

NHDES designates any contributing water shed greater than 640-acres (1.0-square miles) as a Tier 3 stream crossing. At the King's Highway crossing the contributing area for Kennedy Brook is approximately 2.07-Square Miles (see **Appendix D**). As such, the crossing is required to comply with NHDES Env-Wt 904.01 and Env-Wt 904.05 Tier 3 stream crossing design criteria.

NHDOT guidelines require that municipal culverts larger than 54-inches in diameter be able to convey the 50-year or 2% annual exceedance probability (AEP). If the crossing span is larger than 10-feet the structure is required to pass the 2% AEP while maintaining 1-foot of freeboard between the water surface elevation (WSE) and the lowest point on the bridge (low chord elevation).

2.2 Fluvial Geomorphology

State and Federal agencies require that stream crossing designs account for the fluvial geomorphic characteristics of rivers and streams. This requires consideration for characteristics of the streams interaction and movement within the landscape. The intent is to design crossings in such a way that maintains the hydraulic continuity through the crossing during channel-forming (high-flow) events. This can largely be achieved by making structures, at a minimum, as wide as the bankfull channel width.

The US Army Corps of Engineers Programmatic General Permit for New Hampshire (an umbrella permit that allows most wetland and stream projects to avoid a separate federal permit) requires that stream crossings be based on geomorphic and ecologic principals. NHDES requires that crossings comply with the University of New Hampshire Stream Crossing Guidelines (May, 2009), which are incorporated by reference into NHDES stream crossing regulations. The guidelines recommend as a default that stream crossings be 1.2 times the bankfull width plus 2 feet.

The State of New Hampshire developed Regional Hydraulic Geometry Curves in 2005, which estimate bankfull channel width as a function of drainage area. The curves determined the bankfull width for the King's Highway crossing to be 17.8-feet. Applying the 2009 NHDES Stream Crossing Guidelines to the regional curve bankfull width, a stream crossing width of 24-feet would be required at this site (1.2 times bankfull width plus 2 feet). See **Appendix B** for the bankfull width calculation. Based on a field visit conducted in August 2020 the bankfull width was estimated to be 19-feet. Applying the NHDES guidelines to the measured value the crossing should span 25-feet.

2.3 FEMA Floodplain Regulations

Local municipalities regulate development within their respective floodplains following the requirements of the National Flood Insurance Program (NFIP). The effective Flood Insurance Rate Maps (FIRM) for Kennedy Brook are part of the Flood Insurance Study (FIS for Cheshire County, NH dated revised May 23, 2006). This site is presently not mapped as a flood hazard area. No base flood elevations or floodway have been established. No peak discharge data for Kennedy Brook is available. The FIRM for the project site is included in **Appendix C**.

2.4 Nearby Structures

Kennedy Brook crosses a private driveway approximately 3,300-feet downstream from the King's Highway crossing. Geometry for the additional crossing was obtained from a field visit in August 2020. The existing crossing is a stringer bridge with a clear span and height of approximately 20-feet and 7-feet, respectively. The structure width was estimated from LiDAR information and determined to be approximately 25-feet. Elevation information for the crossings inverts was estimated from the available LiDAR data. Along with the concerns previously discussed, the proposed replacement alternatives were assessed on their potential impacts to the downstream crossing. Based on the results of the existing conditions hydraulic analysis it was determined that the downstream structure was inundated during the three storm events assessed. Furthermore, the results suggest that the increased hydraulic capacity of the King's Highway crossing had a less than negligible effect on the water surface elevation and water velocities observed at the private driveway crossing.

3.0 HYDROLOGY

3.1 Watershed Characteristics

The contributing drainage area at the King's Highway crossing is substantially forest with some wetland areas (less than 2% of the total drainage area based on USGS StreamStats results). The total drainage area was delineated using contours derived from LiDAR elevation information and determined to be 2.07-square miles. StreamStats estimated the slope of the basin was estimated to be approximately 0.140-feet per foot. Based on the available survey data the main channel slope at the King's Highway crossing was estimated to be 0.0104-feet per foot.

Flow paths were through the watershed were also estimated using the LiDAR contours. The paths were used to determine the time of concentration through the drainage area. The time of concentration for the subcatchment was determined using the NRCS Velocity Method, as defined in the National Engineers Handbook Part 630 Hydrology, Chapter 15, Time of Concentration. This method involves diving the longest flow path into flow types (sheet, shallow concentrated, and channel), calculating the average velocity, then determining the time of concentration for each section. The time of concentration results are included in the HydroCAD output results in **Appendix F.**

Prior to the confluence with Highland Lake an unnamed tributary converges with Kennedy Brook approximately 3,300-feet downstream of the King's Highway crossing. Using the same methods as described above, the tributary's contributing area at the confluence with Kennedy Brook was determined to be 0.16-square miles. StreamStats estimated the basin slope to be approximately 0.167-feet per foot.

In addition to the topographical information, soil types within the watersheds play a key role in determining the runoff generated by a given storm event. Natural Resources and Conservation Services (NRCS) web soil survey was used to determine existing soil conditions and their respective hydrologic soil groups (HSG) within the watershed. Land cover type within the watershed was determined using orthoimagery. The soil types were paired with the existing land cover type to develop specific curve numbers (CN) for input into the hydrologic model. See **Appendix D** for a map of the delineated watersheds and NRCS soil mapping.

3.2 Estimated Peak Flows

The peak river discharges at the King's Highway crossing and tributary confluence were estimated from a hydrologic model using HydroCAD modeling software. Contours developed from the LiDAR DEM and existing orthoimagery were used to develop flow paths through the watershed. Rainfall estimates were obtained from the National Oceanic and Atmospheric Administration (NOAA) ATLAS-14 online web service. The rainfall data was imported into the modeling software as an intensity duration frequency file, then converted to a custom rainfall distribution for the watershed, see **Appendix E** for NOAA rainfall data. The land cover information, rainfall data, and flow paths discussed previously were then utilized to develop a site specific inflow hydrograph for the 2-year, 10-year, 25-year, 50-year, 100-year, and 500-year storms. Full HydroCAD results can be found in **Appendix F**.

Peak discharges at the King's Highway crossing and tributary confluence were also estimated using the United States Geological Survey (USGS) StreamStats application and USGS regional best fit equations. StreamStats utilizes regression equations to calculate peak flows as a function of the drainage area, percent of storage within the drainage area (wetlands), and mean annual precipitation. The USGS Streamstats documentation and results are included in **Appendix G**.

The regional best fit equations were derived from flow data obtained from "Estimation of Flood Discharges at Selected Recurrence Intervals for Streams in New Hampshire" USGS Scientific Investigations Report 2008-5206. Peak discharges for gauged sites were plotted as a function of drainage area to develop a CFS per square mile drainage area relationship. Plots for the 2-year, 10-year, 25-year, 50-year, 100-year, and 500-year storms can be found in **Appendix H**. This estimation was not done for the tributary, as the small contributing area was well outside of the drainage area values in the data set.

3.3 Results

Table 1 and Figure 1 show the summary of the calculated peak flows for a given annual exceedance probability (AEP) at the King's Highway crossing. The hydrologic analysis computed using HydroCAD (version 10.00) produced the highest peak discharges for all of the evaluated storm events. The results suggest that including watershed characteristics, such as the HSG classifications and calculated time of concentration paths for the watershed, yield a more conservative value than the StreamStats and USGS equations. The HydroCAD results are within the 90% prediction intervals of the StreamStats regression equations as seen in Figure 1. On the basis that they are considered a more detailed representation of the watershed and also fell within the 90% prediction interval of the StreamStats regression equations, the more conservative HydroCAD results were selected for use in the hydraulic assessment.

Figure 1: Summary Graph of Peak Flows at King's Highway Crossing

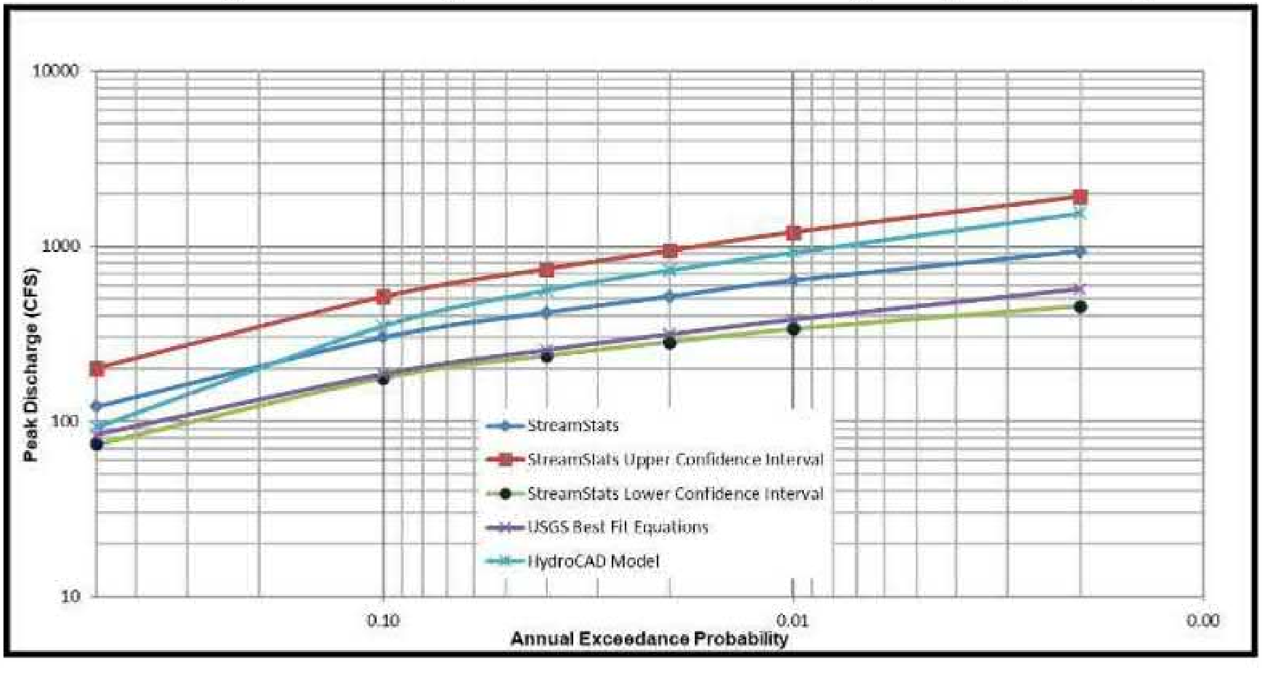


Table 1: Summary Table of Peak Flows (CFS) at King's Highway Crossing

Recurrence Interval [AEP]	USGS StreamStats	USGS Best Fit Equations	HydroCAD Model
2-Year [50%]	172	84	199
10-Year [10%]	368	186	497
25-Year [4%]	500	255	712
50-Year [2%]	616	314	887
100-Year [1%]	744	381	1074
500-Year [0.2%]	887	570	1288

Table 2 shows the summary of the calculated peak flows for a given AEP at the tributary's confluence with Kennedy Brook crossing. The hydrologic analysis computed in HydroCAD produced the highest peak flow results all storm event scenarios. It should be noted that the contributing are for the tributary (0.16-square miles) was outside of the limit for which the StreamStats regression equations should be applied (0.70 – 1290-square miles). Therefore, it was most reasonable to choose the HydroCAD results for use in the hydraulic analysis.

Table 2: Summary Table of Peak Flows (CFS) at Tributary Confluence

Recurrence Interval [AEP]	USGS StreamStats	HydroCAD Model
2-Year [50%]	14.2	19.17
10-Year [10%]	39	53.29
25-Year [4%]	56.4	78.12
50-Year [2%]	71.5	97.53
100-Year [1%]	90.1	118.93
500-Year [0.2%]	139	185.11

4.0 HYDRAULICS

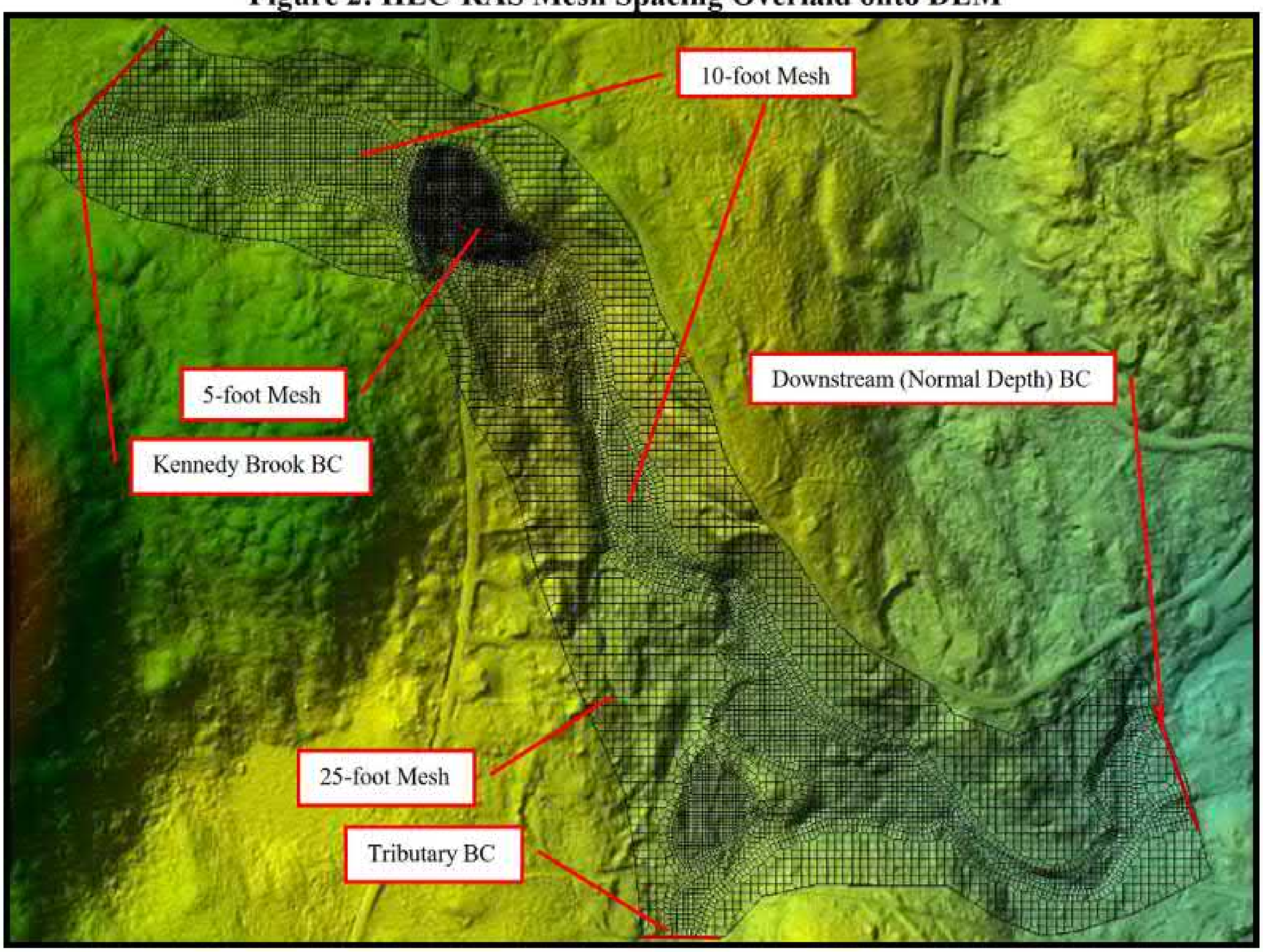
4.1 Methodology

U.S. Army Corps. of Engineers (US ACoE) hydraulic modeling computer software HEC-RAS (version 5.0.7) was used to assess the existing conditions and proposed replacement alternatives. Physical parameters for the crossing, upstream and downstream reaches, and computed peak discharges (50-Year, 100-Year, and 500-Year) are input into the program to develop a number hydraulic variables associated with the crossing. It was assumed that the hydraulic opening for the crossing was unobstructed. The geometry for the existing and proposed alternatives were based on a combination of the field survey and LiDAR data.

The 2D HEC-RAS model used to evaluate the stream crossing begins approximately 1,000-feet upstream of the King's Highway crossing structure and follows the channel to the confluence with Highland Lake. The upstream boundary condition was set to a synthetic hydrograph that utilized the peak values obtained from the HydroCAD analysis. A second upstream boundary condition was set at the unnamed tributary confluence with Kennedy Brook. A synthetic hydrograph generated from the HydroCAD results for the tributary runoff was used for each of the upstream boundary conditions. The hydrographs linearly increased for 4-hours to the peak runoff value, the peak value was held constant for 4-hours, then decreased linearly for 4-hours back down to zero. The downstream boundary condition was set to normal depth (S = 0.0395) based on elevations obtained from LiDAR data. The more detailed full momentum (Saint-Venant) equation was selected for use in the 2D analysis, in order to capture changes in momentum (energy losses) associated with constriction of flow through the culvert crossing as well as changes in flow characteristics during roadway overtopping and high-flow scenarios. Figure 2 shows the mesh spacing of the 2D model overlaid onto the DEM. The mesh spacing was reduced in areas where more detail was desired, specifically at the crossing structure and within the stream channel.

Manning's "n" coefficients have a significant effect on the hydraulic computations in the software as they are used to represent the energy loss through the channel and overbanks, based primarily on surface roughness. The "n" values for the channel were calculated using FHWA standard reference material. The channel "n" value was determined to be 0.0506. See **Appendix I** for calculation of the channel "n" value. The overbank and surrounding areas "n" value was chosen based on orthoimagery and site observations.

Figure 2: HEC-RAS Mesh Spacing Overlaid onto DEM



4.2 Existing Conditions

The existing crossing is summarized in Table 3. The geometric data is based on field survey and LiDAR information where applicable. The existing culverts were modeled using the culvert routine with two identical barrels.

Table 3: Existing Primary Crossing Geometry

Stream Crossing Structure Type	(2) CMP Culverts
Diameter (ft)	4.5
U.S. Waterway Opening (sq. ft)	31.81
Northern Barrel Length Parallel to Flow (ft)	50.64
Northern Barrel U.S. Channel Invert Elev. (ft)	1520.10
Northern Barrel D.S. Channel Invert Elev. (ft)	1520.26
Southern Barrel Length Parallel to Flow (ft)	50.80
Southern Barrel U.S. Channel Invert Elev. (ft)	1519.80
Northern Barrel D.S. Channel Invert Elev. (ft)	1520.20
Road Low Point Elev. (ft)	1528.38

4.3 Proposed Conditions

DuBois & King selected the replacement alternatives to meet varying degrees of design criteria. All alternatives are a substantial improvement over the existing crossing structure. The alternatives were assessed on their ability to meet the following NHDES and NHDOT criteria:

- Convey the 50-year (2% AEP) storm event without overtopping the road
- Convey the 50-year (2% AEP) storm event while maintaining 1-foot of freeboard between the water surface elevation (WSE) and the lowest point on the bridge (low chord elevation).
- Comply with NHDES Env-Wt 904 criteria (1.2 x the bankfull width plus 2-feet)
- Convey the 100-year (0.1% AEP) storm event without overtopping the road

Tables 4 – 7 summarize the geometries that resulted from the specific conditions that needed met. It is important to note, the following invert elevations and hydraulic opening heights listed are in reference to the streambed material. Additional structure height will be required to account for including embedded streambed material if a closed bottom culvert is selected.

Table 4: Alternative A Geometry

Stream Crossing Structure Type	Concrete Box Culvert
Hydraulic Span (ft)	20
Vertical Hydraulic Height (ft)	4.5
U.S. Waterway Opening (sq. ft)	90
Length Parallel to Flow (ft)	47.6
Road Low Point Elev. (ft)	1528.38
U.S. Channel Invert Elev. (ft)	1521.97
D.S. Channel Invert Elev. (ft)	1520.31

Table 5: Alternative B Geometry

Stream Crossing Structure Type	Concrete Box Culvert
Hydraulic Span (ft)	25
Vertical Hydraulic Height (ft)	4.5
U.S. Waterway Opening (sq. ft)	112.5
Length Parallel to Flow (ft)	47.6
Road Low Point Elev. (ft)	1528.38
U.S. Channel Invert Elev. (ft)	1521.97
D.S. Channel Invert Elev. (ft)	1520.31

Table 3: Alternative C Geometry

Stream Crossing Structure Type	Concrete Box Culvert
Hydraulic Span (ft)	30
Vertical Hydraulic Height (ft)	4.5
U.S. Waterway Opening (sq. ft)	135
Length Parallel to Flow (ft)	47.6
Road Low Point Elev. (ft)	1528.38
U.S. Channel Invert Elev. (ft)	1521.97
D.S. Channel Invert Elev. (ft)	1520.31

Table 4: Alternative D Geometry

Stream Crossing Structure Type	Concrete Box Culvert
Hydraulic Span (ft)	25
Vertical Hydraulic Height (ft)	6
U.S. Waterway Opening (sq. ft)	125
Length Parallel to Flow (ft)	47.6
Road Low Point Elev. (ft)	1528.38
U.S. Channel Invert Elev. (ft)	1521.97
D.S. Channel Invert Elev. (ft)	1520.31

4.4 Results

The geometries discussed previously were assessed on their ability to convey the 50-Year, 100-Year, and 500-Year storm events. The results from the hydraulic analysis are outlined in Table 4. Additional output information from HEC-RAS for the existing conditions, Alternative A, Alternative B, Alternative C, and Alternative D can be found in **Appendix J, K, L, M** and **N** respectively.

Table 4: Results of Hydraulic Analysis

Description	Existing	Alternative A	Alternative B	Alternative C	Alternative D
50-Year (2% AEP) = 887 cfs					
Upstream Water Surface Elevation at Bridge Opening (ft)	1529.9	1528.0	1527.1	1526.6	1527.0
Freeboard (ft)	0	0	0	0	1.0
Water over Road low point? (El. 1528.38 ft)	YES	NO	NO	NO	NO
Velocity In Culvert (ft/s)	11.6	8.1	6.5	5.4	4.9
100-Year (1% AEP) = 1074 cfs					
Upstream Water Surface Elevation at Bridge Opening (ft)	1530.3	1529.0	1528.1	1527.4	1528.0
Freeboard (ft)	0	0	0	0	0
Water over Road low point? (El. 1528.38 ft)	YES	YES	NO	NO	NO
Velocity In Culvert (ft/s)	11.6	9.5	8.2	6.8	6.1
500-Year (0.2% AEP) = 1288 cfs					
Upstream Water Surface Elevation at Bridge Opening (ft)	1531.2	1530.3	1529.9	1529.6	1529.5
Freeboard (ft)	0	0	0	0	0
Water over Road low point? (El. 1528.38 ft)	YES	YES	YES	YES	YES
Velocity In Culvert (ft/s)	12.5	11.1	10.3	9.6	8.7

The King's Highway culvert crossing is subject to Tier 3 stream crossing requirements as the contributing drainage area is larger than 1.0-square miles (640-acres). Therefore the crossing is subject to the following design criteria Env-Wt 904.01 and Env-Wt 904.05. Tables 5 and 6 summarizes the proposed replacement alternatives with respect to the required design criteria.

Table 5: Env-Wt 904.01 Design Criteria

Design Criteria	ALT A	ALT B	ALT C	ALT D
a. Not be a barrier for sediment transport	IMP	YES	YES	YES
b. Prevent the restriction of high flows and maintain existing flows	IMP	IMP	IMP	IMP
c. Not obstruct or otherwise substantially disrupt the movement of aquatic life indigenous to the waterbody beyond the actual duration of construction.	YES	YES	YES	YES
d. Not cause an increase in the frequency of flooding or overtopping of the banks.	YES	YES	YES	YES
e. Preserve watercourse connectivity where it currently exists	YES	YES	YES	YES
f. Restore watercourse connectivity 1. Connectivity previously disrupted by human activity 2. Restore to benefit aquatic life	YES	YES	YES	YES
g. Not cause erosion, aggradation, or scour upstream or downstream of the crossing	IMP	YES	YES	YES
h. Not cause water quality degradation	IMP	YES	YES	YES

Notes: NO = Anticipated to not meet state regulation.
YES = Anticipated to meet State regulation.
IMP = Does not necessarily meet state specification but is a significant improvement from existing conditions.

Table 6: Env-Wt 904.05 Design Criteria

Design Criteria	ALT A	ALT B	ALT C	ALT D
a. 1.2 times bankfull width plus 2 feet	IMP	YES	YES	YES
b. Water depths and velocities (within the structure) are comparable to natural channel upstream and downstream	IMP	IMP	YES	YES
c. Provide vegetated bank on both sides of watercourse (within the crossing structure)	IMP	IMP	IMP	IMP
d. Preserve the natural alignment and gradient	YES	YES	YES	YES
e. Accommodate the 100-yr flood	IMP	IMP	YES	YES
f. Simulate a natural stream channel (carries bankfull flow)	YES	YES	YES	YES
g. So as not to alter sediment transport competence	IMP	YES	YES	YES

Notes: NO = Anticipated to not meet state regulation.
YES = Anticipated to meet State regulation.
IMP = Does not necessarily meet state specification but is a significant improvement from existing conditions.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the hydrologic and hydraulic analysis of the existing and proposed replacement alternatives DuBois & King offers the following conclusions and recommendations:

1. The results suggest that the existing structure does not meet the NHDOT design criteria of passing the 50-year (2% AEP) storm event while maintaining 1-foot of freeboard or conveying the 100-year (1% AEP) discharges without overtopping the road. Additionally the existing structure does not meet the NHDES bankfull width design criteria.

2. Several replacement alternatives were selected that partially satisfy the NHDOT and NHDES design criteria. All selected alternatives offer improvement over existing conditions and are described further below:

    a. Alternative A (20-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES bankfull width, 50-year, and 100-year design criteria previously discussed. The results suggest Alternative A does offer improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

    b. Alternative B (25-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES 50-year and 100-year design criteria previously discussed. The results suggest that Alternative B can pass the 100-year storm event without overtopping the road. The results suggest Alternative B offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

    c. Alternative C (30-foot x 4.5-foot Box Culvert) does not meet the NHDOT or NHDES 50-year, and 100-year design criteria previously discussed. The results suggest that Alternative C can pass the 100-year storm event without overtopping the road. The results suggest Alternative C offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

    d. Alternative D (25-foot x 6-foot Box Culvert) meets the NHDOT 50-year and NHDES 100-year storm design criteria. Alternative D does meet the NHDES bankfull width design criteria. The results suggest Alternative D offers improved flood elevations, water velocities, and aquatic organism passage, when compared to the existing crossing.

3. The replacement culvert should have a simulated streambed bottom with gradations matching what is observed in the natural channel.

4. The results suggested that none of the replacement alternatives had a more than negligible effect on water surface elevation, velocity, and flood depths observed at the downstream private driveway crossing.

APPENDIX A

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ENGINEERING • PLANNING • MANAGEMENT • DEVELOPMENT

Scott M. Bourcier, P.E.
Project Manager

MEMORANDUM

TO: James Coffey, Town Administrator

RE: King's Highway Crossing over Kennedy Brook – Existing Culvert Evaluation
Stoddard, NH

DATE: May 14, 2019

Per the Town of Stoddard's (Town) request, DuBois & King made a site visit to the King's Highway on April 17, 2019 and again on May 13, 2019. The purpose of the site visits was to perform a preliminary visual evaluation of the existing cross culvert located King's Highway Crossing over Kennedy Brook. Below are our findings.

1. The stream appears to flow in an easterly direction and contributes to Highland Lake.
2. The stream does not appear to be intermittent as there is evidence of consistent flow.
3. The existing stream crossing consists of two 54-inch corrugated metal pipes (CMP) culverts.
4. The alignment of the culverts appears to be perpendicular (not skewed) to the roadway.
5. The approximate overall combined span of the culverts over Kennedy Brook is 10.50 feet.
6. The existing corrugated metal pipes appear to be in poor condition.
7. Both the inlet and outlet headwalls appear to have been constructed from dry-laid stone.
8. The inlet headwall appears to show evidence of deterioration (loss of stones) leaving the upstream bank unprotected.
9. The outlet and inlet did not appear to show evidence of collecting sedimentation.
10. The roadway within the vicinity of the crossing shows evidence of recent roadway reconstruction.

The approximate overall combined span of the culverts, including the 18-inch distance between the pipes, over Kennedy Brook is 10.50 feet. According to the New Hampshire Department of Transportation (NHDOT) Bridge Standards any crossing over a body of water that is 10 feet in length or greater (including combined culvert crossings meeting certain criteria) is classified as a bridge. This culvert will require registration under the NHDOT as a bridge structure.

The twin corrugated metal pipes and rubble masonry headwalls are showing signs of moderate to severe deterioration. Severe section loss was observed along the bottom (inverts) of both culverts. There is immediate concern the structural capacity of the metal pipe culverts has significantly decreased which may result in an unexpected and sudden failure or collapse of the roadway. The existing roadway above the culverts is not considered safe to travel.

According to regional maps (including Google Maps), King's Highway appears to be the only roadway that provides access to the Hidden Lake Association (HLA); a residential development north of the Kennedy Brook Crossing that services approximately 90 homes. There does not appear to be a secondary access to the HLA community.

A preliminary hydrologic and hydraulic (H&H) evaluation was performed for a 50-year, 24-hour peak storm event utilizing rational method to calculate peak runoff flow and culvert sizing calculation. Based on the rational method, the culvert is anticipated to experience approximately 517 cubic-feet/second (cfs) of flow; the 100-year storm event is 637cfs. The capacity of the existing twin 54-inch culverts is 157.64 cfs. Based on discussions with the Town, the culverts have experienced flooding (i.e. Kennedy Brook overtopping King's Highway).

Below are existing condition photographs of our site visit.

Dry-laid stone inlet headwall

Dry-laid stone outlet headwall

54-inch CMP with corrosion along the invert

Severe section loss along the interior of pipe (bottom of pipe detached from top of pipe)

Summary:

DuBois & King recommends immediately replacing the existing corrugated metal pipe culverts.

As part of the replacement, the Town would be required to file a New Hampshire Department of Environmental Services (NHDES) – Wetland permit (Routine Roadway Notification, Permit-by-Notification, or Standard Dredge & Fill) as the proposed activity will replace a culvert larger the 48 inches in diameter. www.des.nh.gov/organization/divisions/water/wetlands/documents/routine-roadway-notification.pdf

End of Memorandum

APPENDIX B

Guidelines for Naturalized River Channel Design and Bank Stabilization

New Hampshire
Department of Environmental Services
Department of Transportation

February 2007

KINGS HIGHWAY CROSSING
KENNEDY BROOK
DA = 2.07 SQ. MILES

$W = 12.469(2.07)^{0.4892}$
W = 17.7994 FT

1.2*Bankfull Width + 2 FT
= (1.2*17.8)+2
= 24 FT

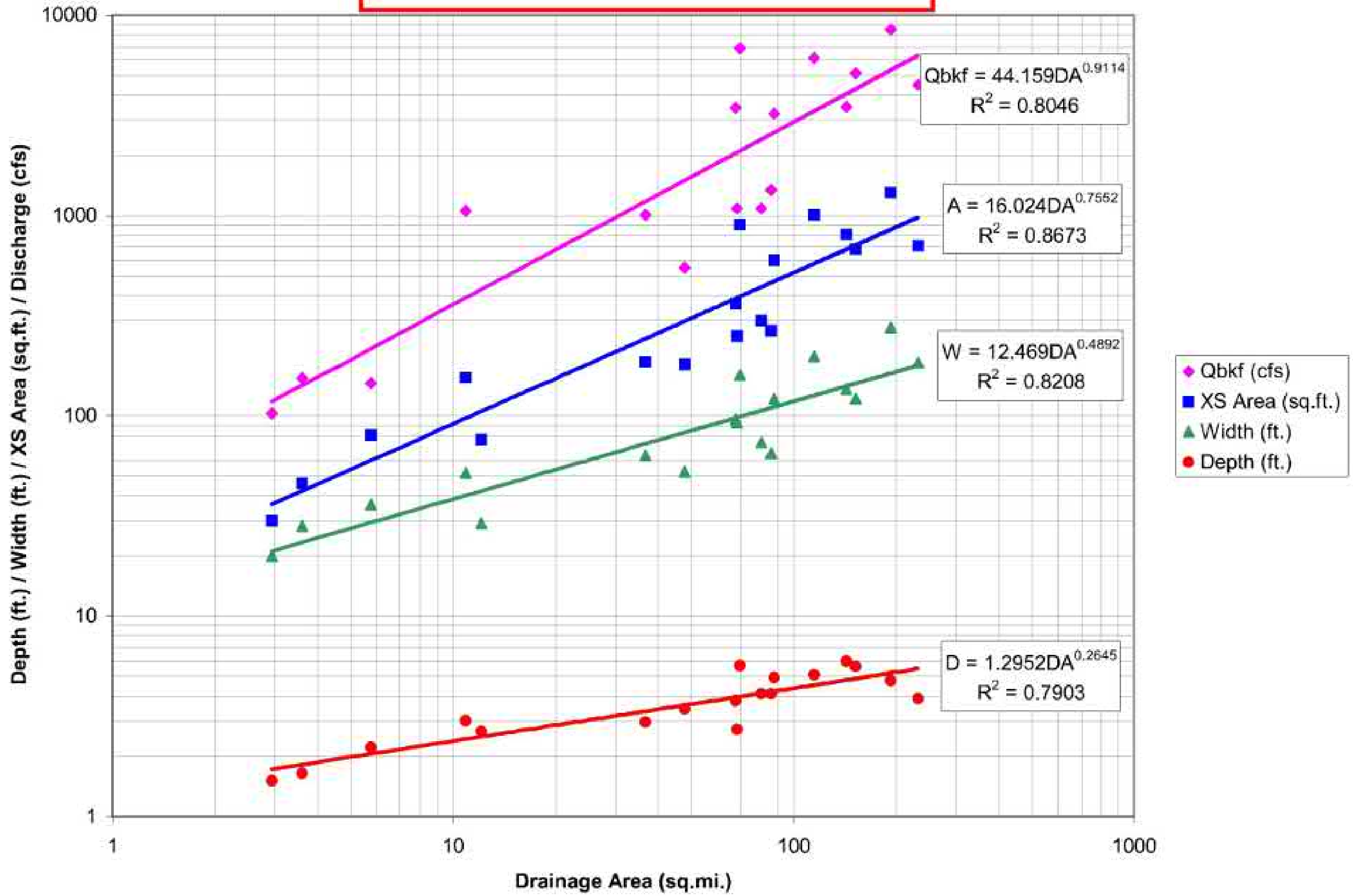
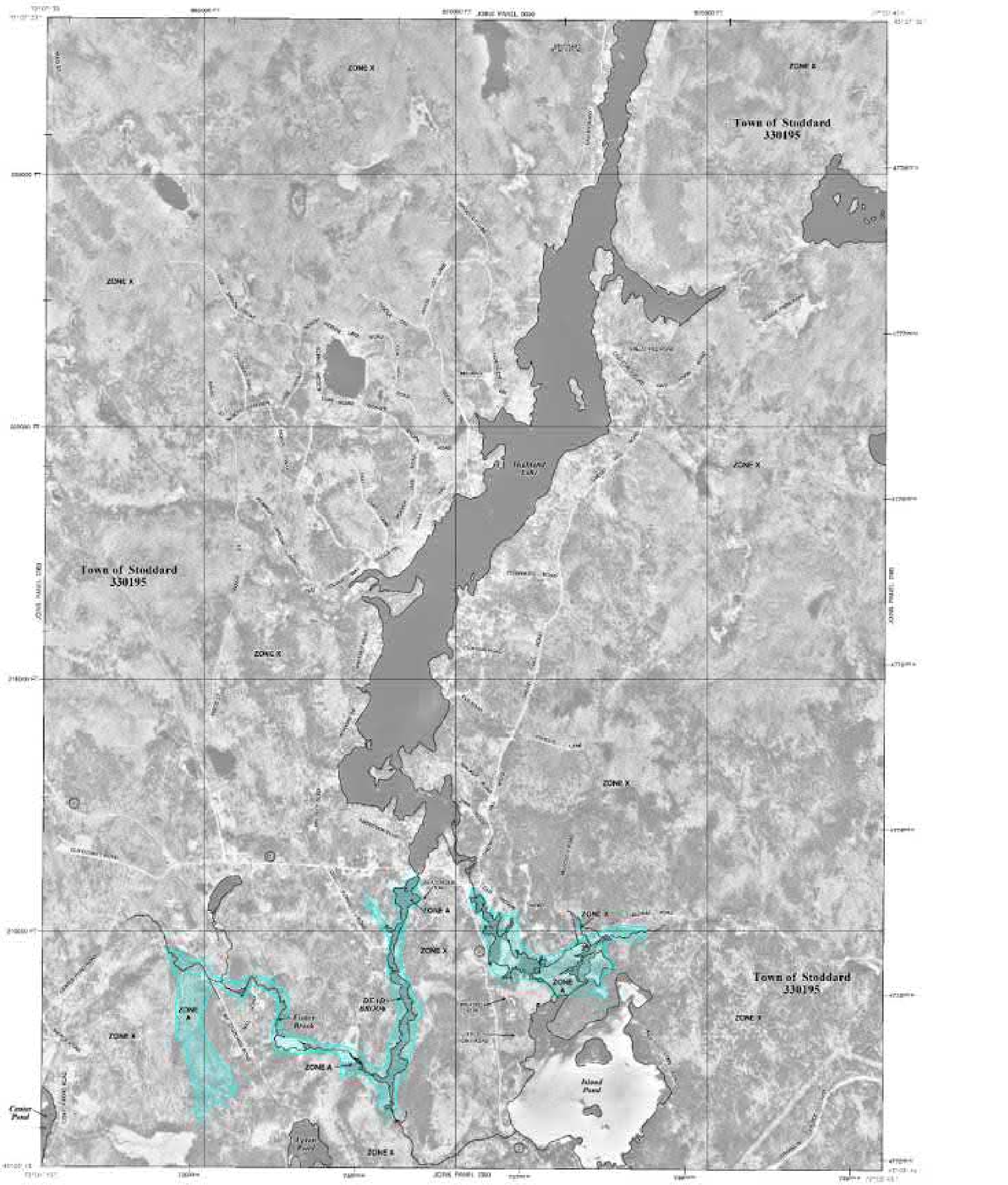


Figure 7-5: New Hampshire 2005 regional hydraulic geometry curves (provisional), which are particularly useful for smaller channels in steeper terrain (Source: NHST, 2005). Outlined curve is used to estimate bankfull flow.

APPENDIX C

NOTES TO USERS



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

OTHER AREAS

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

MAP SCALE 1" = 1000'

PANEL 0180E

FIRM

FLOOD INSURANCE RATE MAP

CHESHIRE COUNTY,
NEW HAMPSHIRE
(ALL JURISDICTIONS)

PANEL 180 OF 610

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

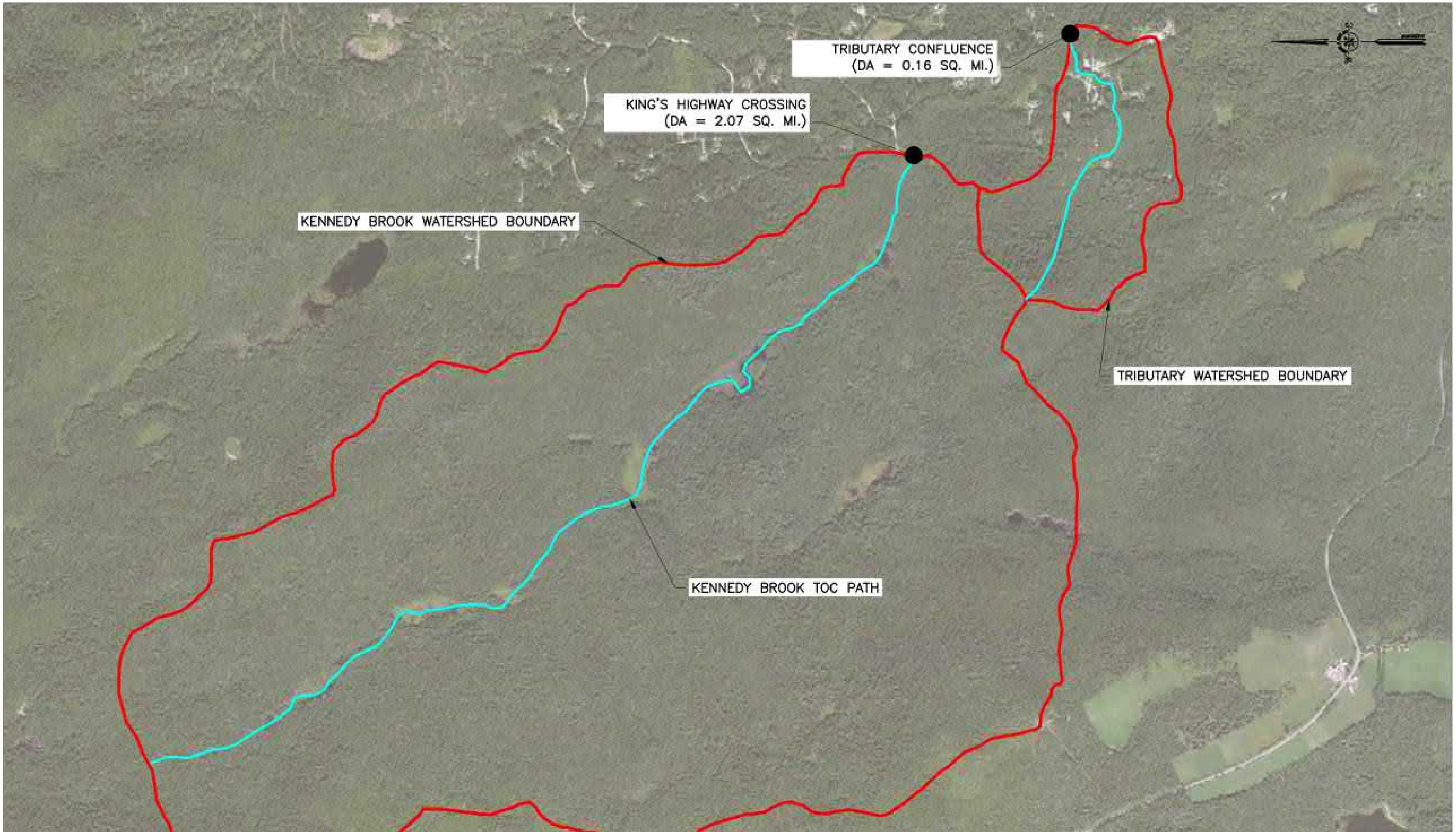
NATIONAL FLOOD INSURANCE PROGRAM

MAP NUMBER
33005C0180E

EFFECTIVE DATE
MAY 23, 2006

Federal Emergency Management Agency

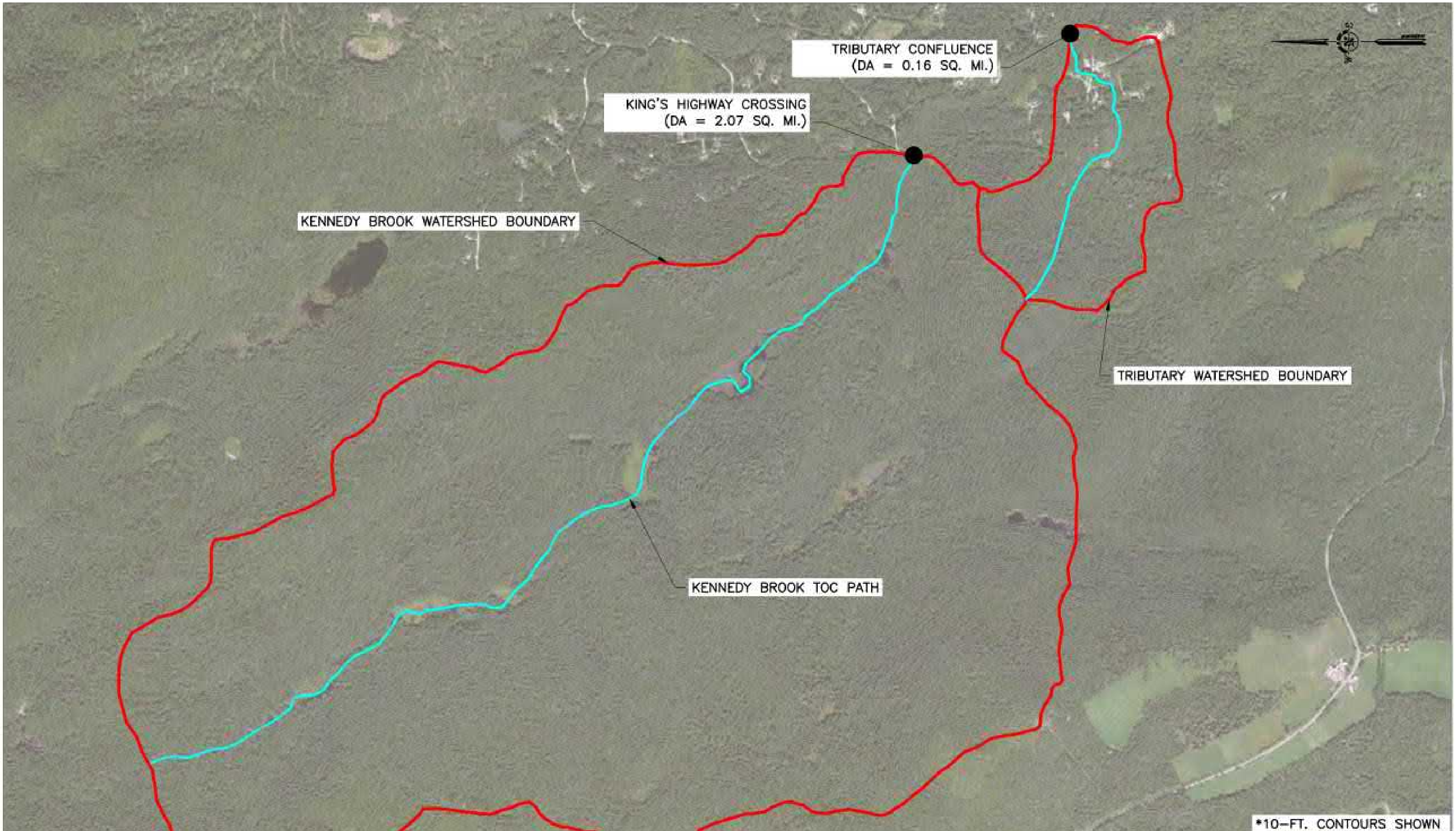
APPENDIX D



DuBois & King inc.
ENGINEERING • PLANNING • MANAGEMENT • DEVELOPMENT

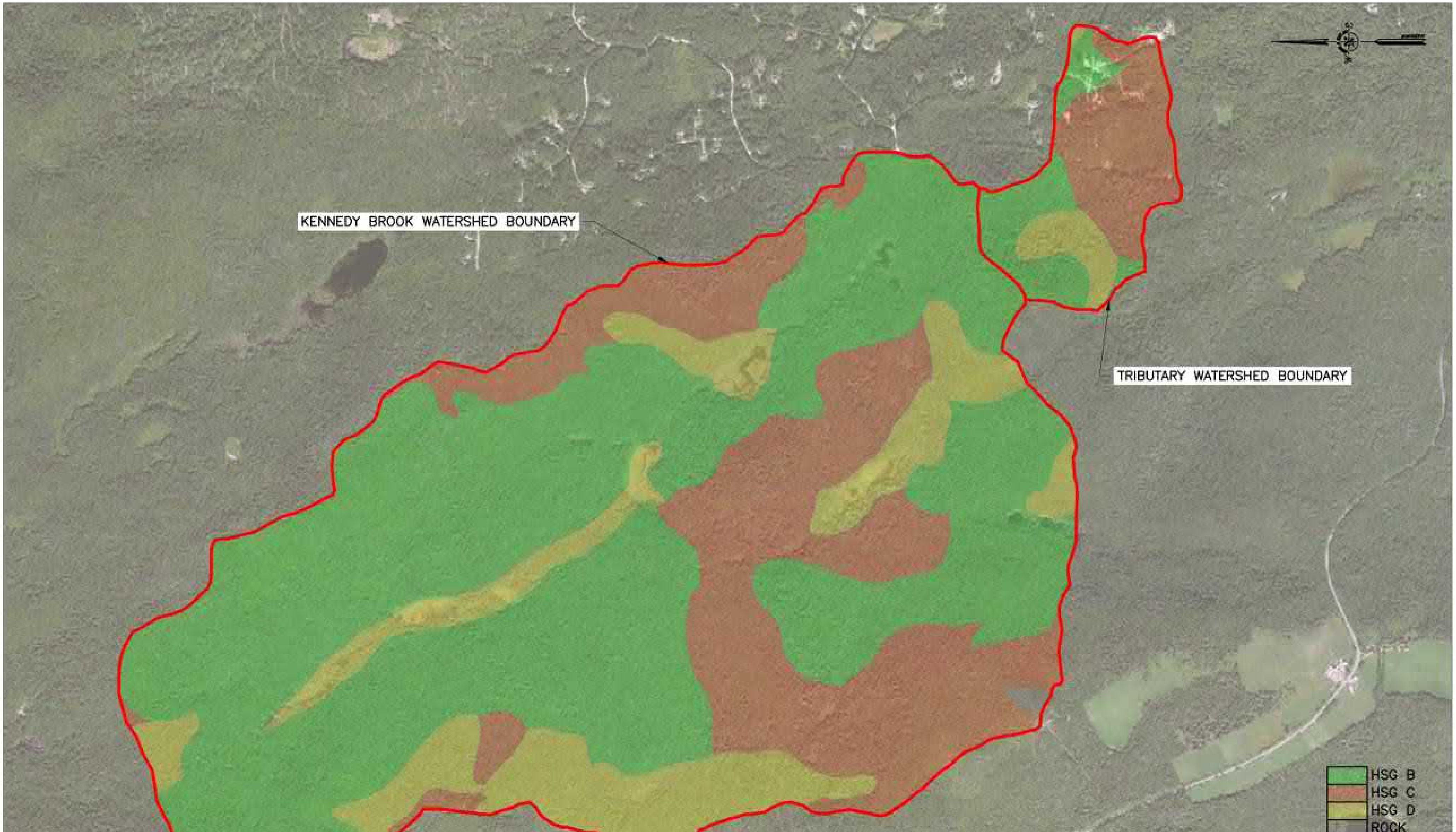
WATERSHED MAP
KENNEDY BROOK AND TRIBUTARY
STODDARD, NH

DRAWN BY	DATE	FIGURE
DC	AUG. 2020	1
CHECKED BY	D&K PROJECT #	
	325288	
PROJ. ENG	SCALE	
DC	1"=1000'	



*10–FT. CONTOURS SHOWN

DuBois & King inc. ENGINEERING • PLANNING • MANAGEMENT • DEVELOPMENT	TOPOGRAPHIC MAP KENNEDY BROOK AND TRIBUTARY STODDARD, NH	DRAWN BY: DC CHECKED BY: PROJ. ENG: DC	DATE: AUG. 2020 D&K PROJECT #: 325288 SCALE: 1"=1000'	FIGURE 2



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HYDROLOGIC SOILD GROUP (HSG) MAP
KENNEDY BROOK AND TRIBUTARY
STODDARD, NH

DRAWN BY: DC	DATE: AUG. 2020	FIGURE
CHECKED BY:	D&K PROJECT #: 325288	3
PROJ. ENG: DC	SCALE: 1"=1000'	

APPENDIX E

NOAA Atlas 14, Volume 10, Version 3
Location name: Stoddard, New Hampshire, USA*
Latitude: 43.0899°, Longitude: -72.1116°
Elevation: 1525.93 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.300 (0.231-0.383)	0.361 (0.278-0.461)	0.460 (0.353-0.589)	0.542 (0.414-0.699)	0.655 (0.486-0.884)	0.740 (0.539-1.02)	0.830 (0.589-1.19)	0.933 (0.627-1.37)	1.08 (0.701-1.64)	1.21 (0.764-1.87)
10-min	0.425 (0.328-0.542)	0.511 (0.394-0.652)	0.652 (0.502-0.836)	0.768 (0.587-0.991)	0.929 (0.689-1.25)	1.05 (0.764-1.45)	1.18 (0.834-1.69)	1.32 (0.888-1.93)	1.53 (0.993-2.33)	1.71 (1.08-2.65)
15-min	0.500 (0.386-0.638)	0.601 (0.463-0.768)	0.766 (0.589-0.982)	0.903 (0.689-1.16)	1.09 (0.810-1.47)	1.23 (0.898-1.70)	1.38 (0.981-1.98)	1.56 (1.04-2.28)	1.81 (1.17-2.74)	2.01 (1.27-3.11)
30-min	0.696 (0.537-0.888)	0.840 (0.647-1.07)	1.08 (0.826-1.38)	1.27 (0.971-1.64)	1.54 (1.14-2.08)	1.74 (1.27-2.40)	1.95 (1.39-2.80)	2.20 (1.48-3.22)	2.55 (1.65-3.87)	2.84 (1.80-4.40)
60-min	0.892 (0.688-1.14)	1.08 (0.831-1.38)	1.38 (1.06-1.77)	1.64 (1.25-2.11)	1.99 (1.47-2.68)	2.25 (1.64-3.10)	2.52 (1.79-3.62)	2.84 (1.91-4.16)	3.30 (2.13-5.00)	3.68 (2.33-5.69)
2-hr	1.13 (0.877-1.43)	1.38 (1.07-1.75)	1.79 (1.38-2.27)	2.12 (1.63-2.72)	2.59 (1.93-3.48)	2.93 (2.15-4.04)	3.30 (2.37-4.74)	3.75 (2.52-5.46)	4.42 (2.87-6.66)	4.99 (3.17-7.68)
3-hr	1.29 (1.01-1.63)	1.58 (1.23-2.00)	2.06 (1.60-2.61)	2.45 (1.89-3.12)	2.99 (2.24-4.01)	3.39 (2.50-4.66)	3.82 (2.75-5.48)	4.35 (2.94-6.31)	5.16 (3.36-7.76)	5.87 (3.73-8.98)
6-hr	1.63 (1.28-2.05)	2.00 (1.57-2.51)	2.59 (2.03-3.26)	3.08 (2.40-3.91)	3.76 (2.84-5.02)	4.26 (3.17-5.83)	4.81 (3.49-6.87)	5.49 (3.72-7.91)	6.55 (4.27-9.77)	7.47 (4.76-11.4)
12-hr	2.06 (1.63-2.56)	2.50 (1.97-3.12)	3.22 (2.53-4.03)	3.82 (2.99-4.81)	4.64 (3.53-6.15)	5.25 (3.92-7.13)	5.92 (4.32-8.40)	6.74 (4.59-9.65)	8.03 (5.25-11.9)	9.14 (5.85-13.8)
24-hr	2.52 (2.01-3.12)	3.05 (2.42-3.77)	3.91 (3.10-4.86)	4.63 (3.64-5.78)	5.61 (4.29-7.37)	6.34 (4.76-8.54)	7.13 (5.21-10.0)	8.10 (5.53-11.5)	9.57 (6.29-14.1)	10.8 (6.96-16.3)
2-day	3.00 (2.40-3.69)	3.62 (2.90-4.46)	4.64 (3.71-5.73)	5.49 (4.36-6.82)	6.66 (5.11-8.67)	7.52 (5.66-10.0)	8.45 (6.19-11.7)	9.56 (6.56-13.5)	11.2 (7.40-16.4)	12.6 (8.12-18.8)
3-day	3.33 (2.68-4.08)	4.01 (3.23-4.92)	5.13 (4.11-6.31)	6.06 (4.83-7.50)	7.34 (5.66-9.52)	8.29 (6.26-11.0)	9.31 (6.83-12.9)	10.5 (7.23-14.8)	12.3 (8.12-17.9)	13.8 (8.89-20.5)
4-day	3.61 (2.92-4.41)	4.34 (3.50-5.31)	5.53 (4.44-6.78)	6.52 (5.20-8.04)	7.87 (6.08-10.2)	8.89 (6.72-11.8)	9.97 (7.32-13.7)	11.2 (7.75-15.7)	13.1 (8.68-19.0)	14.7 (9.48-21.7)
7-day	4.35	5.16	6.48	7.58	9.10	10.2	11.4	12.8	14.9	16.6

	(3.53-5.28)	(4.18-6.27)	(5.24-7.91)	(6.09-9.31)	(7.06-11.7)	(7.77-13.4)	(8.42-15.6)	(8.88-17.9)	(9.88-21.5)	(10.7-24.4)
10-day	**5.04** (4.11-6.10)	**5.90** (4.80-7.14)	**7.30** (5.92-8.87)	**8.46** (6.81-10.3)	**10.1** (7.82-12.8)	**11.2** (8.56-14.7)	**12.5** (9.22-17.0)	**13.9** (9.68-19.3)	**16.0** (10.7-23.0)	**17.7** (11.5-26.0)
20-day	**7.16** (5.87-8.60)	**8.07** (6.61-9.70)	**9.55** (7.80-11.5)	**10.8** (8.76-13.1)	**12.5** (9.76-15.8)	**13.8** (10.5-17.8)	**15.1** (11.1-20.1)	**16.5** (11.5-22.7)	**18.4** (12.3-26.2)	**19.8** (12.9-28.9)
30-day	**8.90** (7.34-10.7)	**9.85** (8.11-11.8)	**11.4** (9.36-13.7)	**12.7** (10.3-15.4)	**14.5** (11.3-18.1)	**15.8** (12.1-20.2)	**17.2** (12.6-22.6)	**18.5** (13.0-25.4)	**20.2** (13.6-28.7)	**21.5** (14.0-31.2)
45-day	**11.1** (9.16-13.2)	**12.1** (9.99-14.4)	**13.7** (11.3-16.5)	**15.1** (12.4-18.2)	**17.0** (13.4-21.2)	**18.5** (14.2-23.5)	**19.9** (14.6-26.0)	**21.2** (14.9-28.9)	**22.8** (15.4-32.2)	**23.9** (15.6-34.6)
60-day	**12.9** (10.7-15.3)	**13.9** (11.6-16.6)	**15.7** (13.0-18.8)	**17.2** (14.1-20.7)	**19.2** (15.2-23.8)	**20.8** (16.0-26.3)	**22.4** (16.4-29.0)	**23.7** (16.7-32.2)	**25.3** (17.1-35.6)	**26.3** (17.2-38.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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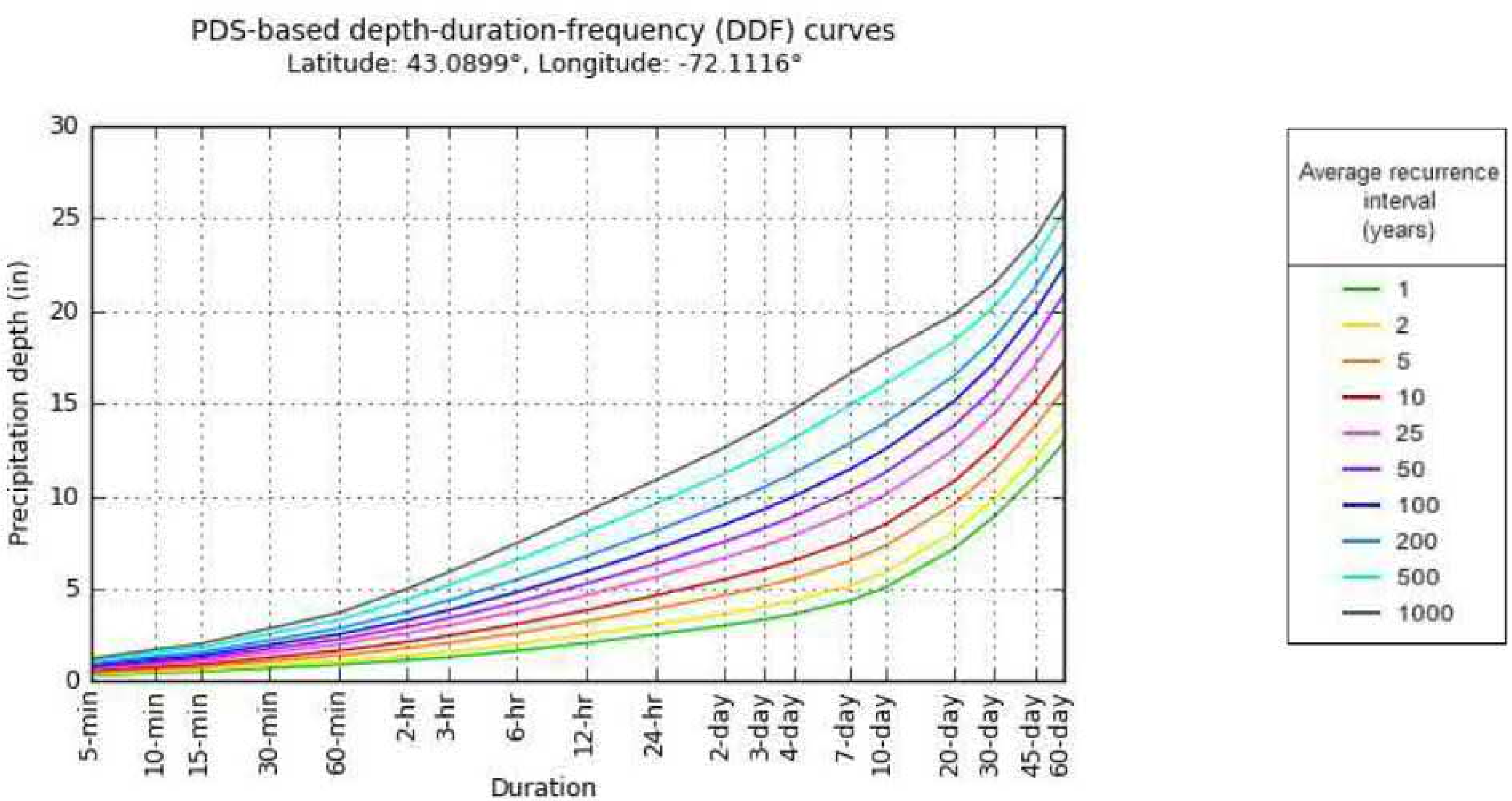
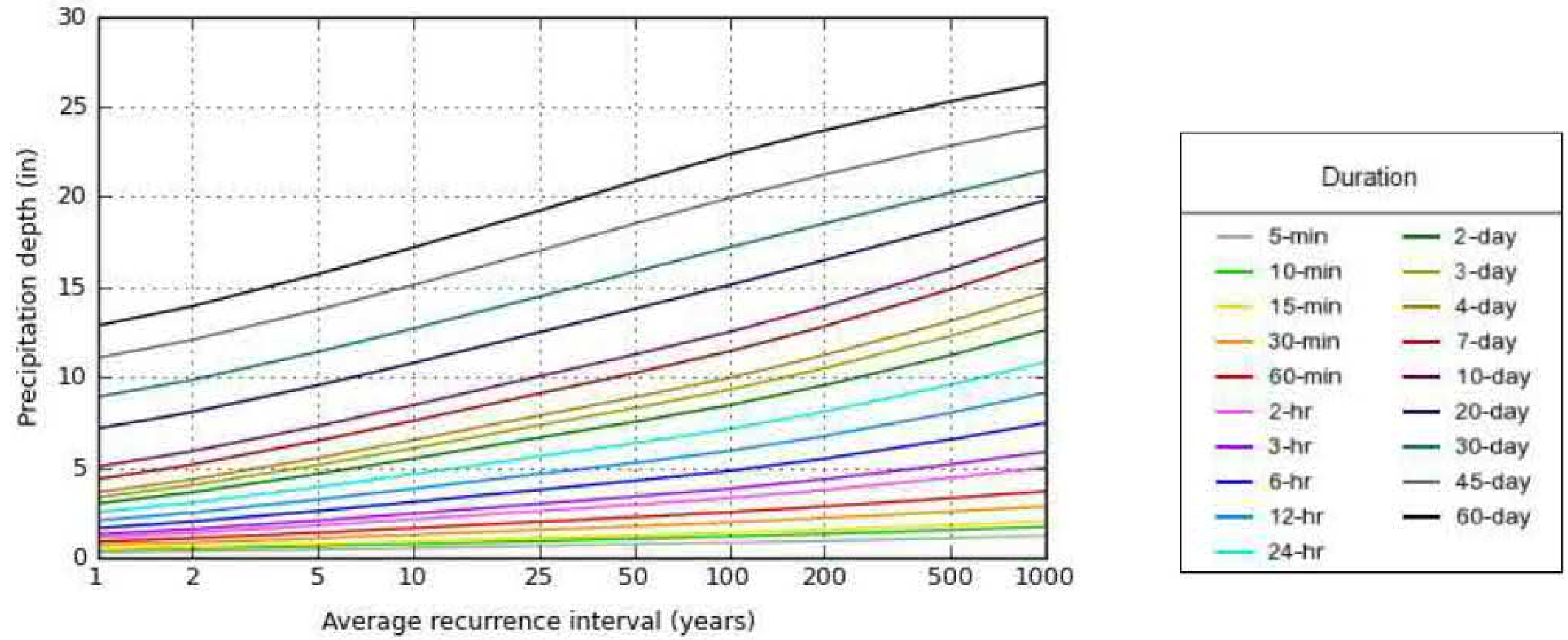
PF graphical





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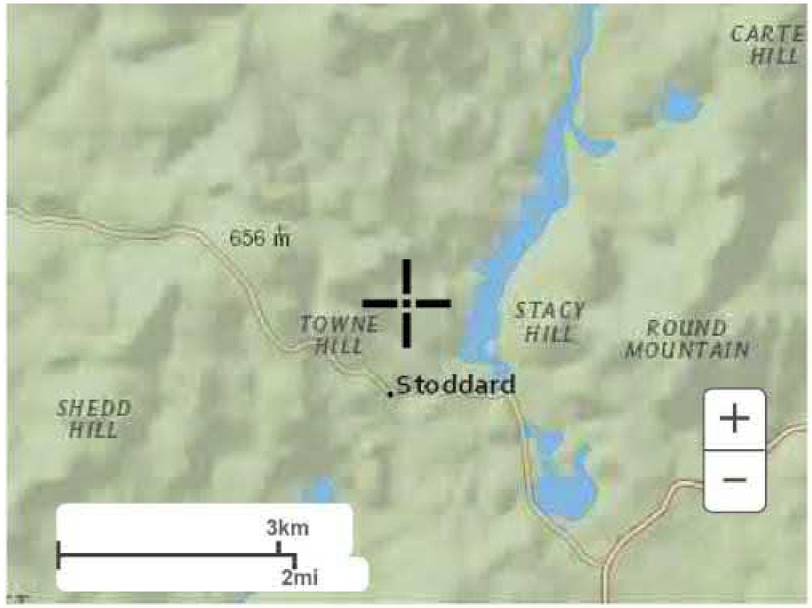
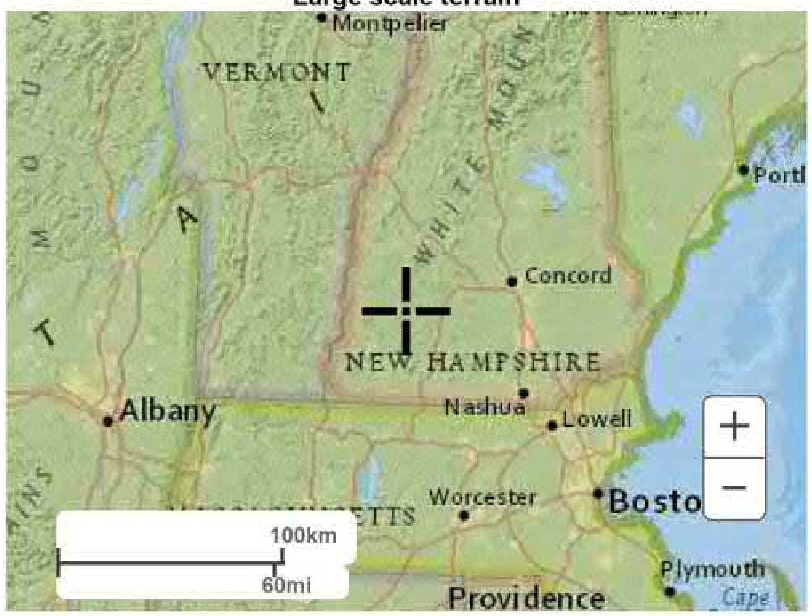
Maps & aerials

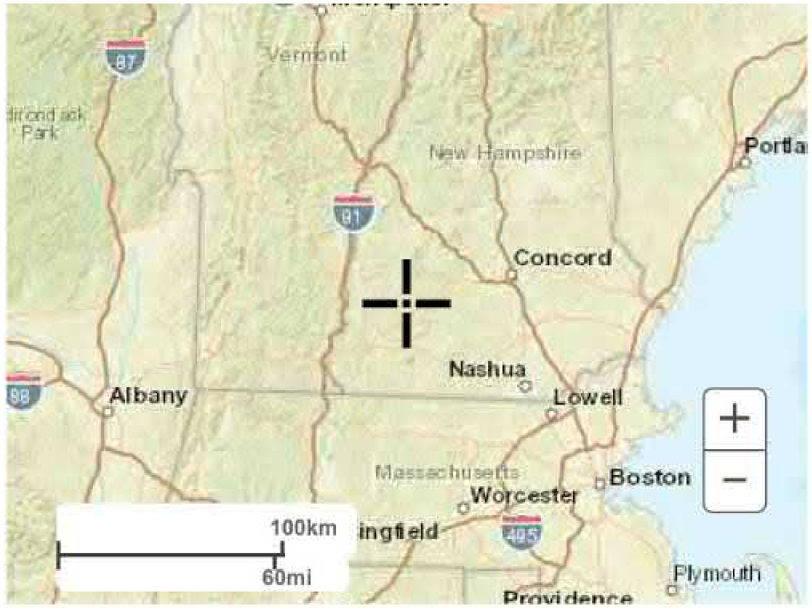
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
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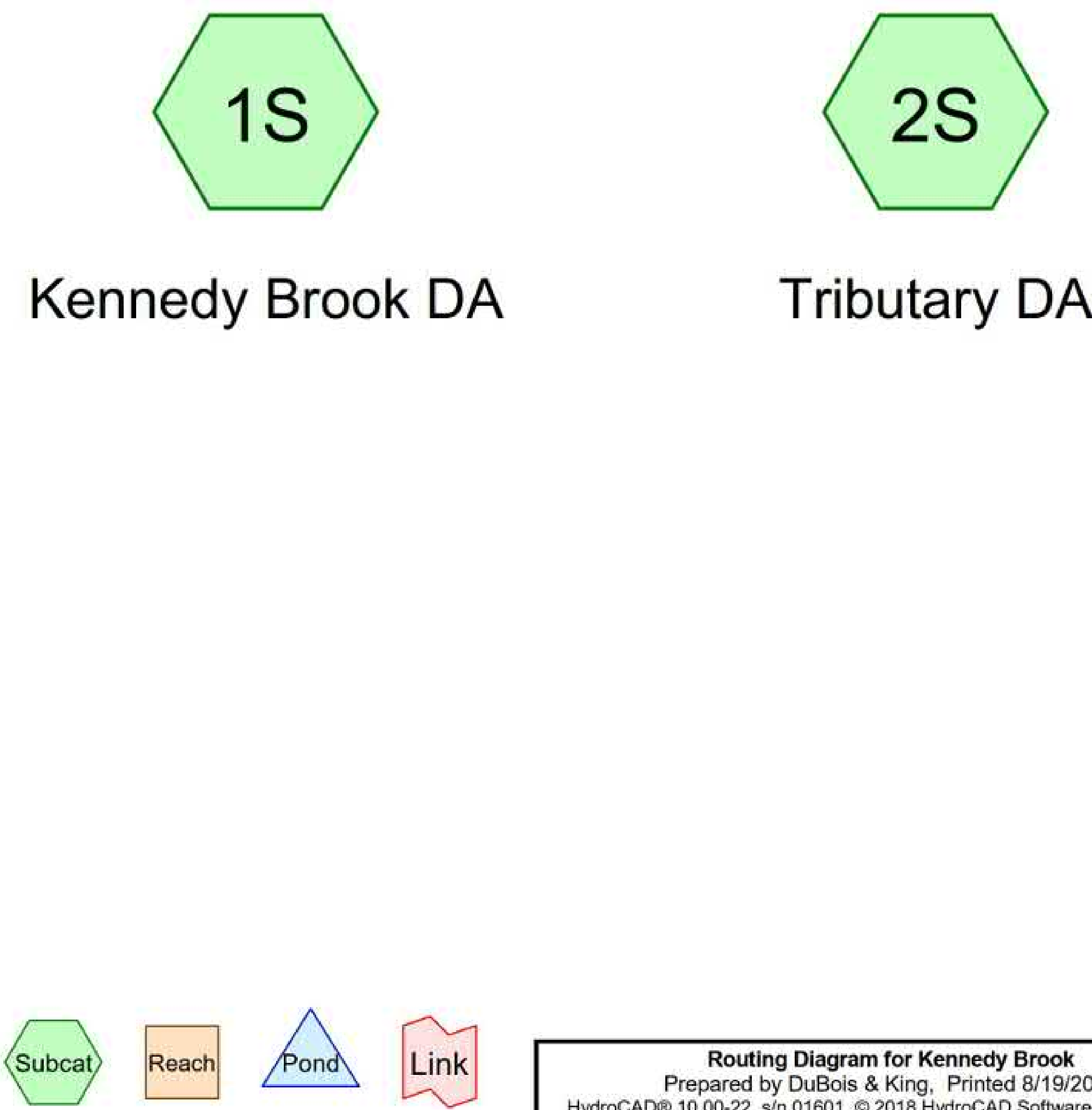
Questions?: HDSC.Questions@noaa.gov

APPENDIX F



Routing Diagram for Kennedy Brook
Prepared by DuBois & King, Printed 8/19/2020

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.404	98	Unconnected pavement, HSG C (1S)
36.469	60	Woods, Fair, HSG B (2S)
53.164	73	Woods, Fair, HSG C (2S)
15.081	79	Woods, Fair, HSG D (2S)
773.903	55	Woods, Good, HSG B (1S)
331.068	70	Woods, Good, HSG C (1S)
218.134	77	Woods, Good, HSG D (1S)
1,430.223	**63**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
810.372	HSG B	1S, 2S
386.636	HSG C	1S, 2S
233.215	HSG D	1S, 2S
0.000	Other	
1,430.223		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	2.404	0.000	0.000	2.404	Unconnected pavement	1S
0.000	36.469	53.164	15.081	0.000	104.714	Woods, Fair	2S
0.000	773.903	331.068	218.134	0.000	1,323.105	Woods, Good	1S
0.000	**810.372**	**386.636**	**233.215**	**0.000**	**1,430.223**	**TOTAL AREA**	

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=0.42"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=92.73 cfs 46.217 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=0.70"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=19.17 cfs 6.079 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 52.296 af Average Runoff Depth = 0.44"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

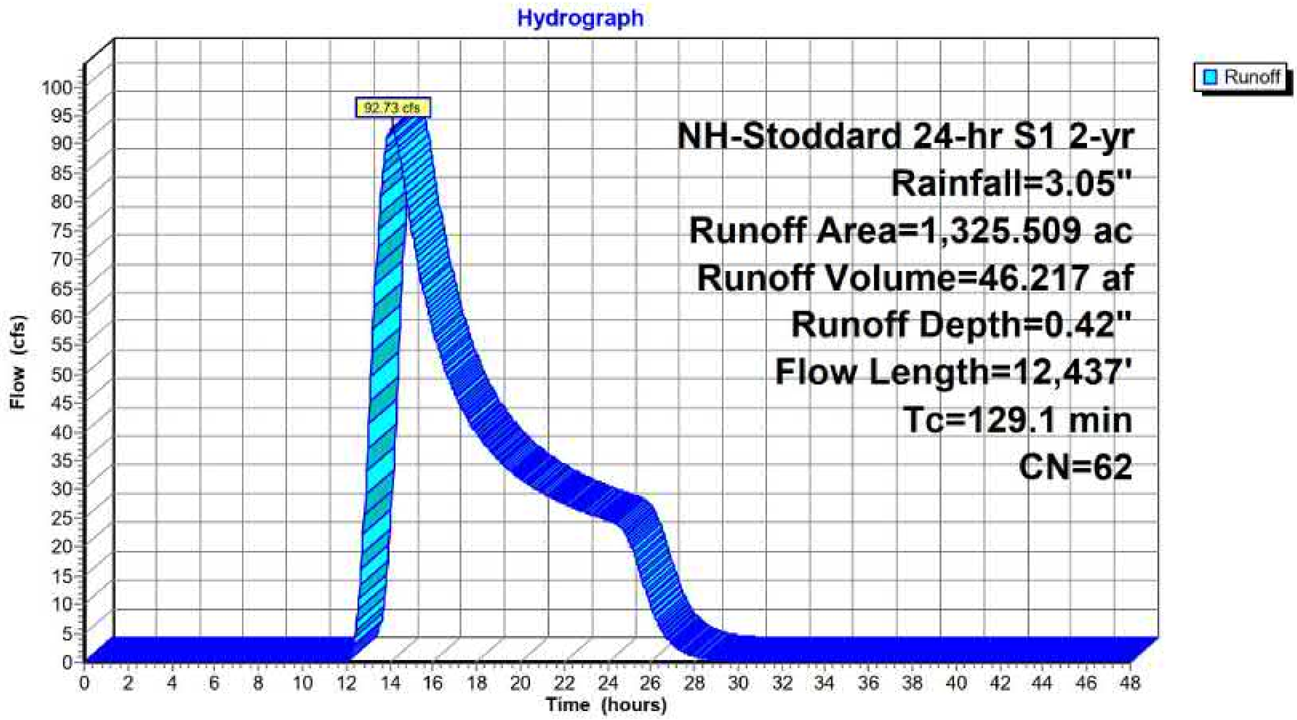
Runoff = 92.73 cfs @ 14.12 hrs, Volume= 46.217 af, Depth= 0.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 2-yr Rainfall=3.05"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

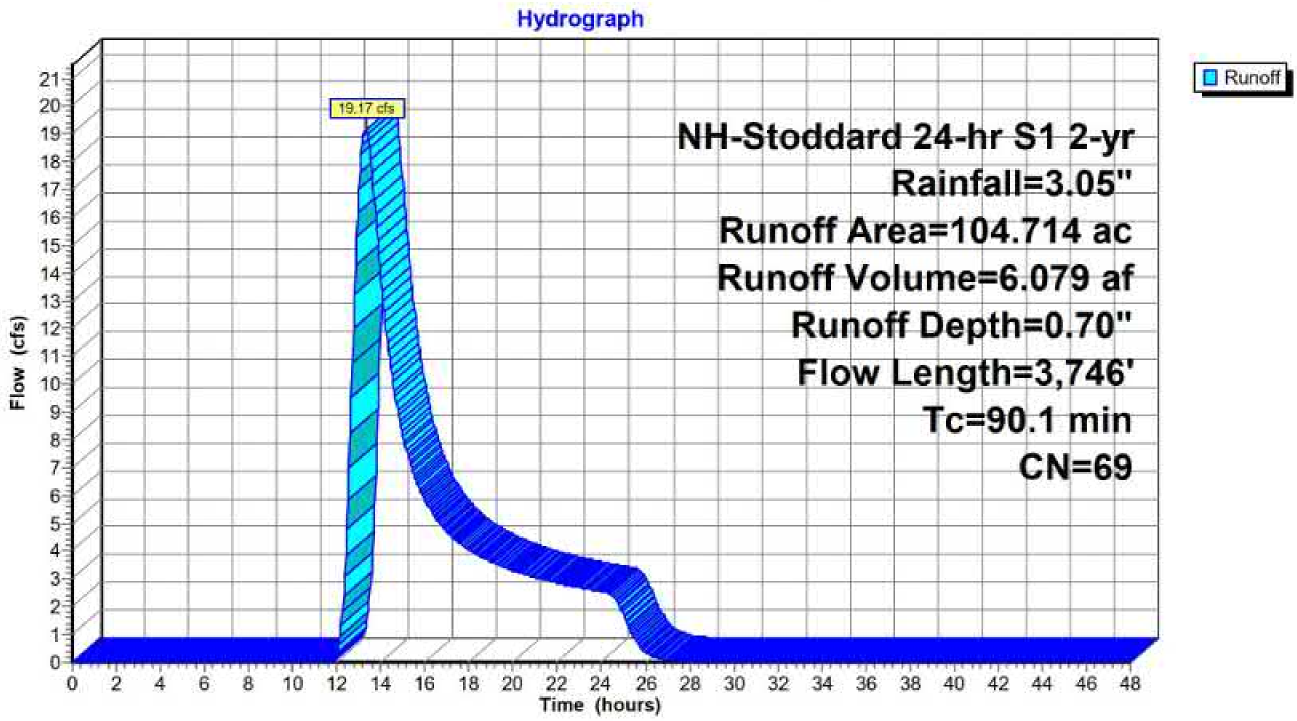
Runoff = 19.17 cfs @ 13.31 hrs, Volume= 6.079 af, Depth= 0.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 2-yr Rainfall=3.05"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

Subcatchment 2S: Tributary DA



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=1.22"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=351.31 cfs 134.922 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=1.70"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=53.29 cfs 14.835 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 149.757 af Average Runoff Depth = 1.26"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

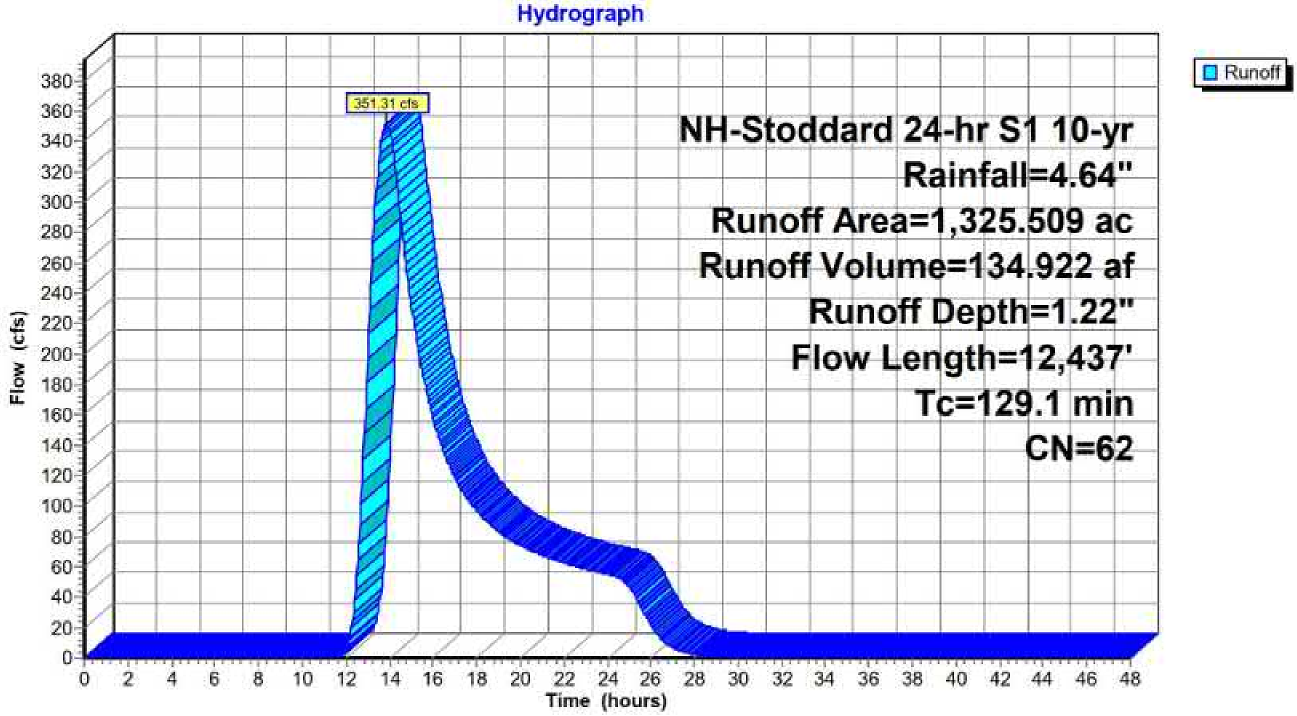
Runoff = 351.31 cfs @ 13.89 hrs, Volume= 134.922 af, Depth= 1.22"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 10-yr Rainfall=4.64"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

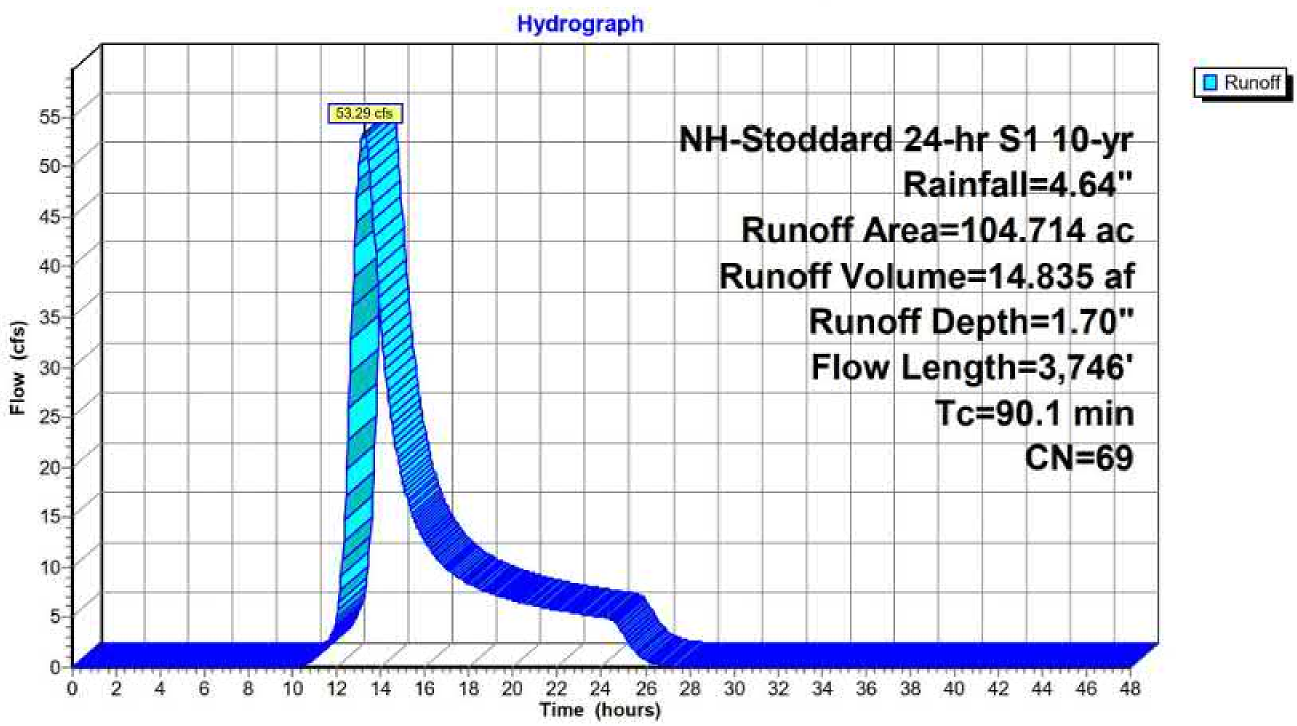
Runoff = 53.29 cfs @ 13.21 hrs, Volume= 14.835 af, Depth= 1.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 10-yr Rainfall=4.64"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

Subcatchment 2S: Tributary DA



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=1.84"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=560.26 cfs 203.410 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=2.43"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=78.12 cfs 21.178 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 224.588 af Average Runoff Depth = 1.88"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

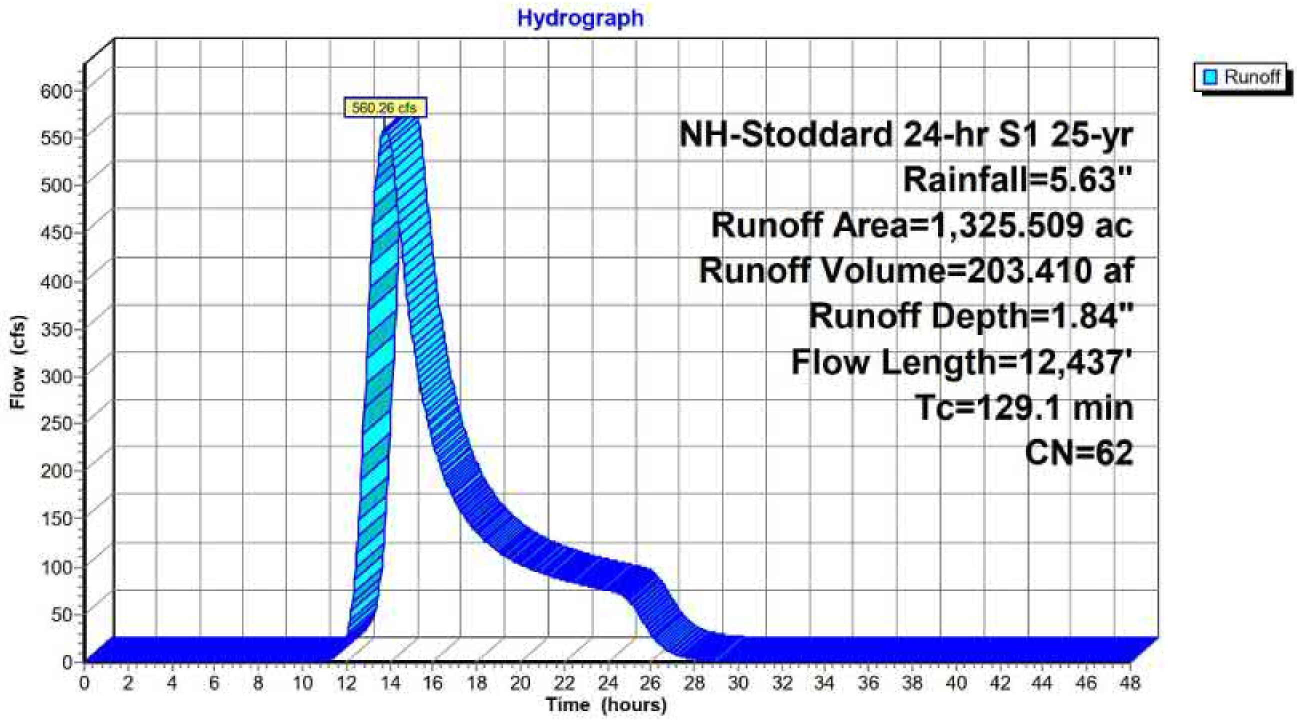
Runoff = 560.26 cfs @ 13.78 hrs, Volume= 203.410 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 25-yr Rainfall=5.63"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

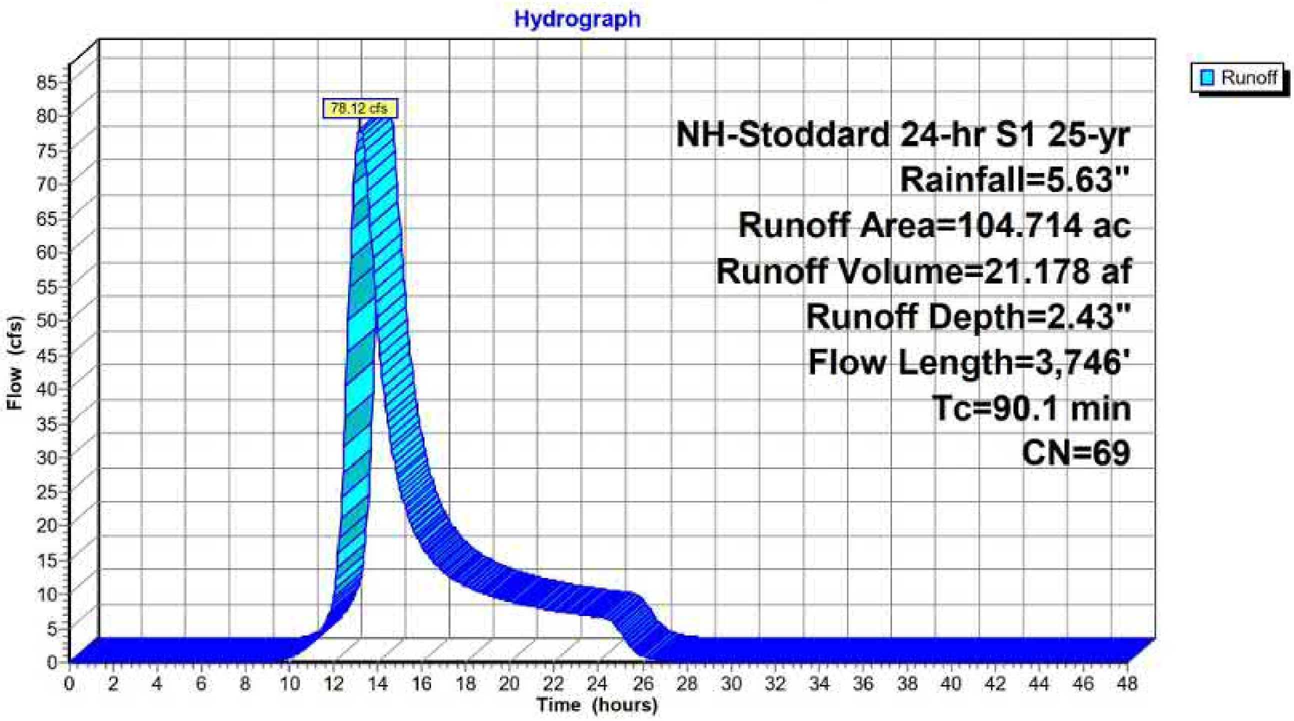
Runoff = 78.12 cfs @ 13.18 hrs, Volume= 21.178 af, Depth= 2.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 25-yr Rainfall=5.63"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

Subcatchment 2S: Tributary DA



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=2.34"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=730.43 cfs 258.513 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=3.00"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=97.58 cfs 26.148 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 284.661 af Average Runoff Depth = 2.39"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

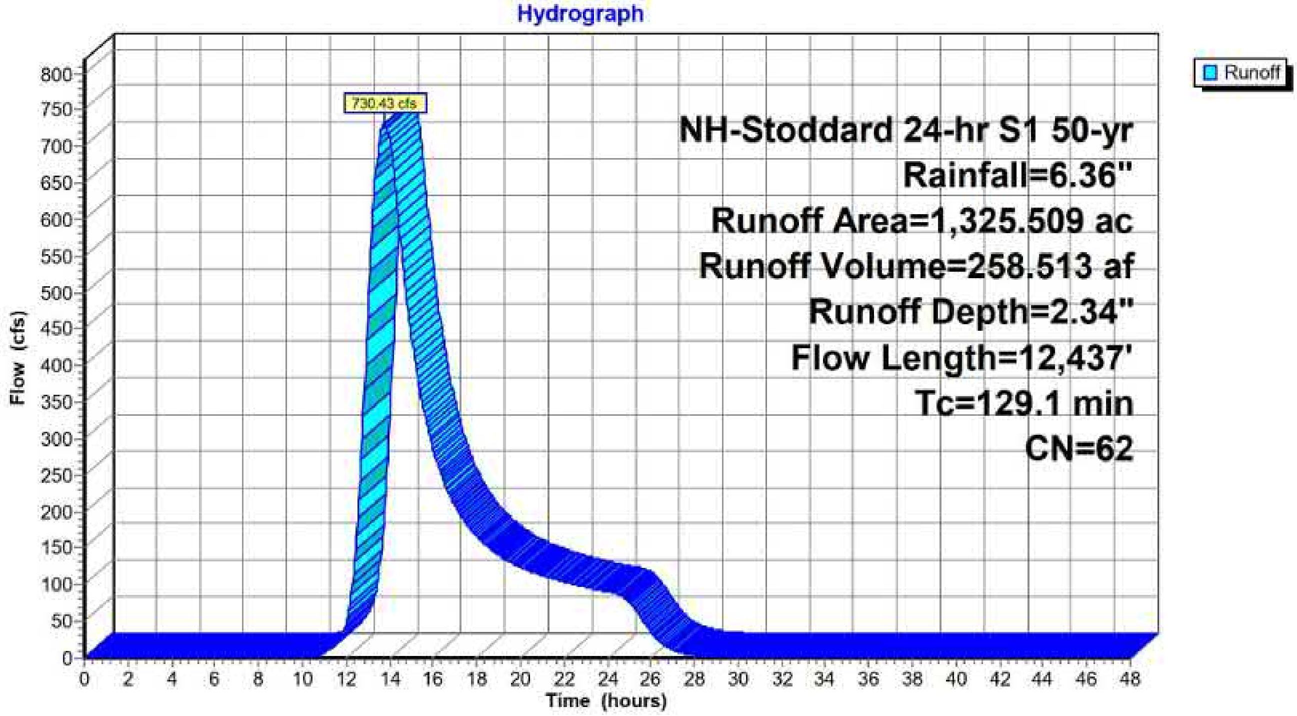
Runoff = 730.43 cfs @ 13.75 hrs, Volume= 258.513 af, Depth= 2.34"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 50-yr Rainfall=6.36"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

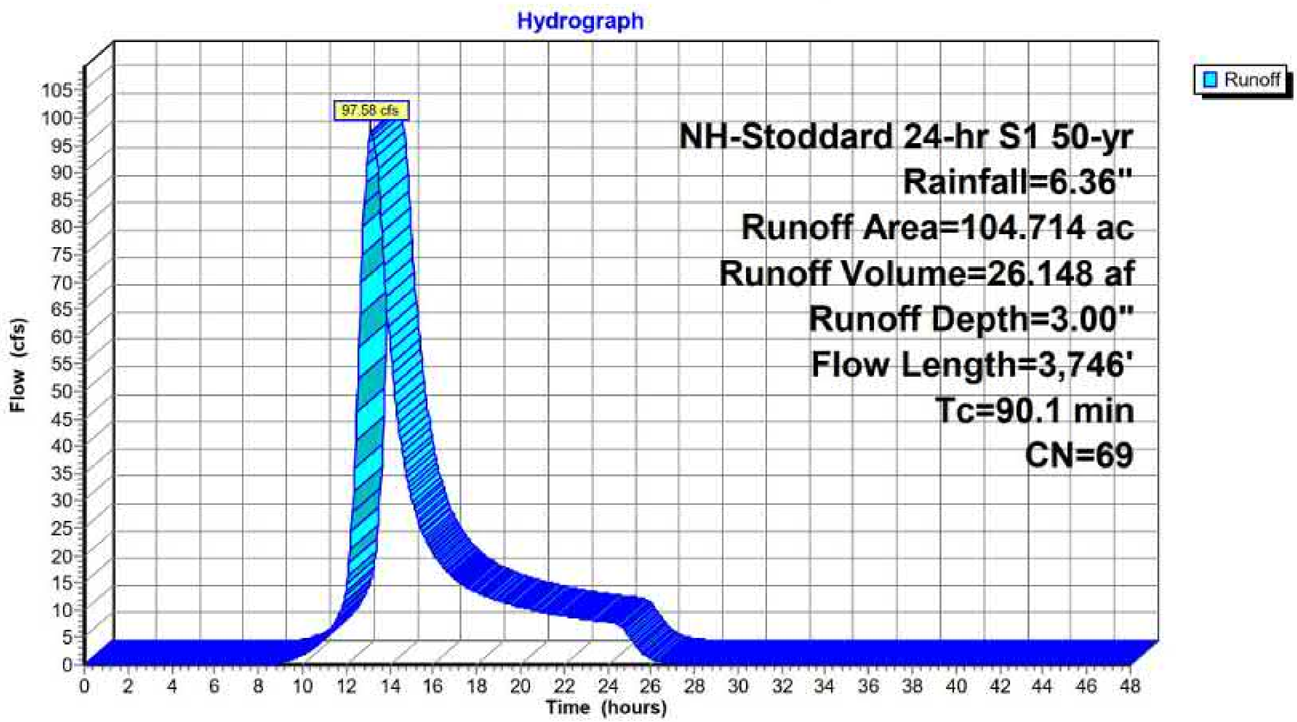
Runoff = 97.58 cfs @ 13.17 hrs, Volume= 26.148 af, Depth= 3.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 50-yr Rainfall=6.36"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

Subcatchment 2S: Tributary DA



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=2.91"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=922.33 cfs 321.630 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=3.64"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=118.93 cfs 31.740 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 353.370 af Average Runoff Depth = 2.96"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

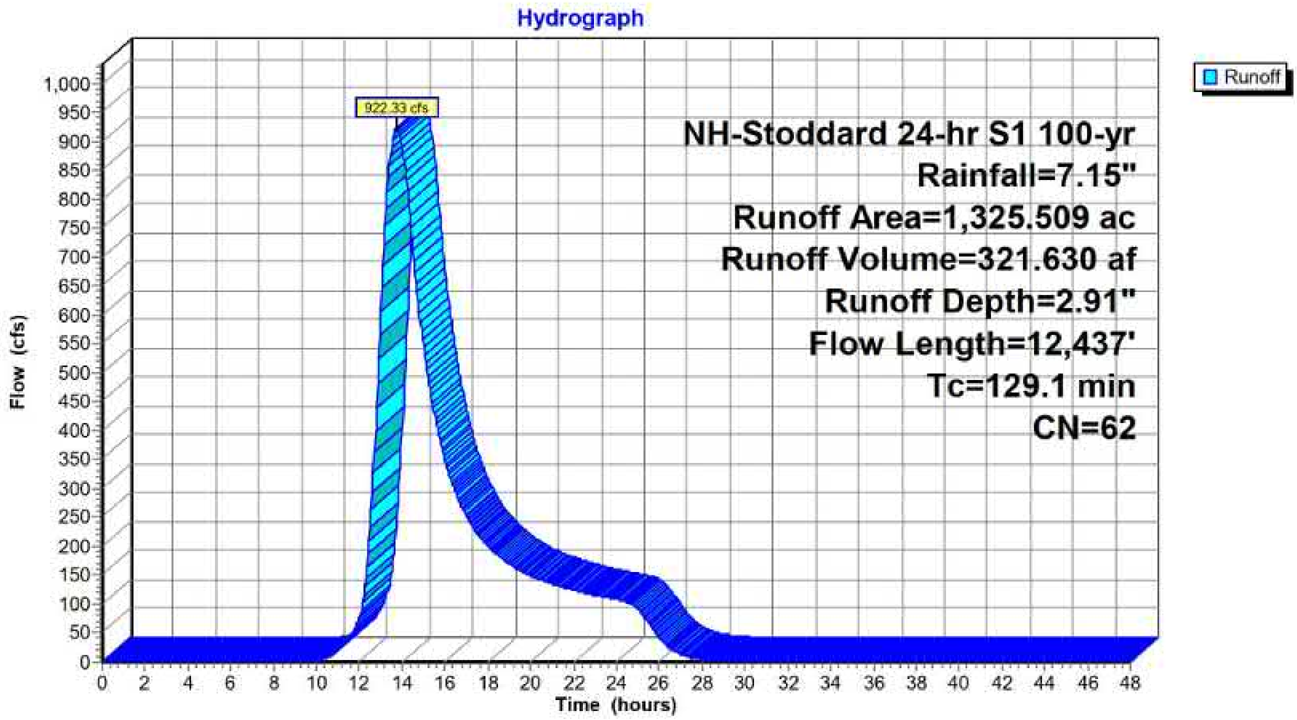
Runoff = 922.33 cfs @ 13.73 hrs, Volume= 321.630 af, Depth= 2.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 100-yr Rainfall=7.15"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

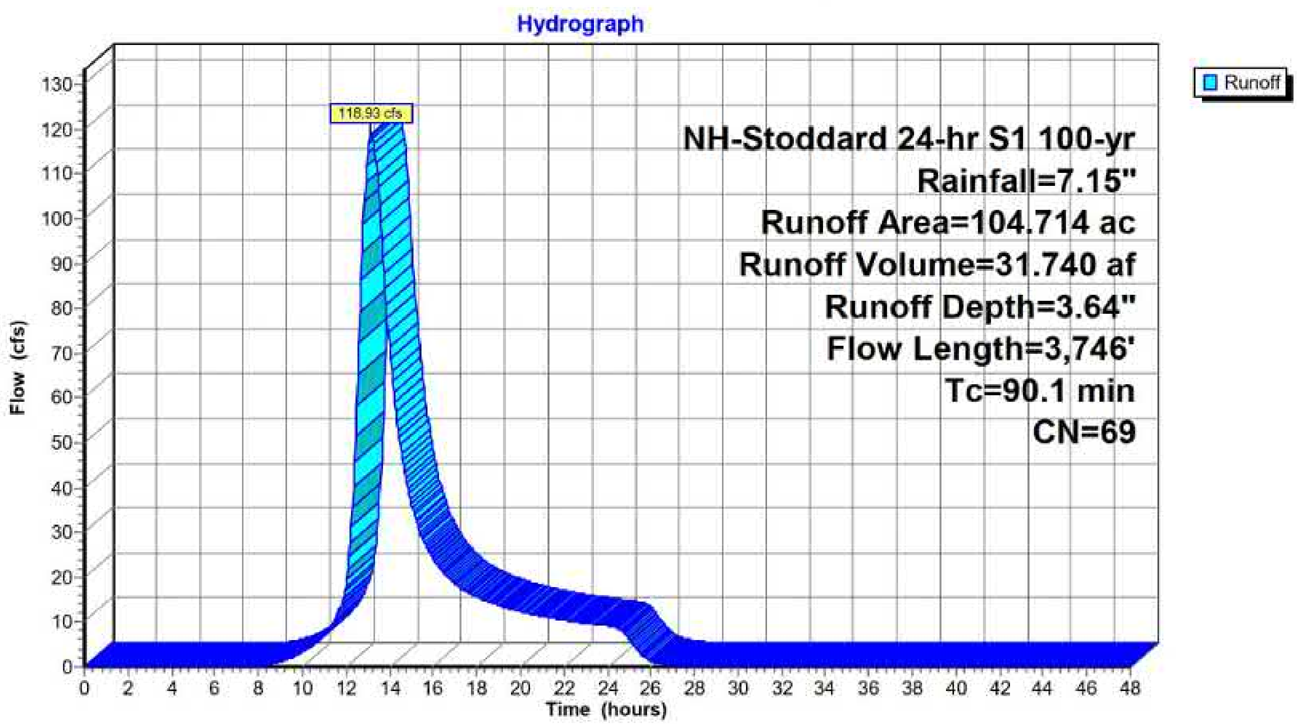
Runoff = 118.93 cfs @ 13.15 hrs, Volume= 31.740 af, Depth= 3.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 100-yr Rainfall=7.15"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

Subcatchment 2S: Tributary DA



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points x 2
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Kennedy Brook DA Runoff Area=1,325.509 ac 0.18% Impervious Runoff Depth=4.84"
Flow Length=12,437' Tc=129.1 min CN=62 Runoff=1,546.13 cfs 534.100 af

Subcatchment 2S: Tributary DA Runoff Area=104.714 ac 0.00% Impervious Runoff Depth=5.74"
Flow Length=3,746' Tc=90.1 min CN=69 Runoff=185.11 cfs 50.075 af

Total Runoff Area = 1,430.223 ac Runoff Volume = 584.176 af Average Runoff Depth = 4.90"
99.83% Pervious = 1,427.819 ac 0.17% Impervious = 2.404 ac

Summary for Subcatchment 1S: Kennedy Brook DA

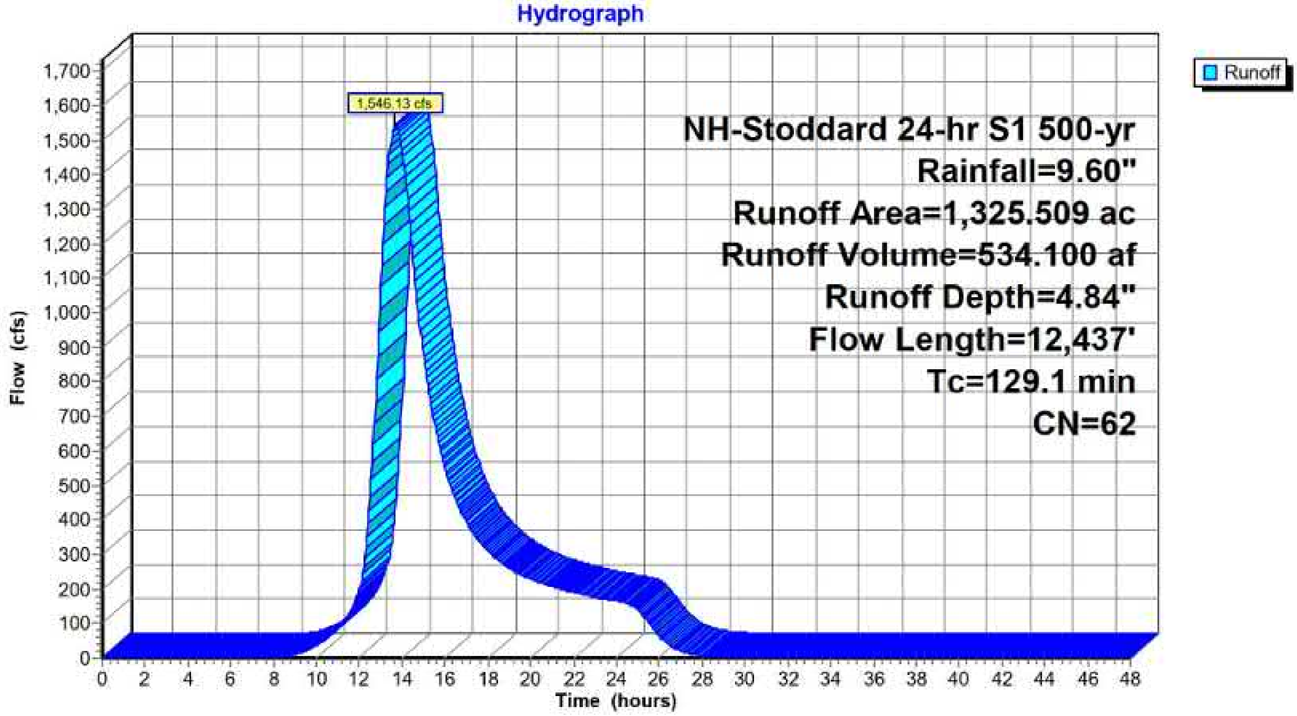
Runoff = 1,546.13 cfs @ 13.66 hrs, Volume= 534.100 af, Depth= 4.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 500-yr Rainfall=9.60"

Area (ac)	CN	Description
773.903	55	Woods, Good, HSG B
331.068	70	Woods, Good, HSG C
218.134	77	Woods, Good, HSG D
2.404	98	Unconnected pavement, HSG C
1,325.509	62	Weighted Average
1,323.105		99.82% Pervious Area
2.404		0.18% Impervious Area
2.404		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
52.7	300	0.0810	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 3.05"
3.6	311	0.0811	1.42		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.8	1,011	0.0594	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.5	1,845	0.0270	4.74	629.16	**Channel Flow,** Area= 132.6 sf Perim= 193.5' r= 0.69' n= 0.040 Mountain streams
9.2	1,727	0.0109	3.13	1,365.89	**Channel Flow,** Area= 436.4 sf Perim= 602.0' r= 0.72' n= 0.040 Mountain streams
6.6	1,543	0.0240	3.88	188.71	**Channel Flow,** Area= 48.6 sf Perim= 87.7' r= 0.55' n= 0.040 Mountain streams
36.7	5,700	0.0142	2.59	101.05	**Channel Flow,** Area= 39.0 sf Perim= 87.1' r= 0.45' n= 0.040 Mountain streams
129.1	12,437	Total			

Subcatchment 1S: Kennedy Brook DA



Summary for Subcatchment 2S: Tributary DA

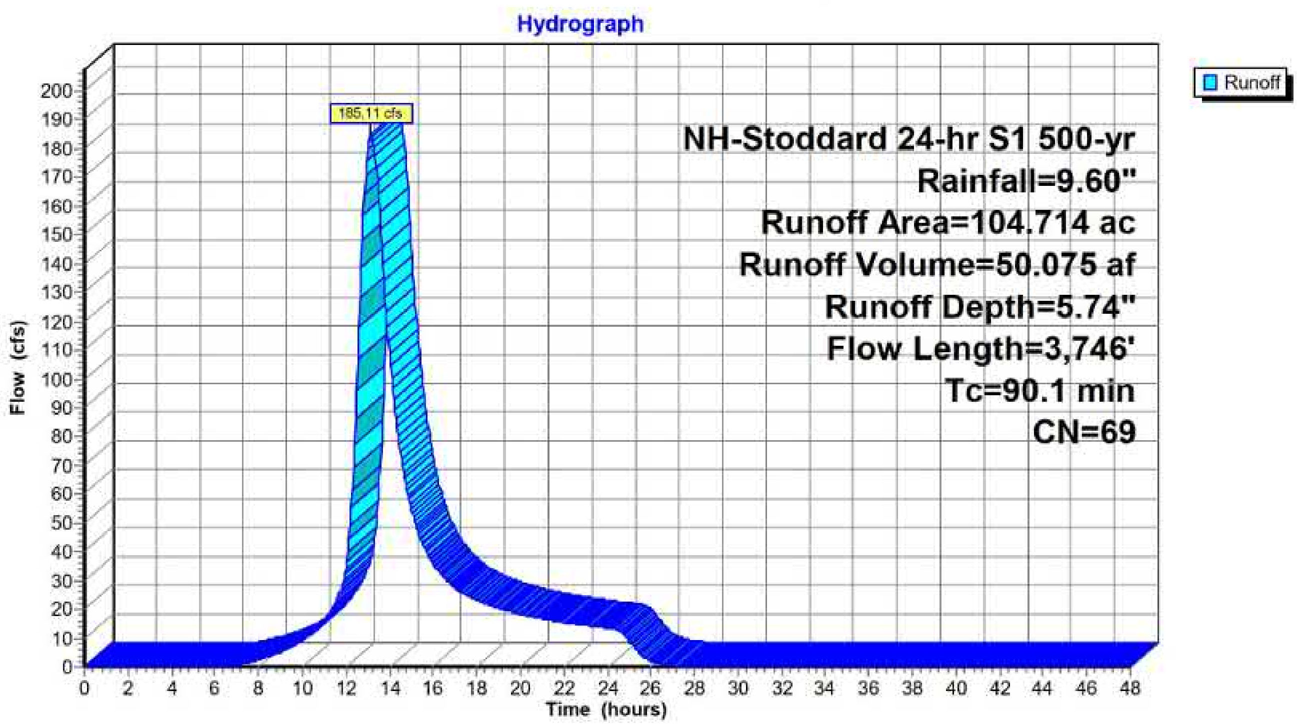
Runoff = 185.11 cfs @ 13.13 hrs, Volume= 50.075 af, Depth= 5.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
NH-Stoddard 24-hr S1 500-yr Rainfall=9.60"

Area (ac)	CN	Description
36.469	60	Woods, Fair, HSG B
15.081	79	Woods, Fair, HSG D
53.164	73	Woods, Fair, HSG C
104.714	69	Weighted Average
104.714		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.6	300	0.3655	0.30		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.05"
4.7	849	0.3655	3.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
42.4	1,172	0.0085	0.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
26.4	1,425	0.0860	0.90	4.05	**Channel Flow,** Area= 4.5 sf Perim= 6.0' r= 0.75' n= 0.400 Sheet flow: Woods+light brush
90.1	3,746	Total			

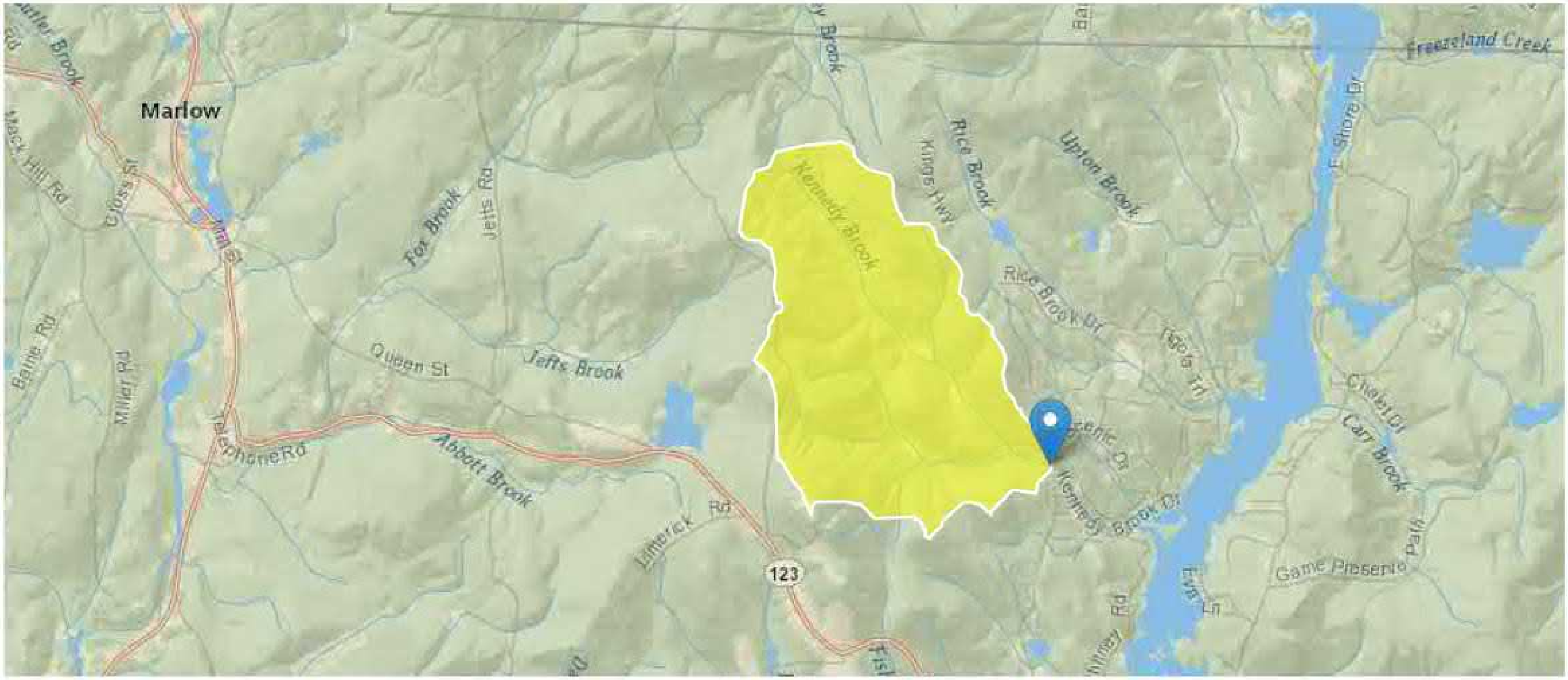
Subcatchment 2S: Tributary DA



APPENDIX G

StreamStats Report

Region ID: NH
Workspace ID: NH20200803115317100000
Clicked Point (Latitude, Longitude): 43.09812, -72.11078
Time: 2020-08-03 07:53:34 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.97	square miles
CONIF	Percentaqe of land surface covered by coniferous forest	13.7043	percent
PREBC0103	Mean annual precipitation of basin centroid for January 1 to March 15 winter period	8.78	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	14.012	percent
MIXFOR	Percentage of land area covered by mixed deciduous and coniferous forest	16.7833	percent
PREG_03_05	Mean precipitation at gaging station location for March 16 to May 31 spring period	10.2	inches
TEMP	Mean Annual Temperature	44.437	degrees F
TEMP_06_10	Basinwide average temperature for June to October summer period	60.473	degrees F
PREG_06_10	Mean precipitation at gaging station location for June to October summer period	20.6	inches
ELEVMAX	Maximum basin elevation	2139.445	feet
APRAVPRE	Mean April Precipitation	4.688	inches
WETLAND	Percentage of Wetlands	1.3392	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	106	feet per mi
PRECIPOUT	Mean annual precip at the stream outlet (based on annual PRISM precip data in inches from 1971-2000)	48	inches
MINTEMP_W	Mean winter minimum air temperature over basin surface area	15.012	degrees F
SNOFALL	Mean Annual Snowfall	98.185	inches
PREBC_1112	Mean annual precipitation of basin centroid for November 1 to December 31 period	8.5	inches
PRECIPCENT	Mean Annual Precip at Basin Centroid	48.2	inches

Seasonal Flow Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.97	square miles	3.26	689
CONIF	Percent Coniferous Forest	13.7043	percent	3.07	56.2
PREBC0103	Jan to Mar Basin Centroid Precip	8.78	inches	5.79	15.1
BSLDEM30M	Mean Basin Slope from 30m DEM	14.012	percent	3.19	38.1
MIXFOR	Percent Mixed Forest	16.7833	percent	6.21	46.1
PREG_03_05	Mar to May Gage Precipitation	10.2	inches	6.83	11.5
TEMP	Mean Annual Temperature	44.437	degrees F	36	48.7
TEMP_06_10	Jun to Oct Mean Basinwide Temp	60.473	degrees F	52.9	64.4
PREG_06_10	Jun to Oct Gage Precipitation	20.6	inches	16.5	23.1
ELEVMAX	Maximum Basin Elevation	2139.445	feet	260	6290

Seasonal Flow Statistics Disclaimers[Low Flow Statewide]

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

Seasonal Flow Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit
Jan to Mar15 60 Percent Flow	1.58	ft^3/s
Jan to Mar15 70 Percent Flow	1.33	ft^3/s
Jan to Mar15 80 Percent Flow	1.13	ft^3/s
Jan to Mar15 90 Percent Flow	0.821	ft^3/s

Statistic	Value	Unit
Jan to Mar15 95 Percent Flow	0.644	ft^3/s
Jan to Mar15 98 Percent Flow	0.51	ft^3/s
Jan to Mar15 7 Day 2 Year Low Flow	1.08	ft^3/s
Jan to Mar15 7 Day 10 Year Low Flow	0.586	ft^3/s
Mar16 to May 60 Percent Flow	4.56	ft^3/s
Mar16 to May 70 Percent Flow	3.55	ft^3/s
Mar16 to May 80 Percent Flow	2.78	ft^3/s
Mar16 to May 90 Percent Flow	1.96	ft^3/s
Mar16 to May 95 Percent Flow	1.46	ft^3/s
Mar16 to May 98 Percent Flow	1.09	ft^3/s
Mar16 to May 7 Day 2 Year Low Flow	1.5	ft^3/s
Mar16 to May 7 Day 10 Year Low Flow	0.822	ft^3/s
Jun to Oct 60 Percent Flow	0.403	ft^3/s
Jun to Oct 70 Percent Flow	0.286	ft^3/s
Jun to Oct 80 Percent Flow	0.196	ft^3/s
Jun to Oct 90 Percent Flow	0.116	ft^3/s
Jun to Oct 95 Percent Flow	0.0787	ft^3/s
Jun to Oct 98 Percent Flow	0.0574	ft^3/s
Jun to Oct 7 Day 2 Year Low Flow	0.139	ft^3/s
Jun to Oct 7 Day 10 Year Low Flow	0.0481	ft^3/s
Nov to Dec 60 Percent Flow	2.12	ft^3/s
Nov to Dec 70 Percent Flow	1.68	ft^3/s

Statistic	Value	Unit
Nov to Dec 80 Percent Flow	1.35	ft^3/s
Nov to Dec 90 Percent Flow	0.919	ft^3/s
Nov to Dec 95 Percent Flow	0.624	ft^3/s
Nov to Dec 98 Percent Flow	0.404	ft^3/s
Oct to Nov 7 Day 2 Year Low Flow	1.27	ft^3/s
Oct to Nov 7 Day 10 Year Low Flow	0.593	ft^3/s

Seasonal Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Flow-Duration Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.97	square miles	3.26	689
PREG_06_10	Jun to Oct Gage Precipitation	20.6	inches	16.5	23.1
TEMP	Mean Annual Temperature	44.437	degrees F	36	48.7

Flow-Duration Statistics Disclaimers[Low Flow Statewide]

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

Flow-Duration Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit

Statistic	Value	Unit
60 Percent Duration	1.37	ft^3/s
70 Percent Duration	0.895	ft^3/s
80 Percent Duration	0.506	ft^3/s
90 Percent Duration	0.241	ft^3/s
95 Percent Duration	0.14	ft^3/s
98 Percent Duration	0.085	ft^3/s

Flow-Duration Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Low-Flow Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.97	square miles	3.26	689
TEMP	Mean Annual Temperature	44.437	degrees F	36	48.7
PREG_06_10	Jun to Oct Gage Precipitation	20.6	inches	16.5	23.1

Low-Flow Statistics Disclaimers[Low Flow Statewide]

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

Low-Flow Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.141	ft^3/s
7 Day 10 Year Low Flow	0.0482	ft^3/s

Low-Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Peak-Flow Statistics Parameters[Peak Flow Statewide SIR2008 5206]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.97	square miles	0.7	1290
APRAVPRE	Mean April Precipitation	4.688	inches	2.79	6.23
WETLAND	Percent Wetlands	1.3392	percent	0	21.8
CSL10_85	Stream Slope 10 and 85 Method	106	feet per mi	5.43	543

Peak-Flow Statistics Flow Report[Peak Flow Statewide SIR2008 5206]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	Plu	SEp	Equiv. Yrs.
2 Year Peak Flood	122	ft^3/s	74	201	30.1	3.2
5 Year Peak Flood	218	ft^3/s	130	364	31.1	4.7
10 Year Peak Flood	302	ft^3/s	177	514	32.3	6.2
25 Year Peak Flood	418	ft^3/s	237	739	34.3	8
50 Year Peak Flood	517	ft^3/s	284	941	36.4	9

Statistic	Value	Unit	PII	Plu	SEp	Equiv. Yrs.
100 Year Peak Flood	637	ft^3/s	337	1200	38.6	9.8
500 Year Peak Flood	935	ft^3/s	456	1920	44.1	11

Peak-Flow Statistics Citations

Olson, S.A.,2009, Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S.Geological Survey Scientific Investigations Report 2008-5206, 57 p. (http://pubs.usgs.gov/sir/2008/5206/)

Recharge Statistics Parameters[Groundwater Recharge Statewide 2004 5019]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PRECIPOUT	Mean Annual Precip at Gage	48	inches	35.83	53.11
TEMP	Mean Annual Temperature	44.437	degrees F	36.05	48.69
MINTEMP_W	Mean Winter Min Temperature	15.012	degrees F	0.8	19.88
CONIF	Percent Coniferous Forest	13.7043	percent	3.07	56.18
PREG_03_05	Mar to May Gage Precipitation	10.2	inches	6.83	11.54
SNOFALL	Mean Annual Snowfall	98.185	inches	54.46	219.07
PREG_06_10	Jun to Oct Gage Precipitation	20.6	inches	16.46	23.11
MIXFOR	Percent Mixed Forest	16.7833	percent	6.21	46.13
PREBC_1112	Nov to Dec Basin Centroid Precip	8.5	inches	6.57	15.2
PRECIPCENT	Mean Annual Precip at Basin Centroid	48.2	inches	37.44	75.91

Recharge Statistics Flow Report[Groundwater Recharge Statewide 2004 5019]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp

Statistic	Value	Unit	SEp
GW_Recharge_Jan_to_Mar15	6.16	in	15.5
GW_Recharge_Mar16_to_May	9.79	in	12.4
GW_Recharge_Jun_to_Oct	4.96	in	26.5
GW_Recharge_Nov_to_Dec	3.96	in	15.8
GW_Recharge_Ann	24	in	12.4

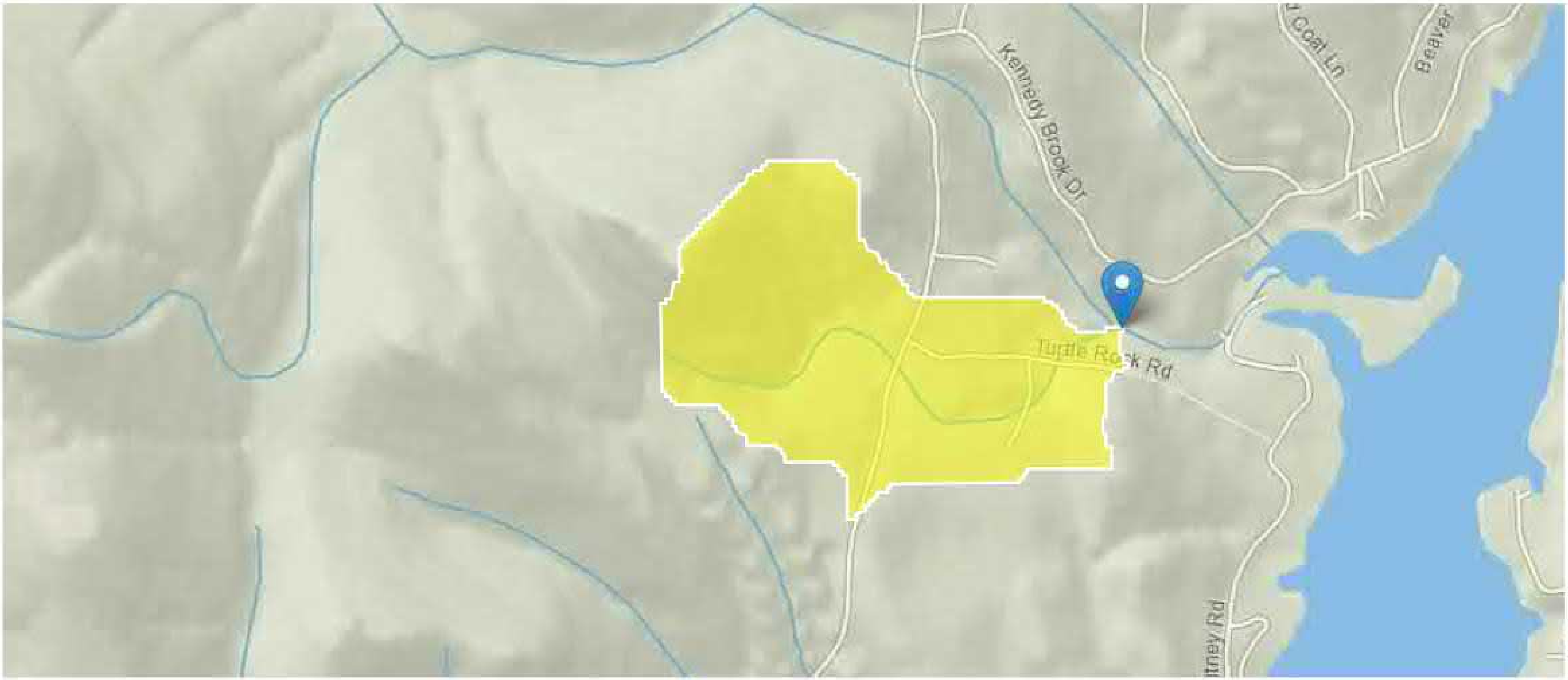
Recharge Statistics Citations

Flynn, R.H. and Tasker, G.D.,2004, Generalized Estimates from Streamflow Data of Annual and Seasonal Ground-Water-Recharge Rates for Drainage Basins in New Hampshire, U.S. Geological Survey Scientific Investigations Report 2004-5019, 67 p. (http://pubs.usgs.gov/sir/2004/5019/http://pubs.usgs.gov/sir/2004/5019/)

Application Version: 4.3.11

StreamStats Report

Region ID: NH
Workspace ID: NH20200805123320162000
Clicked Point (Latitude, Longitude): 43.09320, -72.10542
Time: 2020-08-05 08:33:37 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.16	square miles
CONIF	Percentaqe of land surface covered by coniferous forest	13.9668	percent
PREBC0103	Mean annual precipitation of basin centroid for January 1 to March 15 winter period	8.66	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	16.673	percent
MIXFOR	Percentage of land area covered by mixed deciduous and coniferous forest	13.3934	percent
PREG_03_05	Mean precipitation at gaging station location for March 16 to May 31 spring period	10.2	inches
TEMP	Mean Annual Temperature	44.42	degrees F
TEMP_06_10	Basinwide average temperature for June to October summer period	60.409	degrees F
PREG_06_10	Mean precipitation at gaging station location for June to October summer period	20.4	inches
ELEVMAX	Maximum basin elevation	1886.501	feet
APRAVPRE	Mean April Precipitation	4.45	inches
WETLAND	Percentage of Wetlands	0	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	367	feet per mi
PRECIPOUT	Mean annual precip at the stream outlet (based on annual PRISM precip data in inches from 1971-2000)	47.8	inches
MINTEMP_W	Mean winter minimum air temperature over basin surface area	15.098	degrees F
SNOFALL	Mean Annual Snowfall	96.626	inches
PREBC_1112	Mean annual precipitation of basin centroid for November 1 to December 31 period	8.43	inches
PRECIPCENT	Mean Annual Precip at Basin Centroid	47.9	inches

Seasonal Flow Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.16	square miles	3.26	689
CONIF	Percent Coniferous Forest	13.9668	percent	3.07	56.2
PREBC0103	Jan to Mar Basin Centroid Precip	8.66	inches	5.79	15.1
BSLDEM30M	Mean Basin Slope from 30m DEM	16.673	percent	3.19	38.1
MIXFOR	Percent Mixed Forest	13.3934	percent	6.21	46.1
PREG_03_05	Mar to May Gage Precipitation	10.2	inches	6.83	11.5
TEMP	Mean Annual Temperature	44.42	degrees F	36	48.7
TEMP_06_10	Jun to Oct Mean Basinwide Temp	60.409	degrees F	52.9	64.4
PREG_06_10	Jun to Oct Gage Precipitation	20.4	inches	16.5	23.1
ELEVMAX	Maximum Basin Elevation	1886.501	feet	260	6290

Seasonal Flow Statistics Disclaimers[Low Flow Statewide]

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

Seasonal Flow Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit
Jan to Mar15 60 Percent Flow	0.11	ft^3/s
Jan to Mar15 70 Percent Flow	0.0907	ft^3/s
Jan to Mar15 80 Percent Flow	0.0786	ft^3/s
Jan to Mar15 90 Percent Flow	0.0556	ft^3/s

Statistic	Value	Unit
Jan to Mar15 95 Percent Flow	0.0434	ft^3/s
Jan to Mar15 98 Percent Flow	0.0355	ft^3/s
Jan to Mar15 7 Day 2 Year Low Flow	0.075	ft^3/s
Jan to Mar15 7 Day 10 Year Low Flow	0.0378	ft^3/s
Mar16 to May 60 Percent Flow	0.378	ft^3/s
Mar16 to May 70 Percent Flow	0.291	ft^3/s
Mar16 to May 80 Percent Flow	0.23	ft^3/s
Mar16 to May 90 Percent Flow	0.162	ft^3/s
Mar16 to May 95 Percent Flow	0.12	ft^3/s
Mar16 to May 98 Percent Flow	0.0905	ft^3/s
Mar16 to May 7 Day 2 Year Low Flow	0.109	ft^3/s
Mar16 to May 7 Day 10 Year Low Flow	0.0572	ft^3/s
Jun to Oct 60 Percent Flow	0.0202	ft^3/s
Jun to Oct 70 Percent Flow	0.0138	ft^3/s
Jun to Oct 80 Percent Flow	0.00921	ft^3/s
Jun to Oct 90 Percent Flow	0.00511	ft^3/s
Jun to Oct 95 Percent Flow	0.0031	ft^3/s
Jun to Oct 98 Percent Flow	0.00246	ft^3/s
Jun to Oct 7 Day 2 Year Low Flow	0.00629	ft^3/s
Jun to Oct 7 Day 10 Year Low Flow	0.00152	ft^3/s
Nov to Dec 60 Percent Flow	0.19	ft^3/s
Nov to Dec 70 Percent Flow	0.148	ft^3/s

Statistic	Value	Unit
Nov to Dec 80 Percent Flow	0.118	ft^3/s
Nov to Dec 90 Percent Flow	0.0777	ft^3/s
Nov to Dec 95 Percent Flow	0.0483	ft^3/s
Nov to Dec 98 Percent Flow	0.0282	ft^3/s
Oct to Nov 7 Day 2 Year Low Flow	0.108	ft^3/s
Oct to Nov 7 Day 10 Year Low Flow	0.047	ft^3/s

Seasonal Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Flow-Duration Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.16	square miles	3.26	689
PREG_06_10	Jun to Oct Gage Precipitation	20.4	inches	16.5	23.1
TEMP	Mean Annual Temperature	44.42	degrees F	36	48.7

Flow-Duration Statistics Disclaimers[Low Flow Statewide]

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

Flow-Duration Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit

Statistic	Value	Unit
60 Percent Duration	0.0874	ft^3/s
70 Percent Duration	0.0555	ft^3/s
80 Percent Duration	0.028	ft^3/s
90 Percent Duration	0.0117	ft^3/s
95 Percent Duration	0.00619	ft^3/s
98 Percent Duration	0.00332	ft^3/s

Flow-Duration Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Low-Flow Statistics Parameters[Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.16	square miles	3.26	689
TEMP	Mean Annual Temperature	44.42	degrees F	36	48.7
PREG_06_10	Jun to Oct Gage Precipitation	20.4	inches	16.5	23.1

Low-Flow Statistics Disclaimers[Low Flow Statewide]

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

Low-Flow Statistics Flow Report[Low Flow Statewide]

Statistic	Value	Unit

Statistic	Value	Unit
7 Day 2 Year Low Flow	0.00598	ft^3/s
7 Day 10 Year Low Flow	0.0014	ft^3/s

Low-Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (http://pubs.water.usgs.gov/wrir02-4298)

Peak-Flow Statistics Parameters[Peak Flow Statewide SIR2008 5206]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.16	square miles	0.7	1290
APRAVPRE	Mean April Precipitation	4.45	inches	2.79	6.23
WETLAND	Percent Wetlands	0	percent	0	21.8
CSL10_85	Stream Slope 10 and 85 Method	367	feet per mi	5.43	543

Peak-Flow Statistics Disclaimers[Peak Flow Statewide SIR2008 5206]

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

Peak-Flow Statistics Flow Report[Peak Flow Statewide SIR2008 5206]

Statistic	Value	Unit
2 Year Peak Flood	14.2	ft^3/s
5 Year Peak Flood	27.1	ft^3/s
10 Year Peak Flood	39	ft^3/s

Statistic	Value	Unit
25 Year Peak Flood	56.4	ft^3/s
50 Year Peak Flood	71.5	ft^3/s
100 Year Peak Flood	90.1	ft^3/s
500 Year Peak Flood	139	ft^3/s

Peak-Flow Statistics Citations

Olson, S.A.,2009, Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S.Geological Survey Scientific Investigations Report 2008-5206, 57 p. (http://pubs.usgs.gov/sir/2008/5206/)

Recharge Statistics Parameters[Groundwater Recharge Statewide 2004 5019]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PRECIPOUT	Mean Annual Precip at Gage	47.8	inches	35.83	53.11
TEMP	Mean Annual Temperature	44.42	degrees F	36.05	48.69
MINTEMP_W	Mean Winter Min Temperature	15.098	degrees F	0.8	19.88
CONIF	Percent Coniferous Forest	13.9668	percent	3.07	56.18
PREG_03_05	Mar to May Gage Precipitation	10.2	inches	6.83	11.54
SNOFALL	Mean Annual Snowfall	96.626	inches	54.46	219.07
PREG_06_10	Jun to Oct Gage Precipitation	20.4	inches	16.46	23.11
MIXFOR	Percent Mixed Forest	13.3934	percent	6.21	46.13
PREBC_1112	Nov to Dec Basin Centroid Precip	8.43	inches	6.57	15.2
PRECIPCENT	Mean Annual Precip at Basin Centroid	47.9	inches	37.44	75.91

Recharge Statistics Flow Report[Groundwater Recharge Statewide 2004 5019]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
GW_Recharge_Jan_to_Mar15	6.13	in	15.5
GW_Recharge_Mar16_to_May	9.71	in	12.4
GW_Recharge_Jun_to_Oct	4.99	in	26.5
GW_Recharge_Nov_to_Dec	3.91	in	15.8
GW_Recharge_Ann	23.8	in	12.4

Recharge Statistics Citations

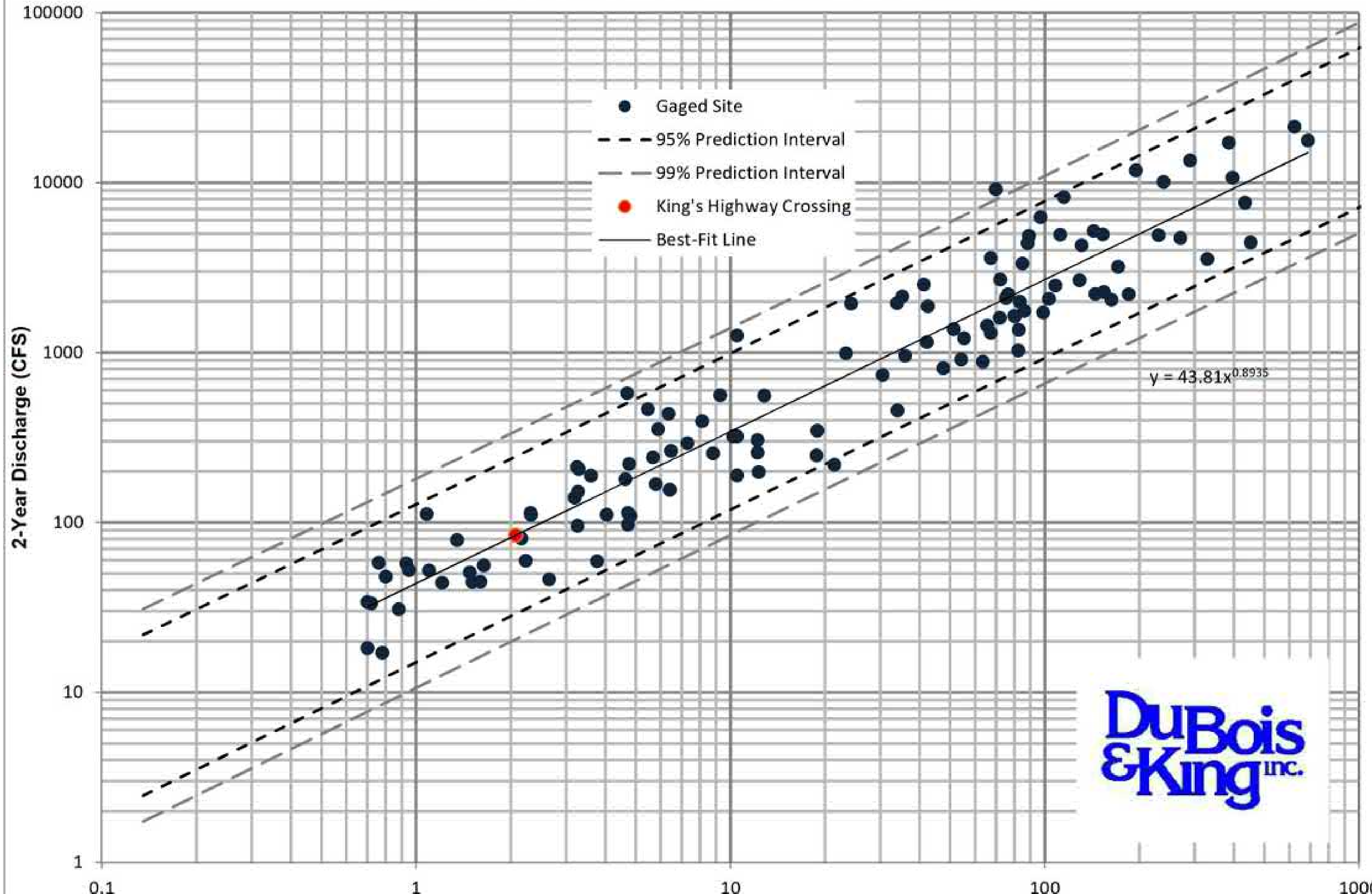
Flynn, R.H. and Tasker, G.D.,2004, Generalized Estimates from Streamflow Data of Annual and Seasonal Ground-Water-Recharge Rates for Drainage Basins in New Hampshire, U.S. Geological Survey Scientific Investigations Report 2004-5019, 67 p. (http://pubs.usgs.gov/sir/2004/5019/http://pubs.usgs.gov/sir/2004/5019/)

Application Version: 4.3.11

APPENDIX H

Discharge at Gaged Sites in New Hampshire

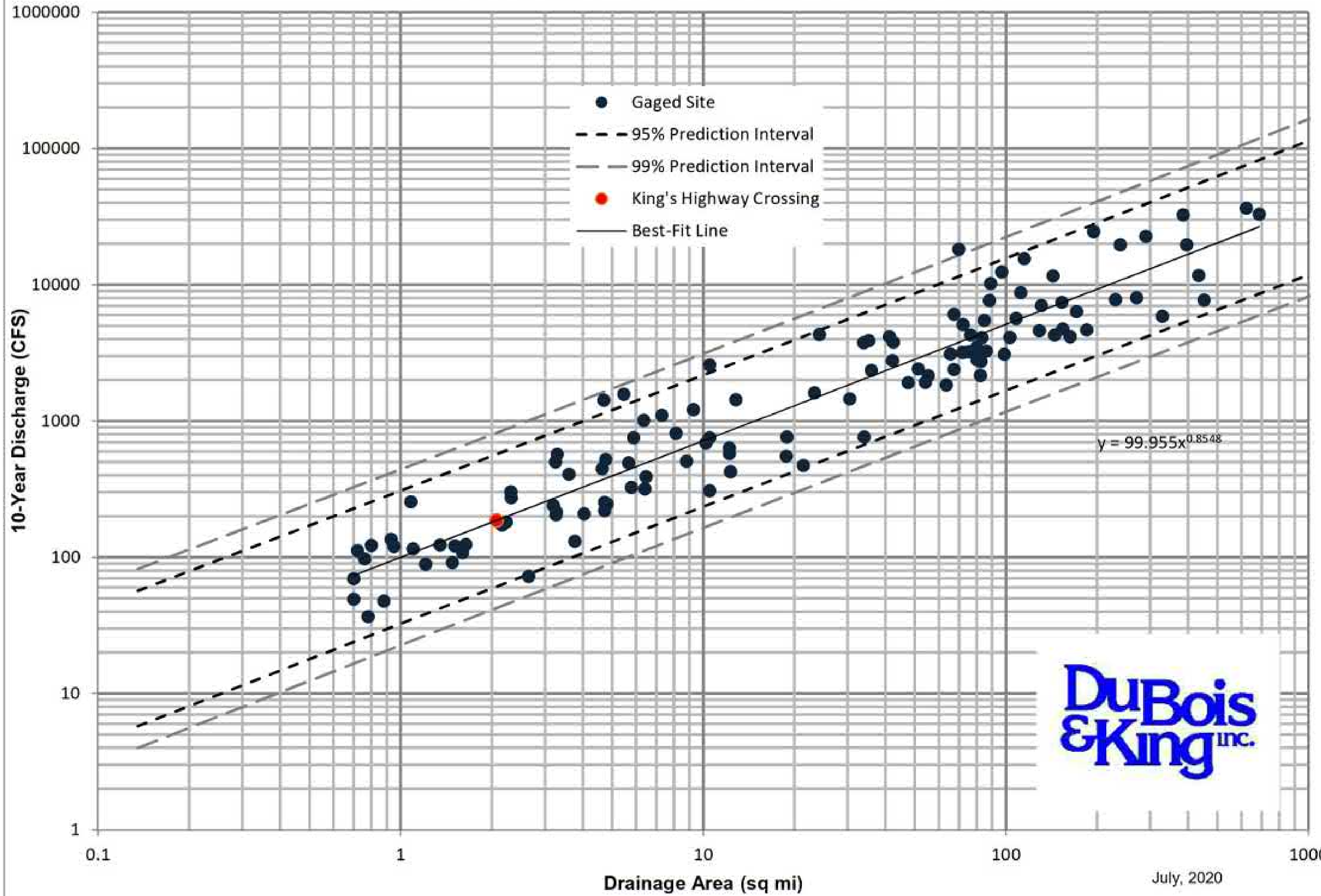
source: Water Resources Investigations Report 2008-5206 (USGS Report dated 2008)



July, 2020

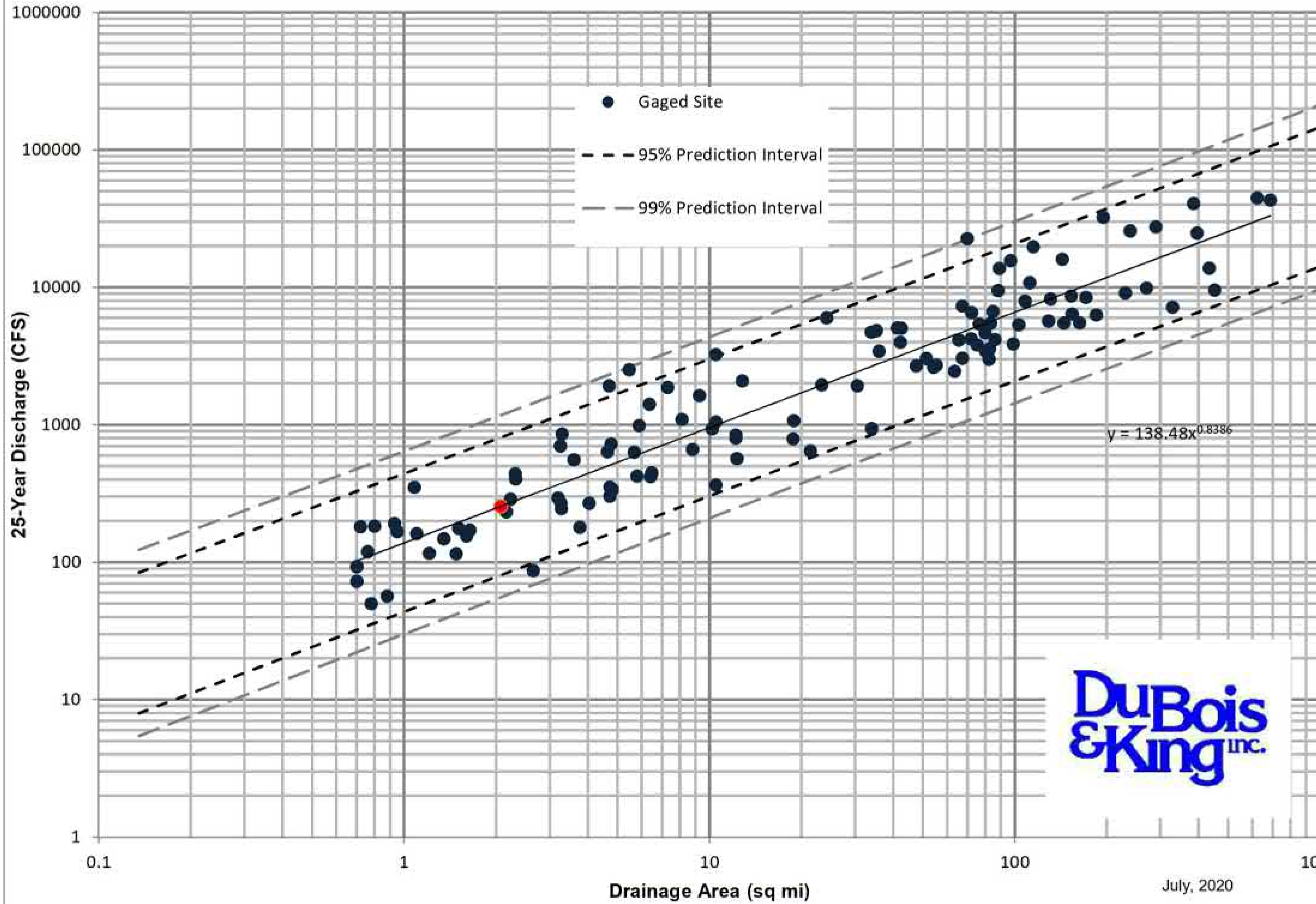
Discharge at Gaged Sites in New Hampshire

source: Water Resources Investigations Report 2008-5206 (USGS Report dated 2008)



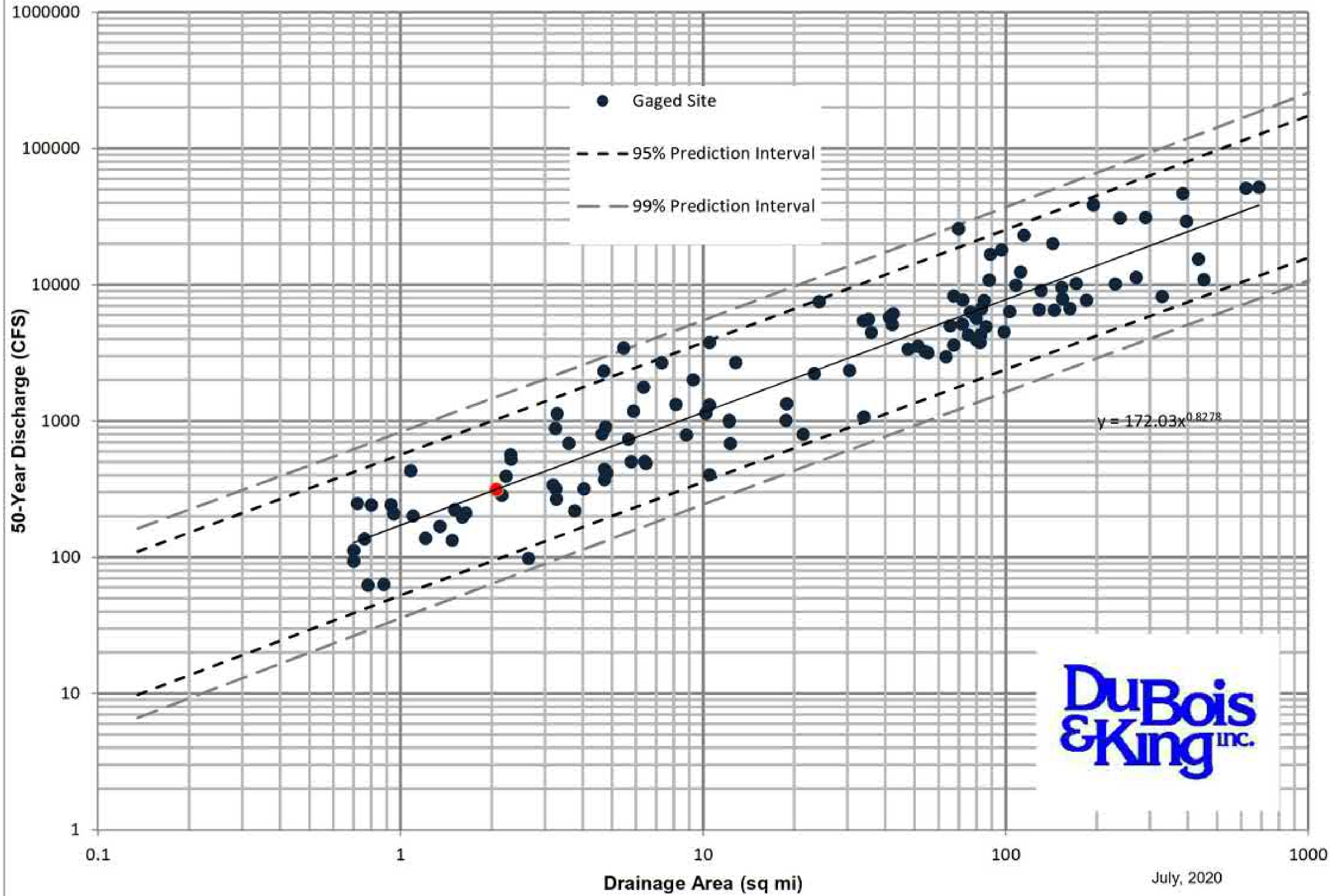
Discharge at Gaged Sites in New Hampshire

source: Water Resources Investigations Report 2008-5206 (USGS Report dated 2008)



Discharge at Gaged Sites in New Hampshire

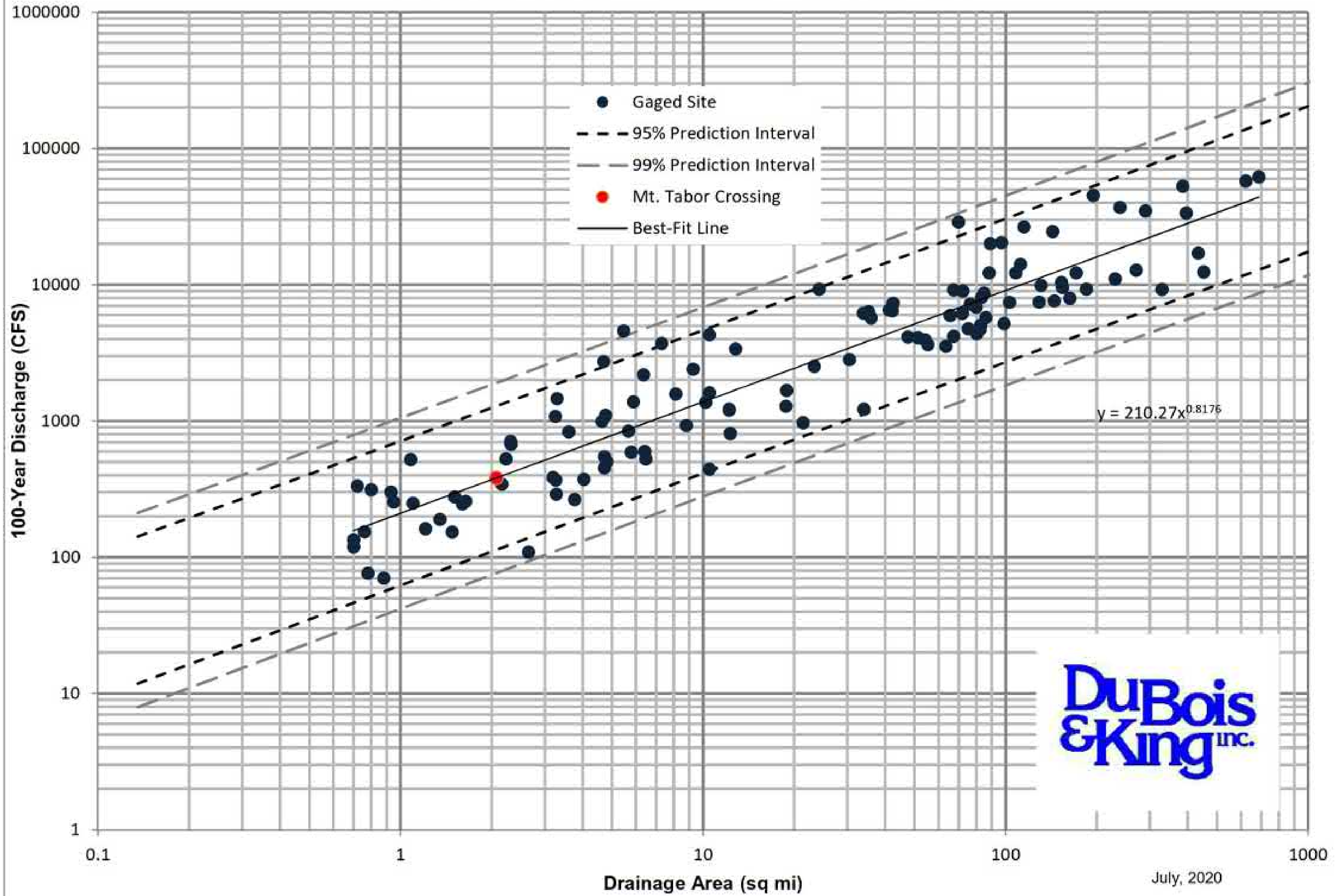
source: Water Resources Investigations Report 2008-5206 (USGS Report dated 2008)



July, 2020

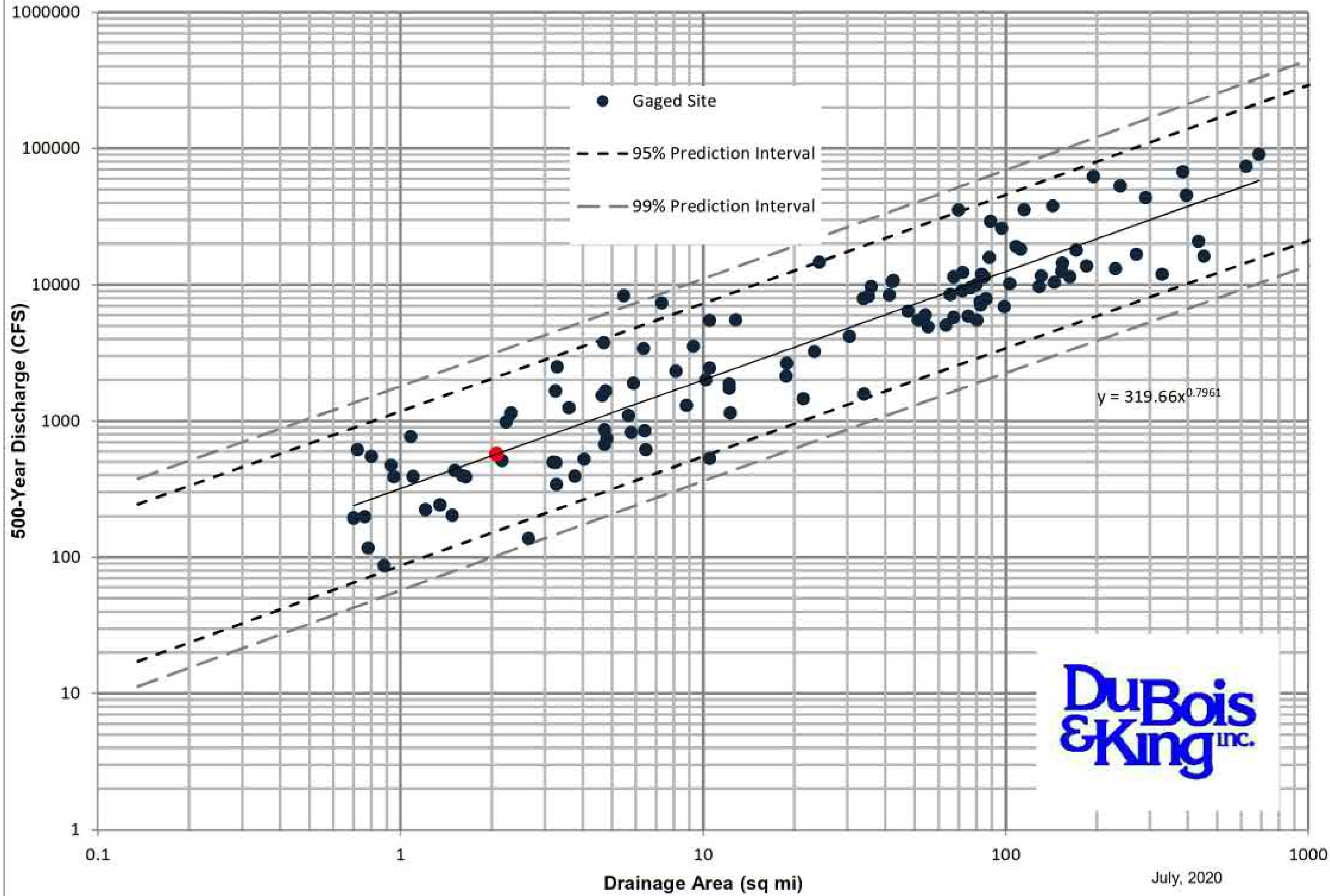
Discharge at Gaged Sites in New Hampshire

source: Water Resources Investigations 2008-5206 (USGS Report dated 2008)



Discharge at Gaged Sites in New Hampshire

source: Water Resources Investigations 2008-5206 (USGS Report dated 2008)



July, 2020

APPENDIX I

April 2012
Publication No. FHWA-HIF-12-004

Hydraulic Engineering Circular No. 20

Stream Stability at Highway Structures
Fourth Edition

U.S. Department of Transportation
Federal Highway Administration

Another effect of bed forms on highway crossings is that with dunes on the bed, there is a fluctuating pattern of scour on the bed and around piers. The average height of dunes is approximately one-third of the average depth of flow, and the maximum height of a dune may approach one-half the average depth of flow. With the passage of a dune through a bridge opening, an increase in local scour would be anticipated when the trough of the dune arrives at the bridge. It has been determined experimentally that local scour increases by 30% or more over equilibrium scour depth with the passage of a large dune trough (FHWA 2012a and b) (see also Section 7.4.3).

A very important effect of bed forms and bars is the change of flow direction in channels. At low flow, the bars can be residual and cause high velocity flow along or at a pier or other structures in the streambed, causing deeper than anticipated scour.

Care must be used in analyzing crossings of sand-bed streams in order to anticipate changes that may occur in bed forms and the impact of these changes on the resistance to flow, sediment transport, and the stability of the reach and highway structures. As described in Section 3.4.4, with a dune bed, the Manning n (see Section 3.3.3) could be as large as 0.040. Whereas, with a plane bed, the n value could be as low as 0.010. A change from a dune bed to a plane bed, or the reverse, can have an appreciable effect on depth and velocity. In the design of a bridge or a stream stability or scour countermeasure, it is good engineering practice to assume a dune bed (large n value) when establishing the water surface elevations, and a plane bed (low n value) for calculations involving velocity.

3.4.4 Resistance to Flow

Use of the Manning equation (Section 3.3.3) to compute flow in open channels and floodplains assumes one-dimensional flow. Procedures for summing the results of computations for subsections to obtain results for the total cross section involve use of the following assumptions: (1) mean velocity in each subsection is the same, (2) the total force resisting flow is equal to the sum of forces in the subsections, and (3) total flow in the cross section is equal to the sum of the flows in the subsections. This implies that the slope of the energy grade line is the same for each subsection (Figure 3.2). Assumption (3) is the basis for computing total conveyance for a cross section by adding conveyances of subsections (see Section 3.3.3).

<u>Resistance to Flow in Channels</u>. The general approach for estimating the resistance to flow in a stream channel is to select a base n value for materials in the channel boundaries assuming a straight, uniform channel, and then to make corrections to the base n value to account for channel irregularities, sinuosity, and other factors which affect the resistance to flow (Cowan 1956, FHWA 2001). Equation 3.9 is used to compute the equivalent material roughness coefficient "n" for a channel:

$$n = (n_b + n_1 + n_2 + n_3 + n_4)m \tag{3.9}$$

where:

n_b	=	Base value for straight, uniform channel
n_1	=	Value for surface irregularities in the cross section
n_2	=	Value for variations in shape and size of the channel
n_3	=	Value for obstructions
n_4	=	Value for vegetation and flow conditions
m	=	Correction factor for sinuosity of the channel

Table 3.1 provides base n values for stable channels and sand channels, while Table 3.2 provides adjustment factors for use in Equation 3.9. HDS 6 and Arcement and Schneider provide more detailed descriptions of conditions that affect the selection of appropriate values (FHWA 2001, USGS 1984).

Resistance to Flow in Sand-Bed Channels. The value of n varies greatly in sand-bed channels because of the varying bed forms that occur with lower and upper flow regimes. Figure 3.5 shows the relative resistance to flow in channels in lower regime, transition, and upper regime flow and the bed forms which exist for each regime.

Sand-bed channels with bed materials having a median diameter from 0.14 to 0.4 mm usually plane out during high flows. Manning n values change from as large as 0.040 at low flows to as small as 0.010 at high flow. Table 3.3 provides typical ranges of n values for sand-bed channels.

Table 3.1. Base Values of Manning n (n_b).

Channel or Floodplain Type	Median Size, Bed Material		Base n Value	
	Millimeters (mm)	Inches (in)	Benson and Dalrymple	Chow
Sand Channels*	0.2	-- --	0.012	-- --
	.3	-- --	0.017	-- --
	.4	-- --	0.020	-- --
	.5	-- --	0.022	-- --
	.6	-- --	0.023	-- --
	.8	-- --	0.025	-- --
	1.0	-- --	0.026	-- --
Stable Channels and Floodplains				
Concrete	-- --	-- --	0.012 - 0.018	0.011
Rock cut	-- --	-- --	-- --	0.025
Firm soil	-- --	-- --	0.025 - 0.032	0.020
Coarse sand	1 - 2	-- --	0.026 - 0.035	-- --
Fine gravel	-- --	-- --	-- --	0.024
Gravel	2 - 64	0.08 – 2.5	0.028 - 0.035	-- --
Coarse gravel	-- --	-- --	-- --	0.026
Cobble	64 - 256	2.5 – 10.1	0.030 - 0.050	-- --
Boulder	> 256	> 10.1	0.040 - 0.070	-- --

* For Sand Channels note only for upper regime flow where grain roughness is predominant

Table 3.2. Adjustment Factors for the Determination of n Values for Channels.			
n factor	Conditions	n Value	Remarks
n_1	Smooth	0	Smoothest channel
	Minor	0.001-0.005	Slightly eroded side slopes
	Moderate	0.006-0.010	Moderately rough bed and banks
	Severe	0.011-0.020	Badly sloughed and scalloped banks
n_2	Gradual	0	Gradual Changes
	Alternating Occasionally	0.001-0.005	Occasional shifts from large to small sections
	Alternating Frequently	0.010-0.015	Frequent changes in cross-sectional shape
n_3	Negligible	0-0.004	Obstructions < 5% of cross-section area
	Minor	0.005-0.015	Obstructions < 15% of cross-section area
	Appreciable	0.020-0.030	Obstructions 15-50% of cross-section area
	Severe	0.040-0.060	Obstructions > 50% of cross-section area
n_4	Small	0.002-0.010	Flow depth > 2 x vegetation height
	Medium	0.010-0.025	Flow depth > vegetation height
	Large	0.025-0.050	Flow depth < vegetation height
	Very Large	0.050-0.100	Flow depth < 0.5 vegetation height
m	Minor	1.00	Sinuosity < 1.2
	Appreciable	1.15	1.2 < Sinuosity < 1.5
	Severe	1.30	Sinuosity > 1.5

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JOB 325788 - KINGSHIGWAY CULVERT
SHEET NO. 1 OF 1
CALCULATED BY DC DATE 8/6/2020
CHECKED BY ______ DATE ______
SCALE ______

KENNEDY BROOK MANNING'S "n" CALC

$n_b = 0.04$ (ASSUMED FROM SITE VISIT PHOTOS ON 3-18-20

$n_1 = 0.001$

$n_2 = 0.002$

$n_3 = 0.001$

$n_4 = 0.002$

$m = 1.1$ SINUOSITY ≈ 1.34

$n = (n_b + n_1 + n_2 + n_3 + n_4)m$

$n = (0.04 + 0.001 + 0.002 + 0.001 + 0.002)1.1$

$n = 0.0506$

APPENDIX J

King's Highway Over Kennedy Brook - Stoddard, NH

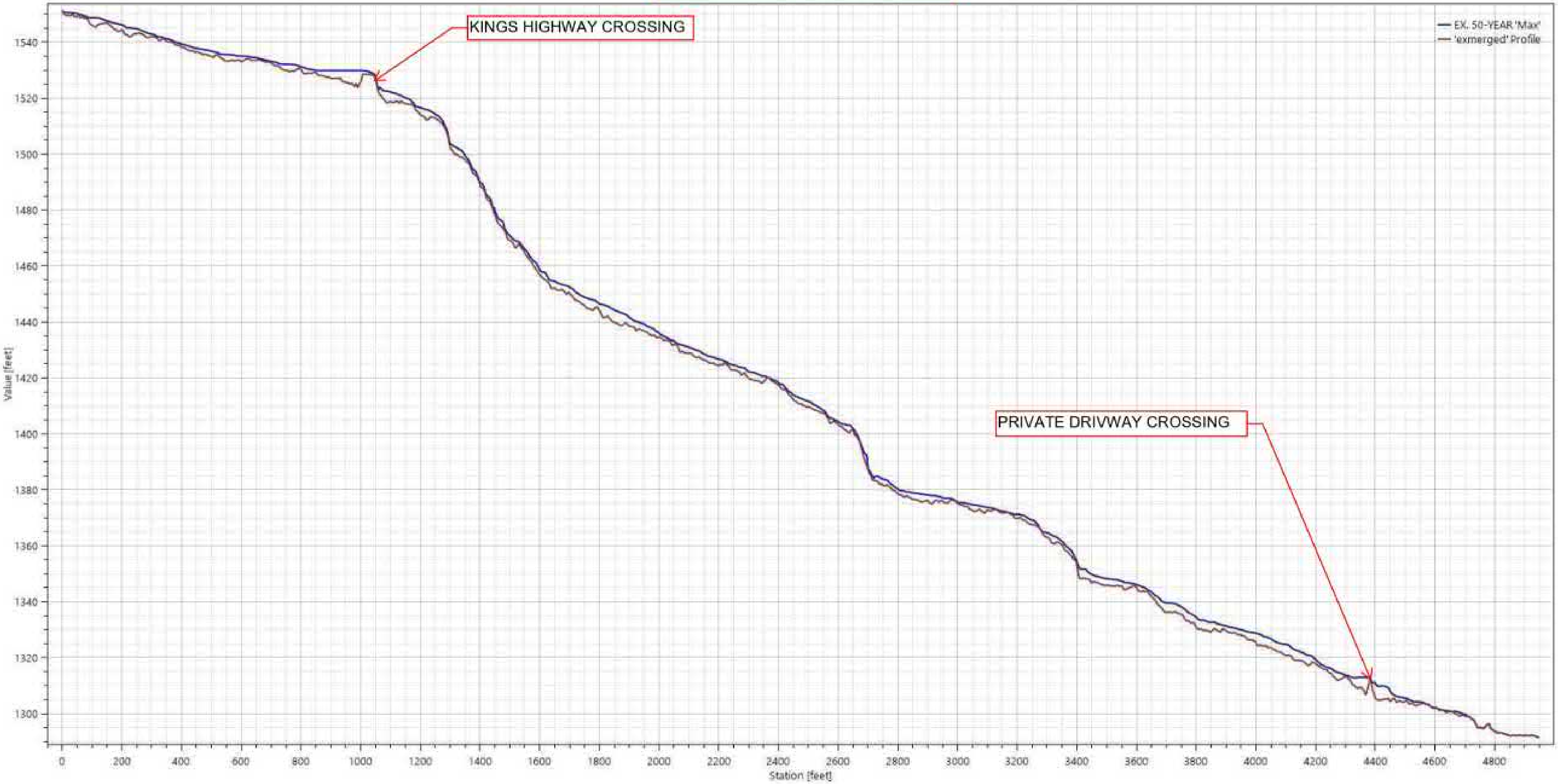
2D HEC-RAS Model Output (From Select Locations, See Figures)
Existing Conditions

Profile Line / Location	50-YR MAX Water Surface Elevation	100-YR MAX Water Surface Elevation	500-YR MAX Water Surface Elevation
XS 1	1537.76	1537.93	1538.46
XS 2	1531.94	1532.16	1532.76
XS 3	1529.99	1530.30	1531.15
XS 4	1529.96	1530.31	1531.05
XS 5	1523.67	1523.89	1526.20
XS 6	1512.26	1512.73	1512.60
XS 7	1313.47	1313.97	1315.13
XS 8	1310.82	1310.89	1311.75

Profile Line / Location	50-YR MAX Depth (feet)	100-YR MAX Depth (feet)	500-YR MAX Depth (feet)
XS 1	2.15	2.31	2.83
XS 2	2.02	2.18	2.71
XS 3	10.17	10.51	11.36
XS 4	1.14	1.34	1.87
XS 5	5.46	6.00	6.92
XS 6	2.36	2.61	2.93
XS 7	6.31	6.84	8.00
XS 8	4.94	5.31	6.12

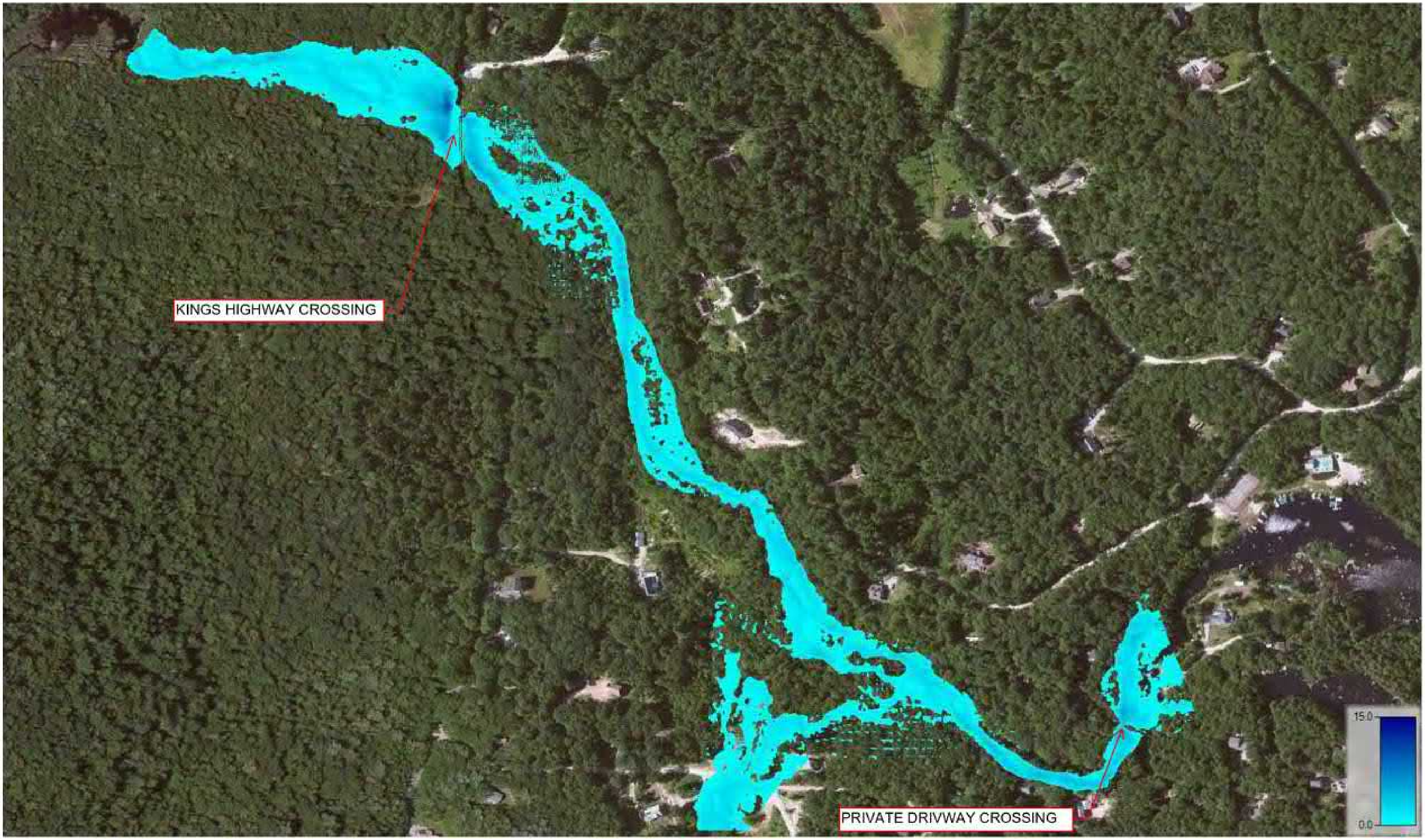
Profile Line / Location	50-YR MAX Velocity (ft/s)	100-YR MAX Velocity (ft/s)	500-YR MAX Velocity (ft/s)
XS 1	6.26	6.93	8.43
XS 2	5.51	5.85	6.61
XS 3	4.22	4.20	4.33
XS 4	4.47	5.51	6.63
XS 5	5.57	8.12	7.18
XS 6	6.51	17.11	9.22
XS 7	7.10	18.27	12.46
XS 8	4.76	4.86	5.47

50-YEAR WATER SURFACE PROFILE
EXISTING CONDITIONS

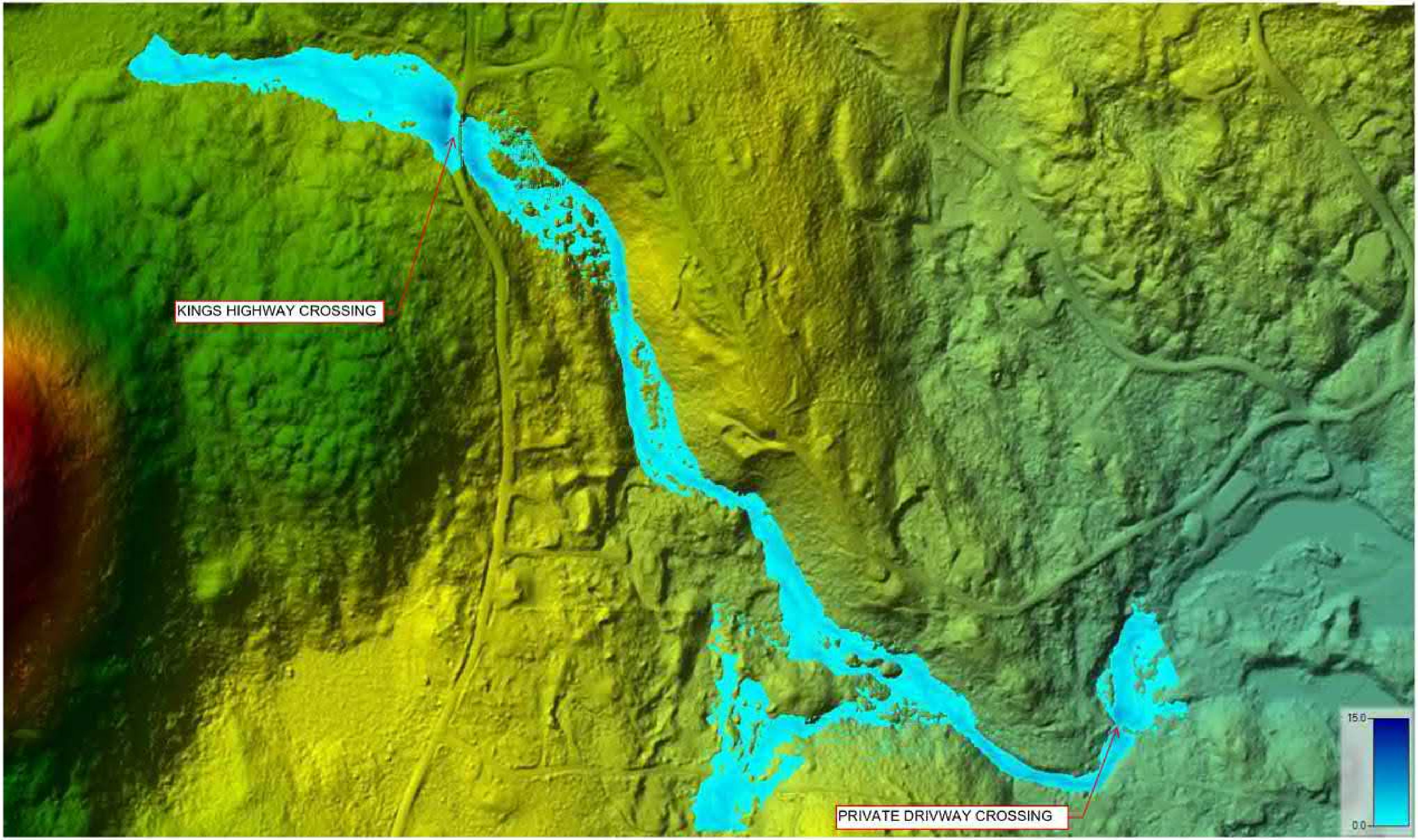


50-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS

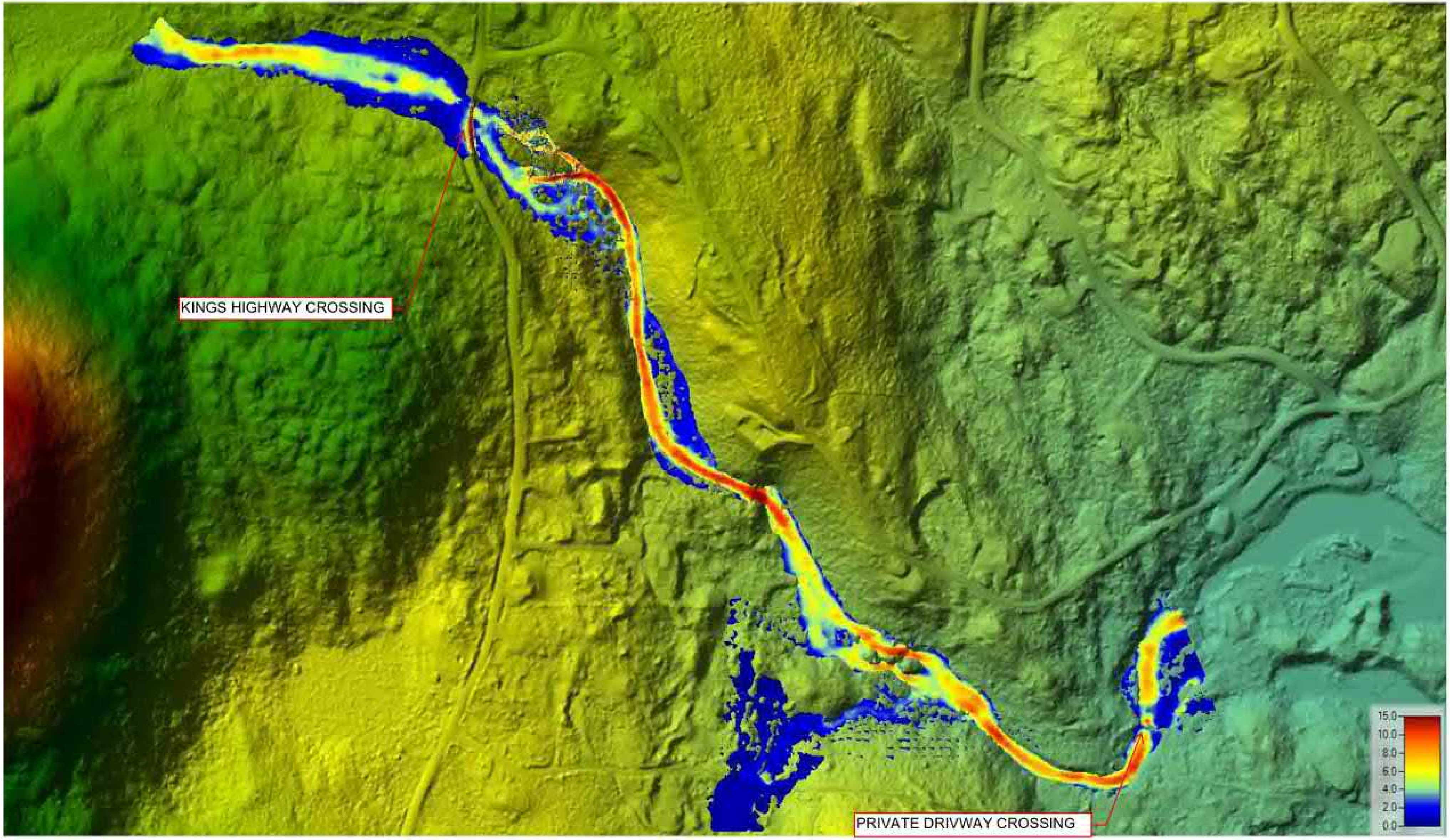
DuBois & King inc.

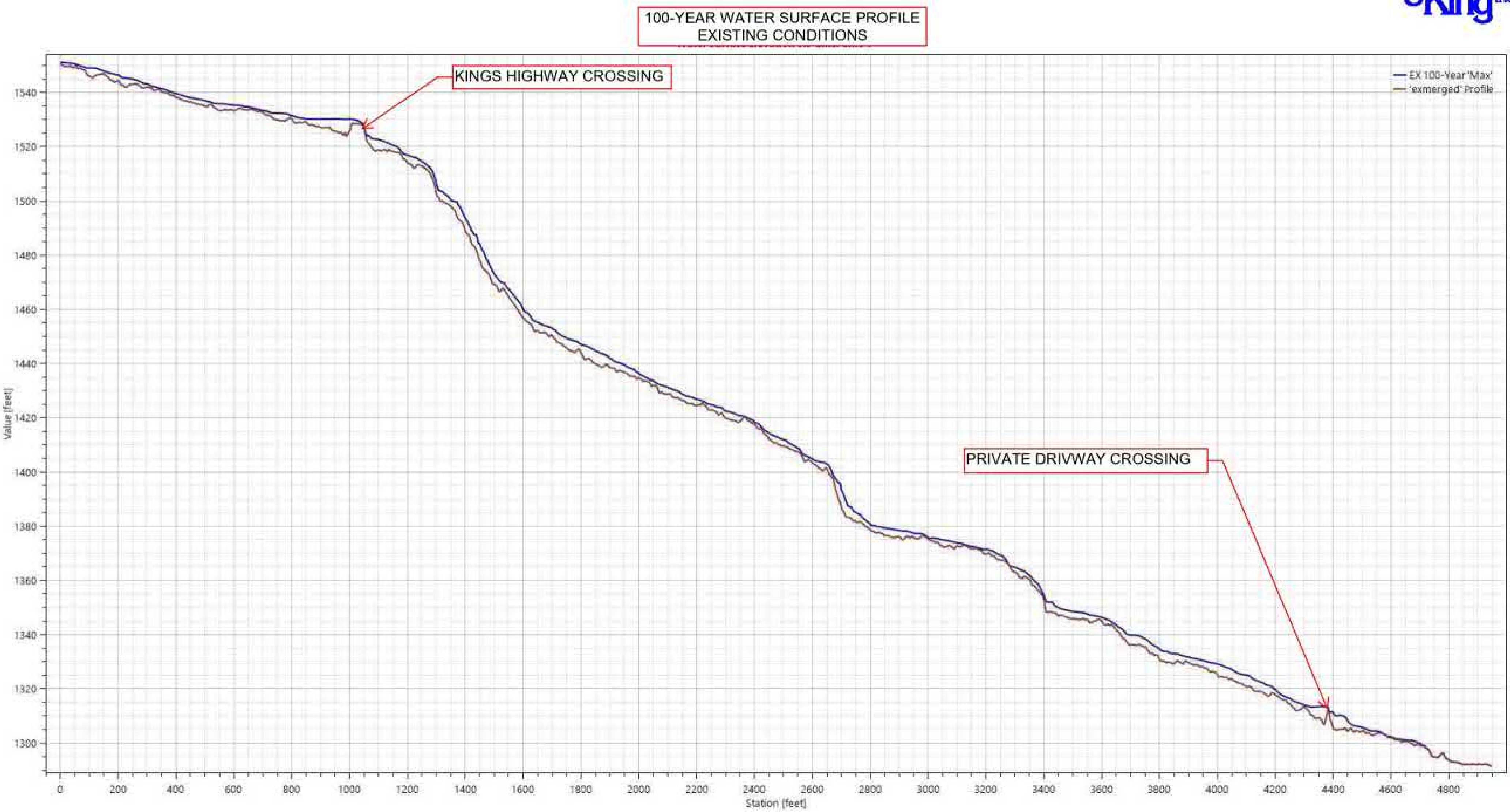


50-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS

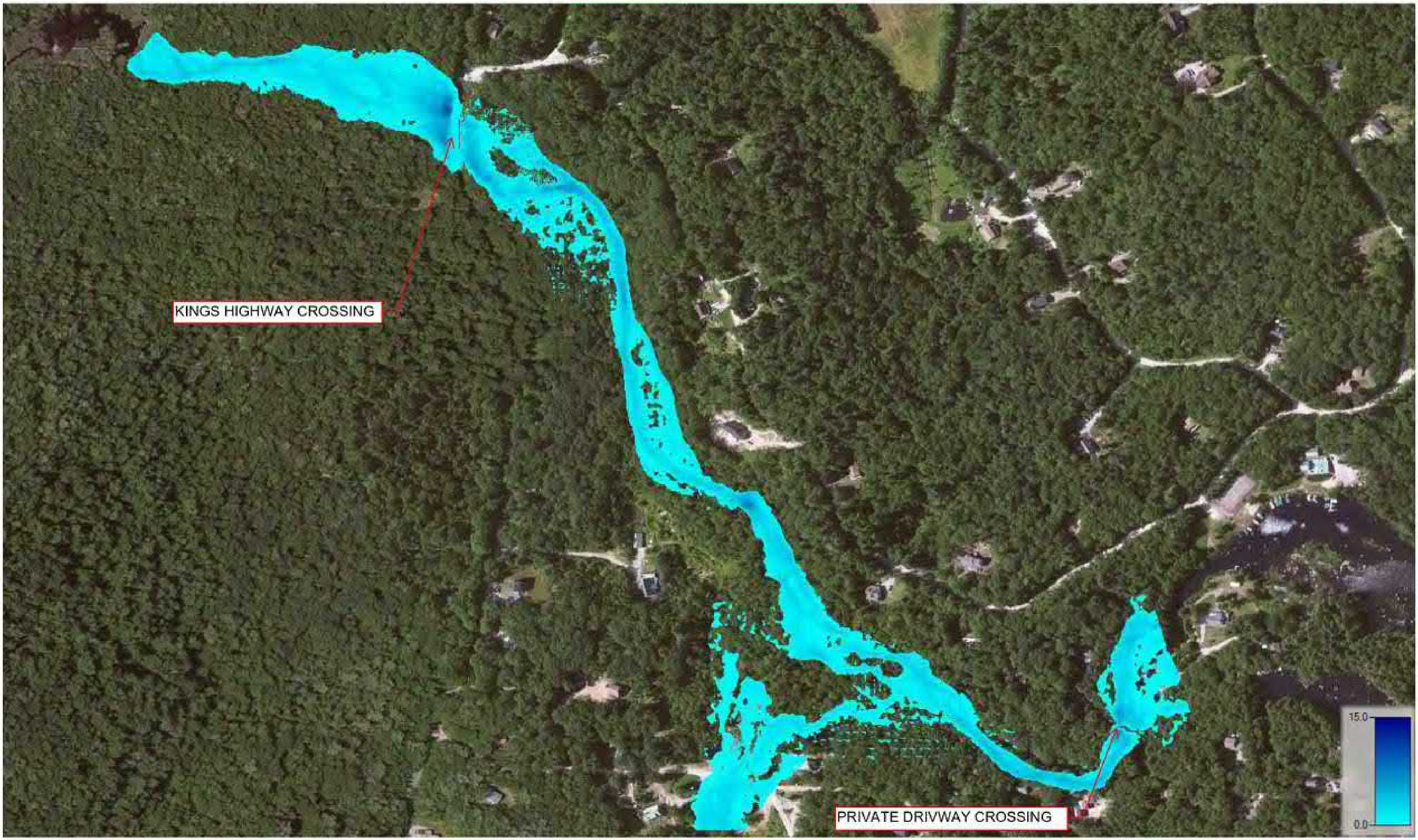


50-YEAR WATER VELOCITIES
EXISTING CONDITIONS

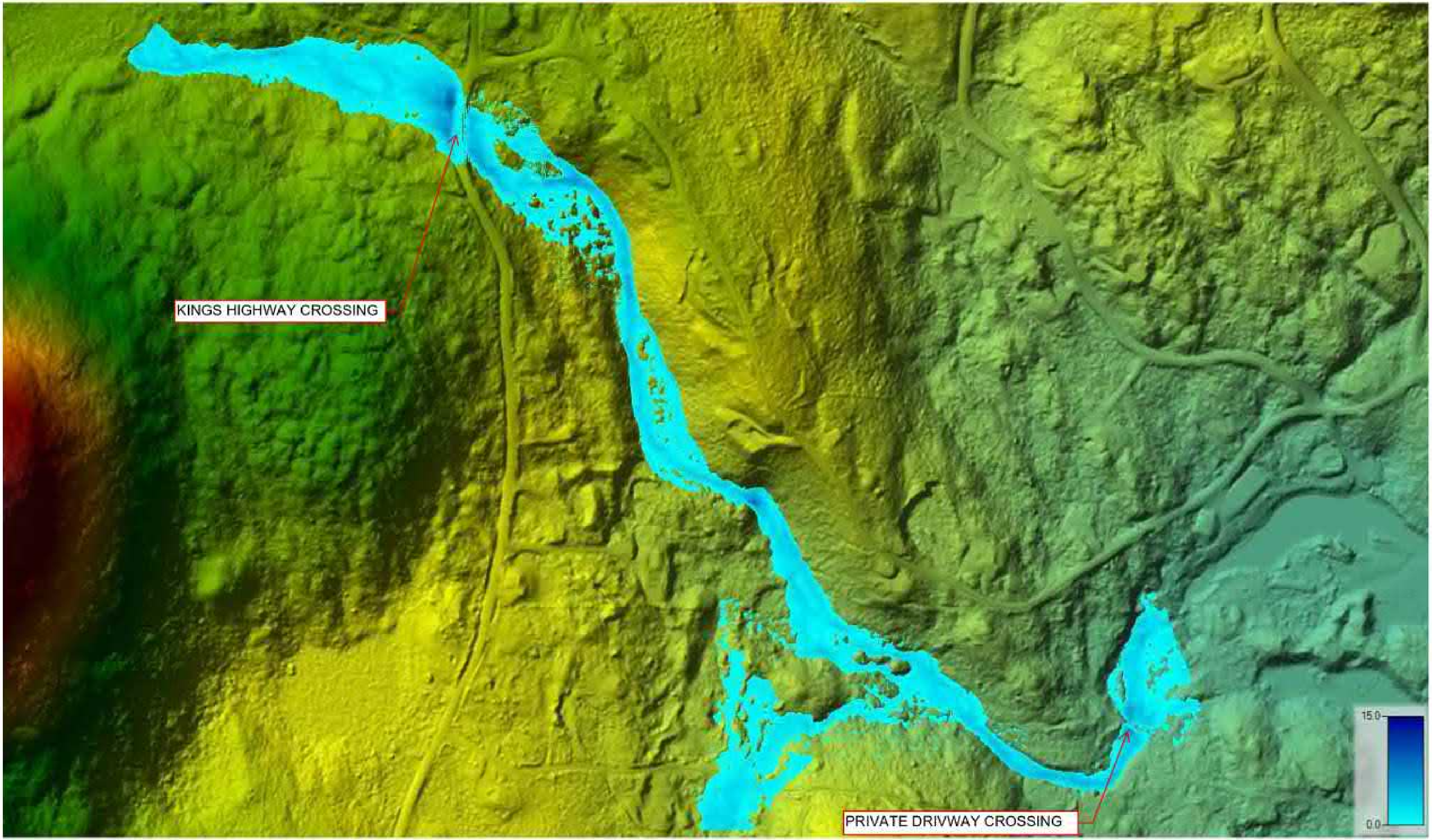



100-YEAR WATER SURFACE PROFILE
EXISTING CONDITIONS
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
EX 100-Year 'Max'
'exmerged' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

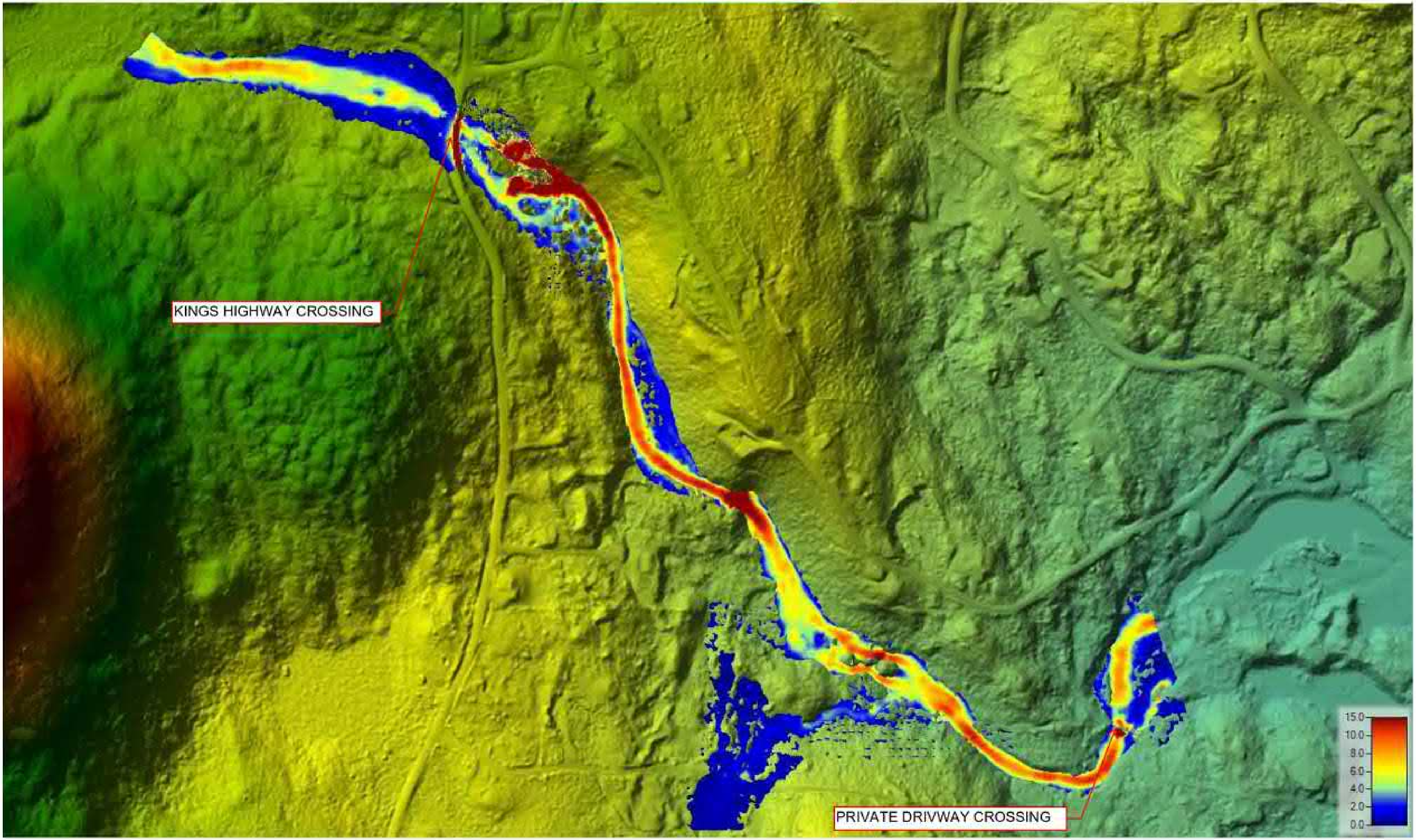
100-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS



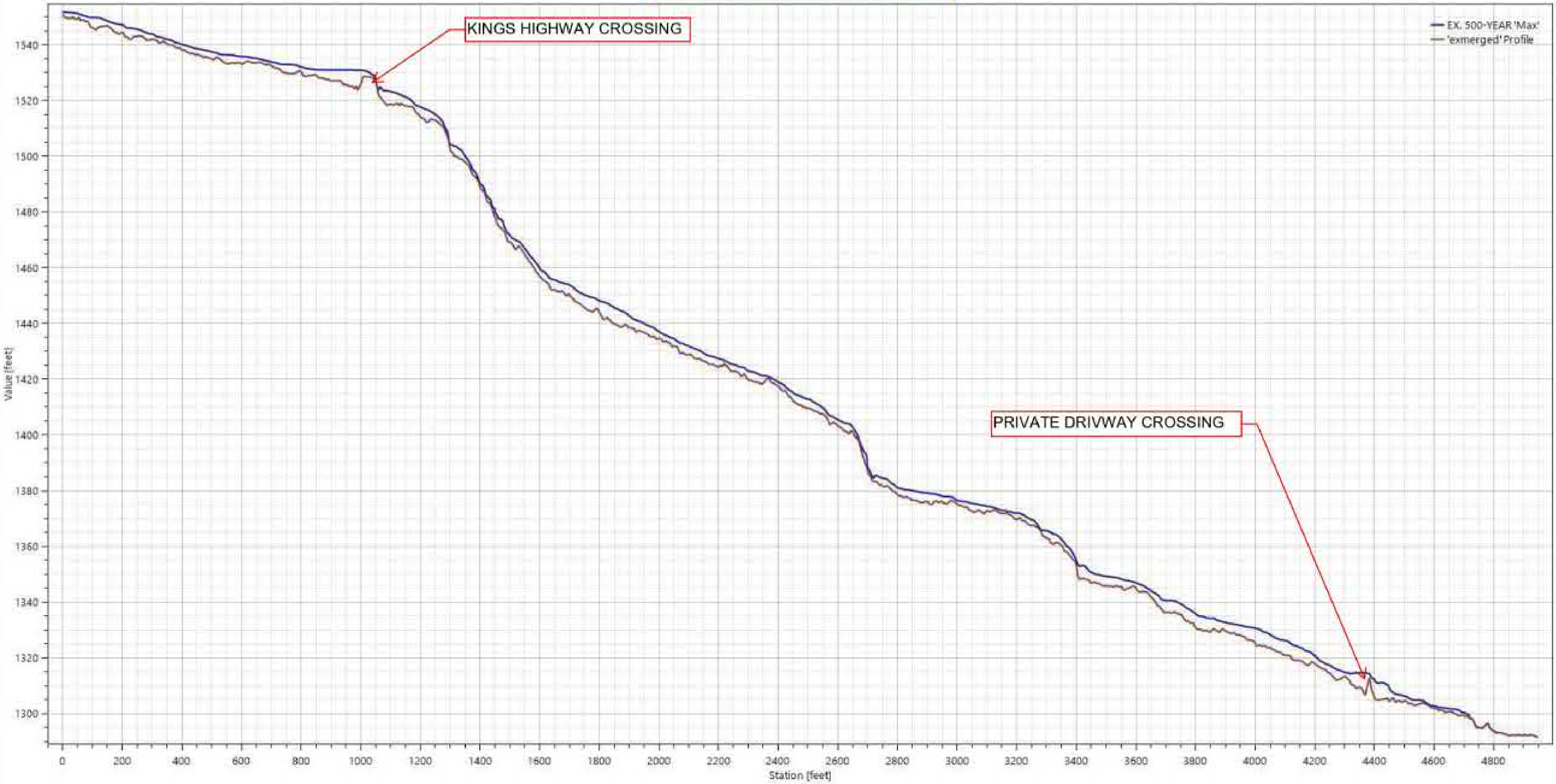
100-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS



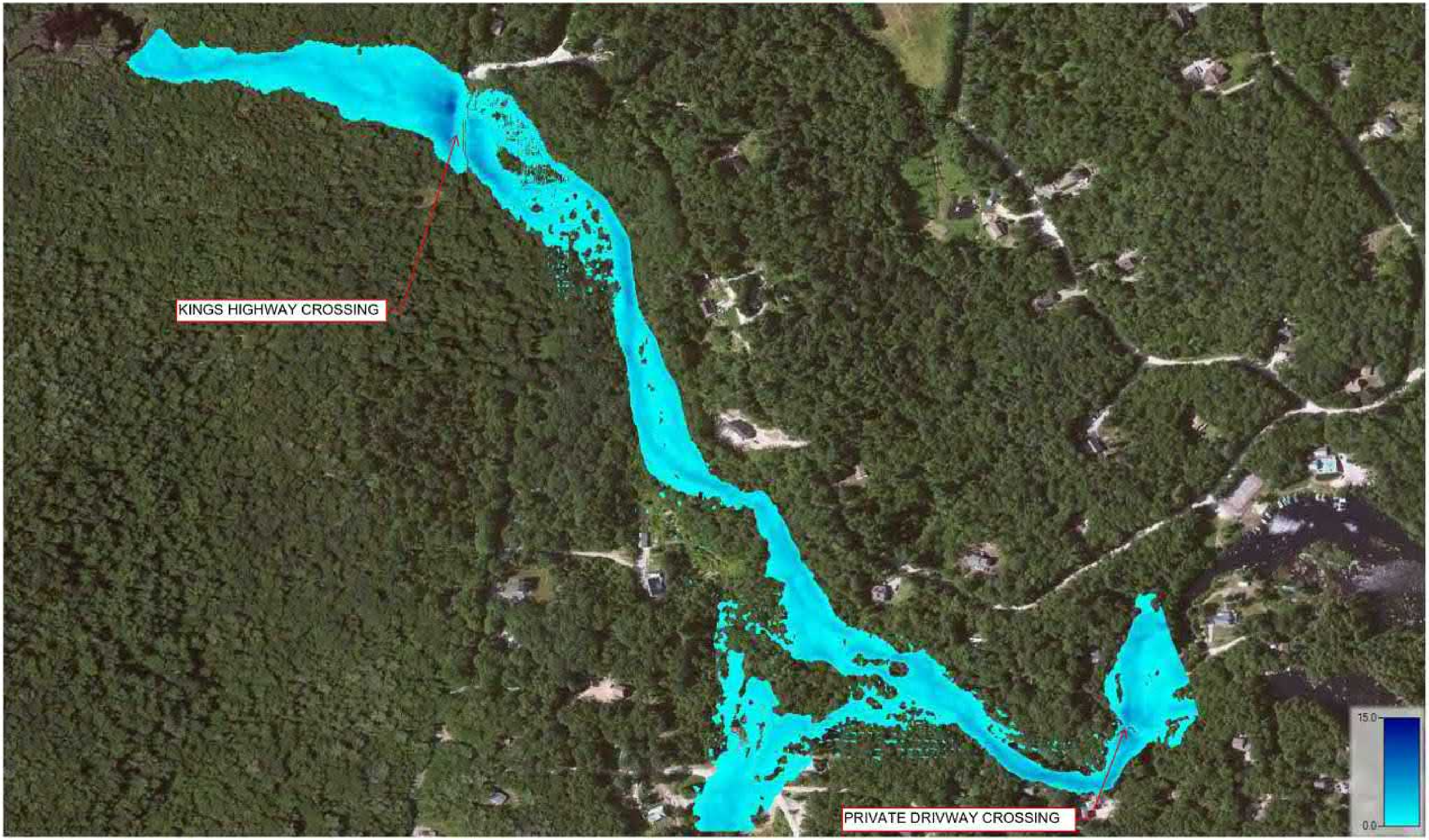
100-YEAR WATER VELOCITIES
EXISTING CONDITIONS



500-YEAR WATER SURFACE PROFILE
EXISTING CONDITIONS

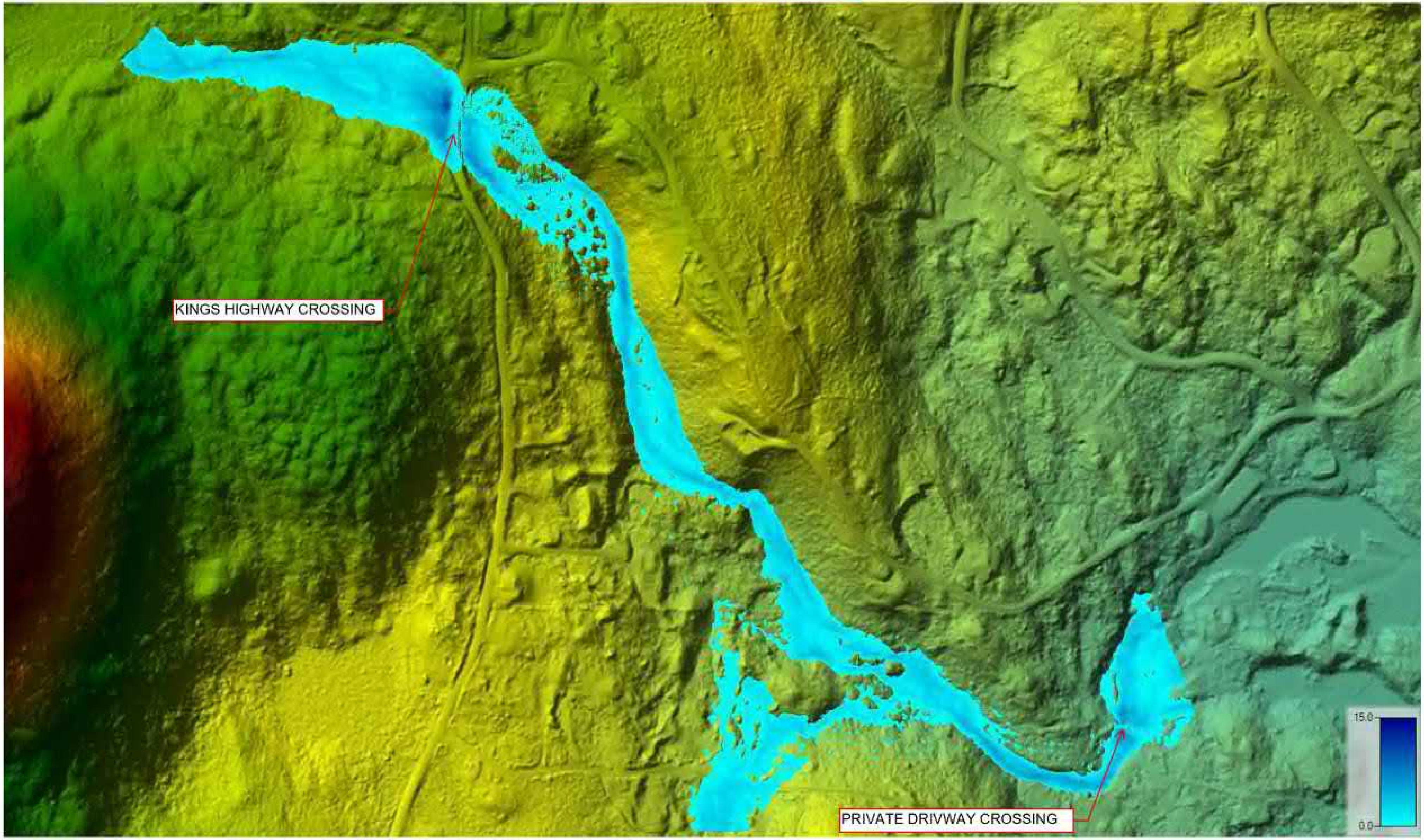


500-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS

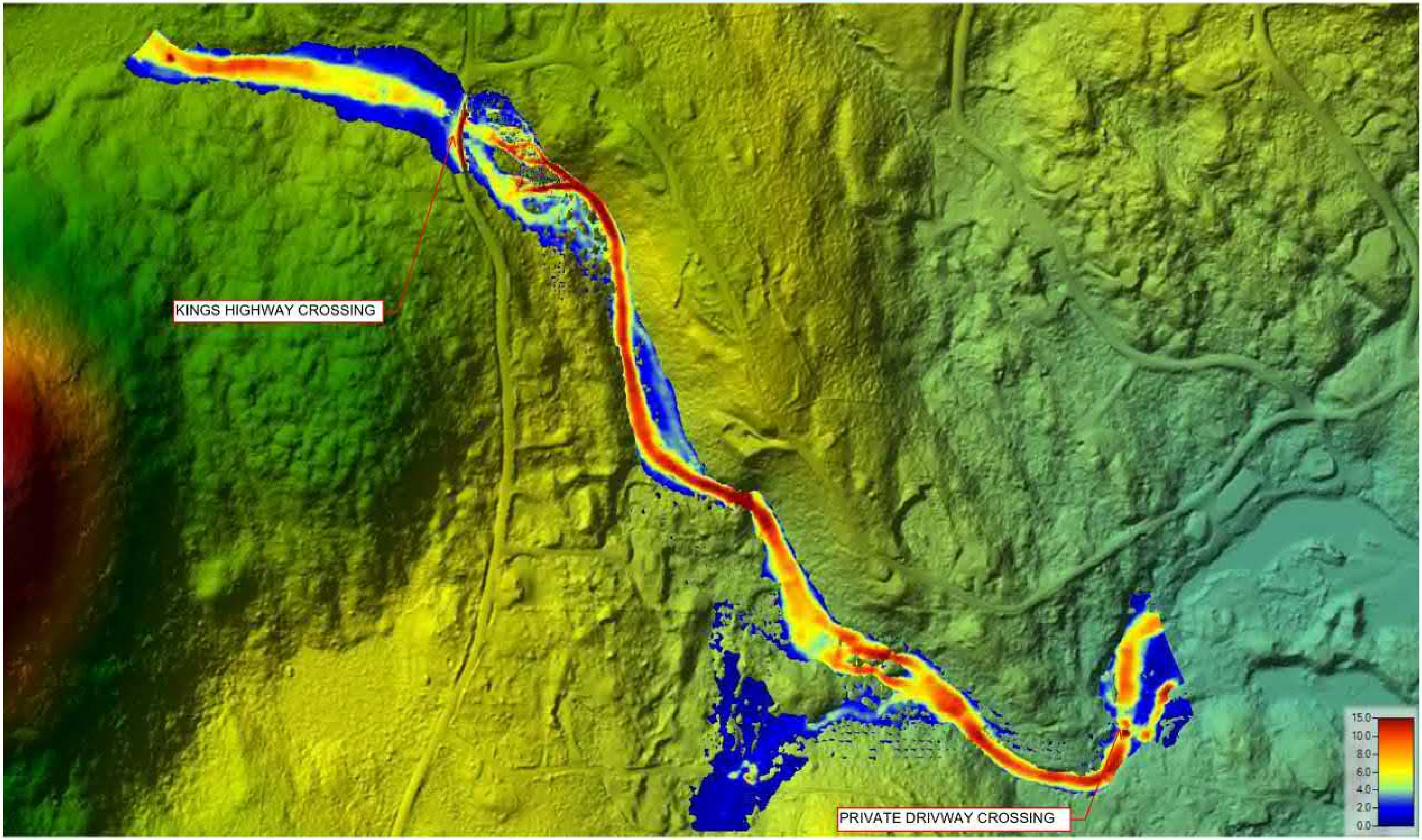


500-YEAR WATER SURFACE DEPTH
EXISTING CONDITIONS

DuBois & King inc.



50-YEAR WATER VELOCITIES
EXISTING CONDITIONS



APPENDIX K

King's Highway Over Kennedy Brook - Stoddard, NH

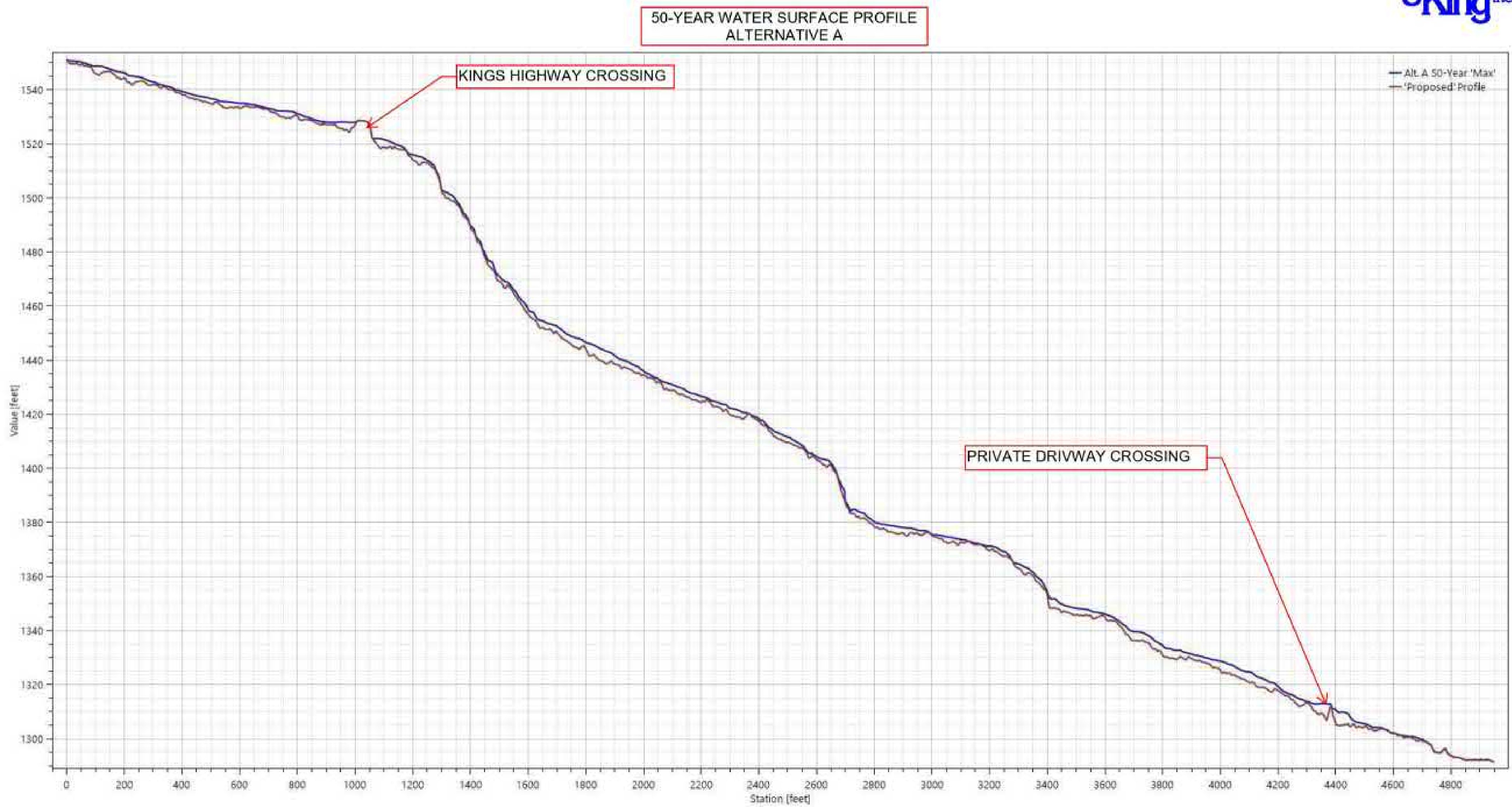
2D HEC-RAS Model Output (From Select Locations, See Figures)
Alternative A

Profile Line / Location	50-YR MAX Water Surface Elevation	100-YR MAX Water Surface Elevation	500-YR MAX Water Surface Elevation
XS 1	1537.76	1537.94	1538.46
XS 2	1531.93	1532.14	1532.72
XS 3	1528.04	1529.17	1530.46
XS 4	N/A	1529.07	1530.30
XS 5	1525.63	1525.63	1525.77
XS 6	1512.04	1512.16	1512.49
XS 7	1313.47	1313.96	1315.13
XS 8	1310.82	1310.95	1311.75

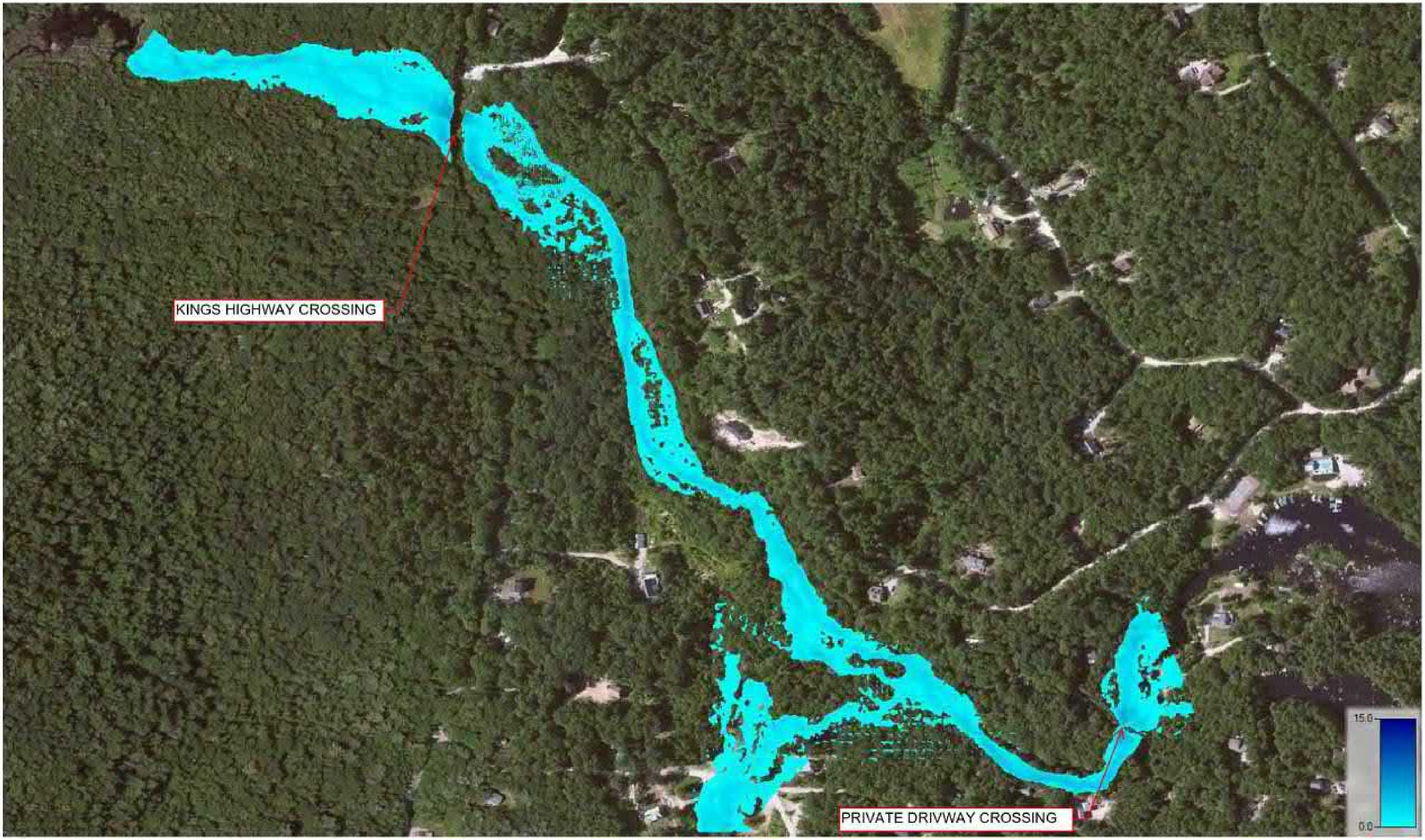
Profile Line / Location	50-YR MAX Depth (feet)	100-YR MAX Depth (feet)	500-YR MAX Depth (feet)
XS 1	2.15	2.32	2.82
XS 2	2.01	2.19	2.77
XS 3	5.29	6.31	7.56
XS 4	N/A	0.49	1.35
XS 5	4.20	4.84	6.27
XS 6	2.36	2.66	3.33
XS 7	6.30	6.84	8.00
XS 8	4.94	5.29	6.12

Profile Line / Location	50-YR MAX Velocity (ft/s)	100-YR MAX Velocity (ft/s)	500-YR MAX Velocity (ft/s)
XS 1	6.26	6.91	8.43
XS 2	5.56	5.96	6.78
XS 3	5.22	5.26	5.33
XS 4	N/A	3.02	4.89
XS 5	8.00	8.39	8.79
XS 6	8.54	9.12	10.10
XS 7	7.26	7.16	7.68
XS 8	4.73	4.92	5.36

DuBois & King inc.

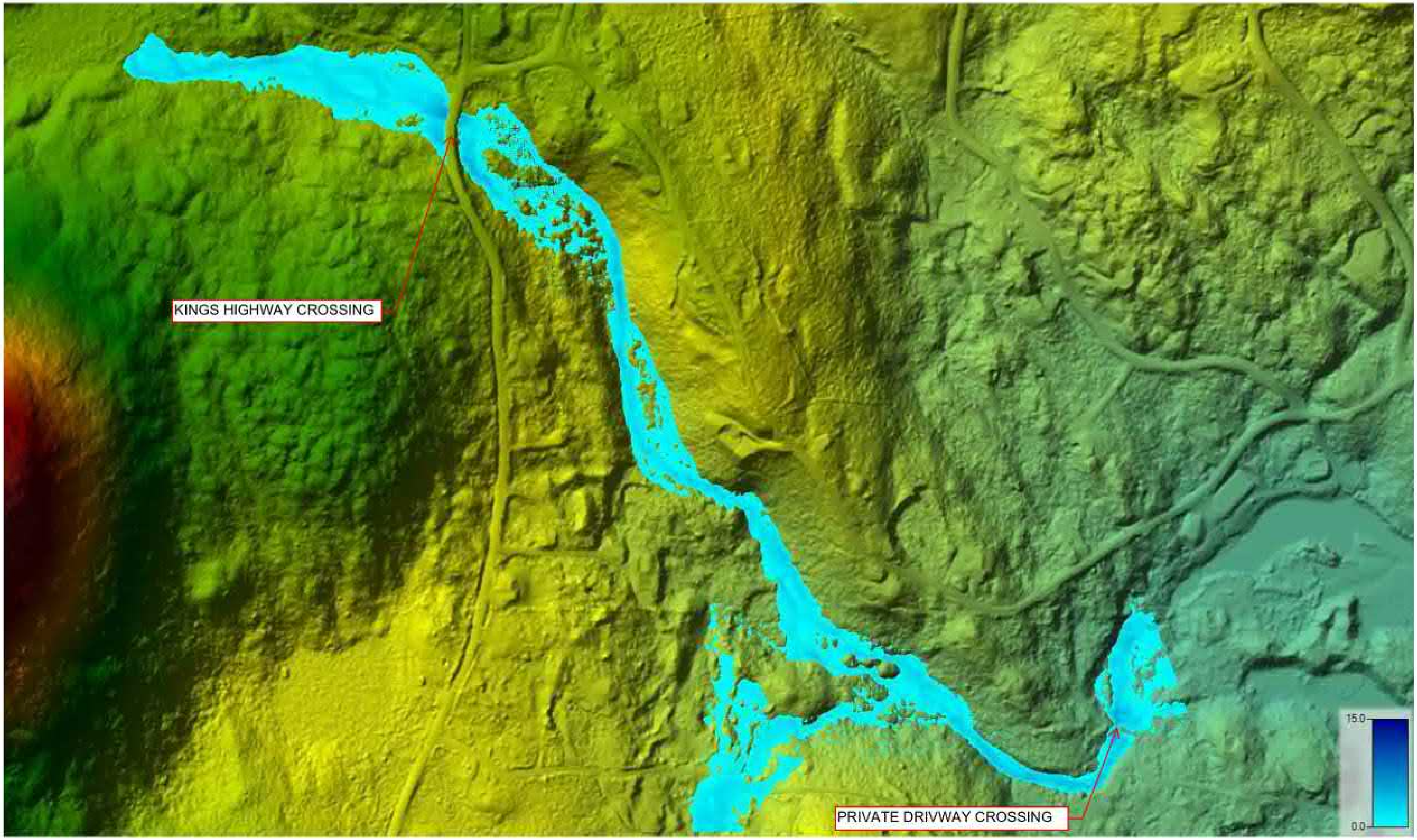


50-YEAR WATER SURFACE DEPTH
ALTERNATIVE A

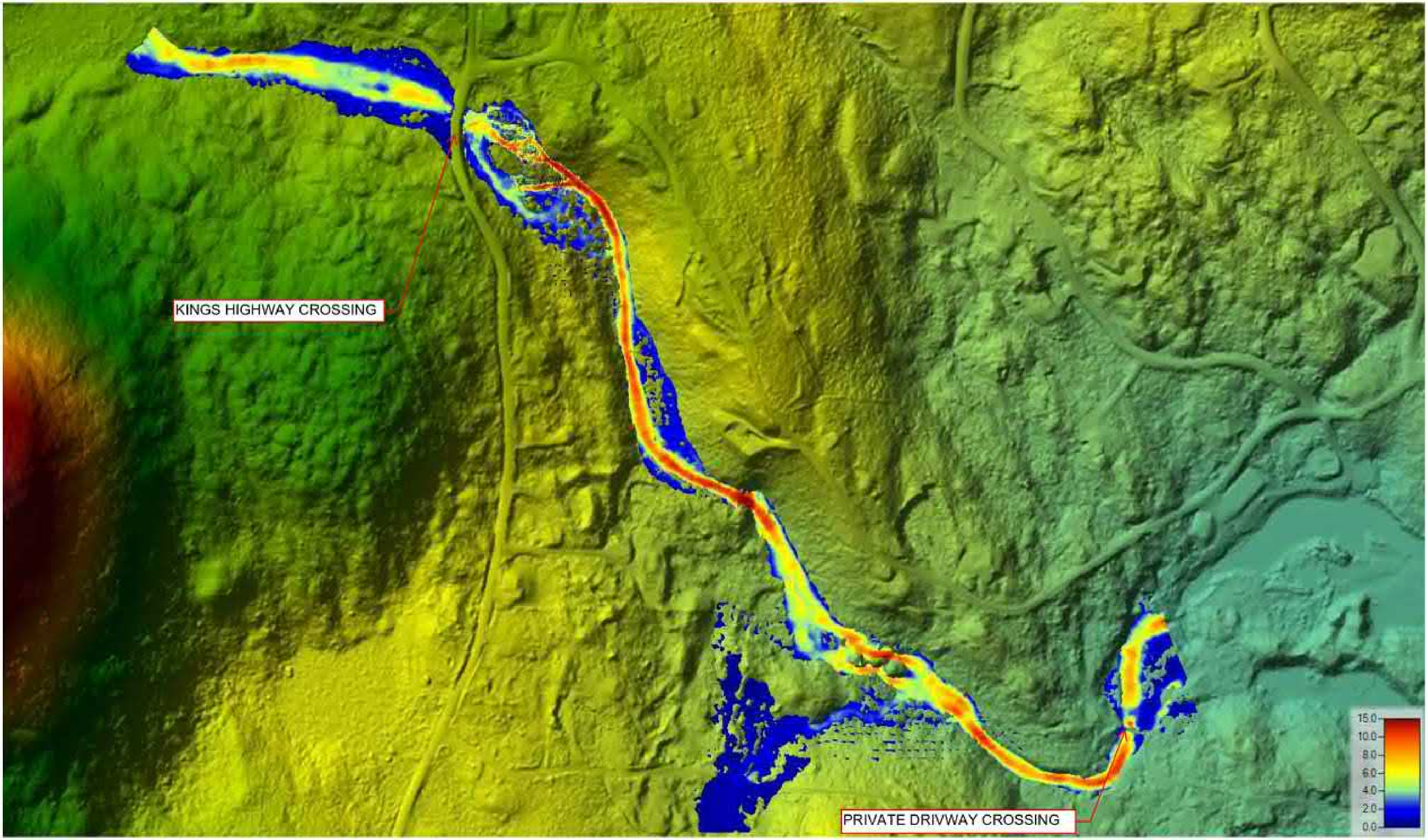


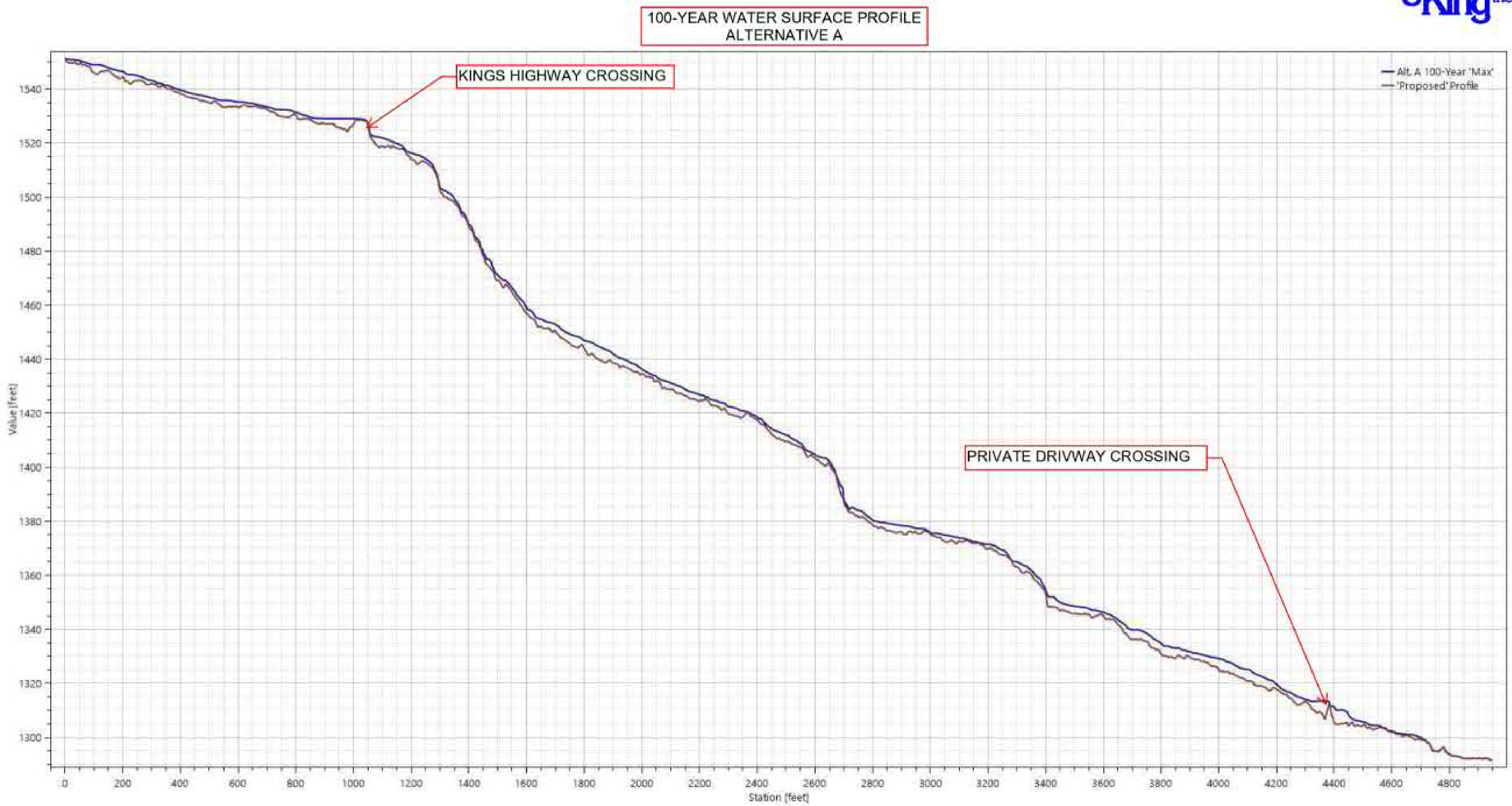
DuBois & King inc.

50-YEAR WATER SURFACE DEPTH
ALTERNATIVE A

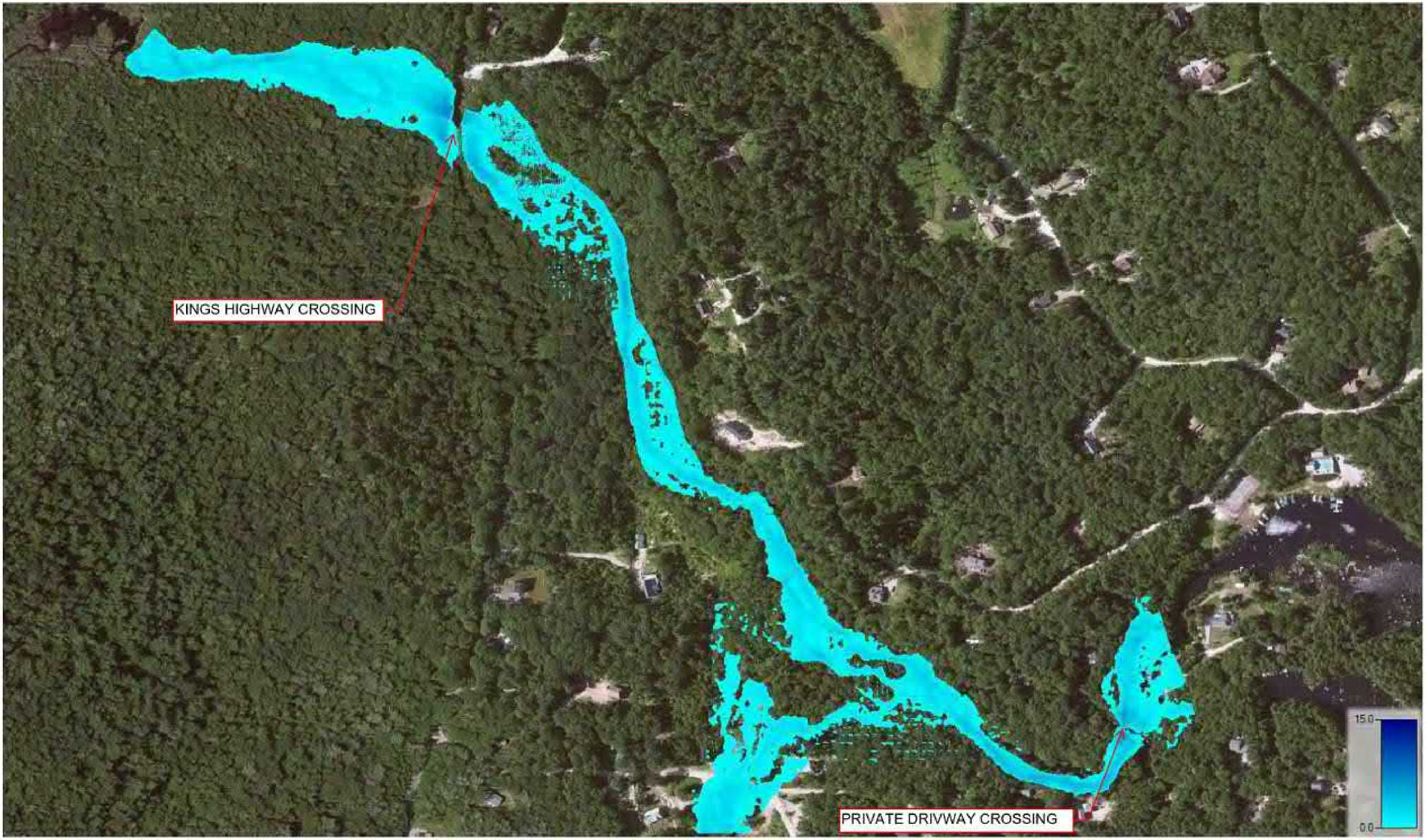


50-YEAR WATER VELOCITIES
ALTERNATIVE A

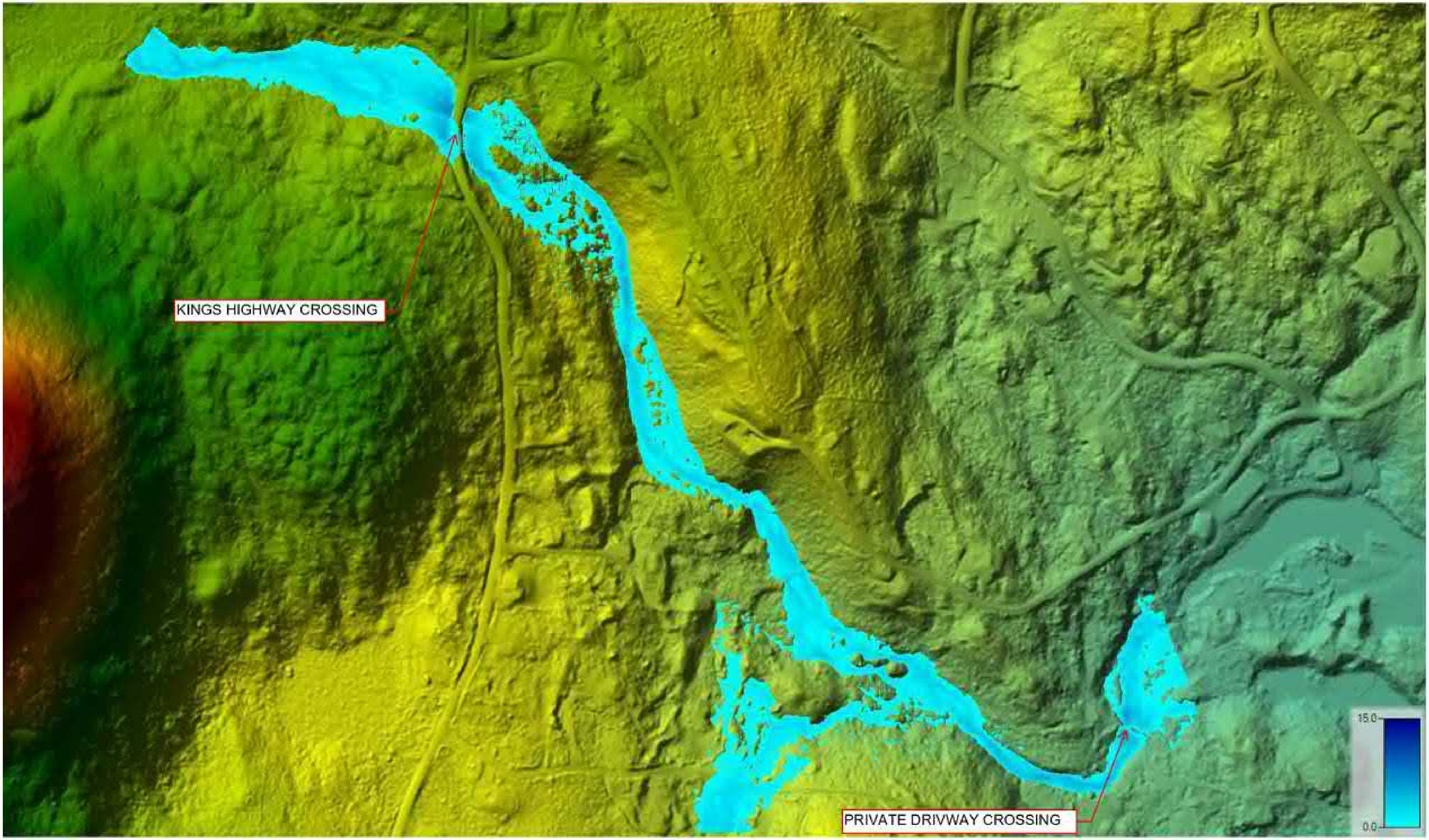


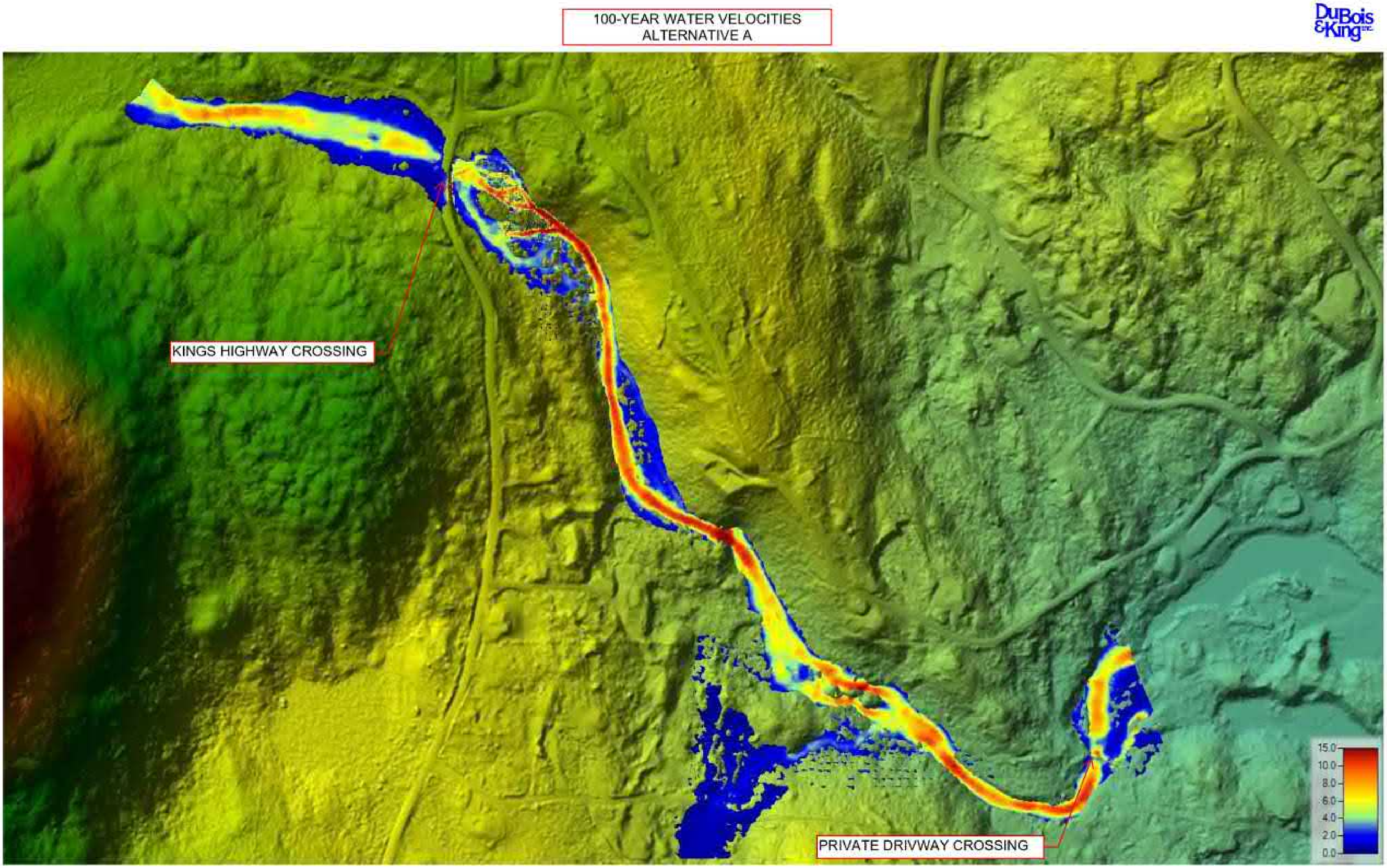

100-YEAR WATER SURFACE PROFILE
ALTERNATIVE A
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. A 100-Year 'Max'
'Proposed' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

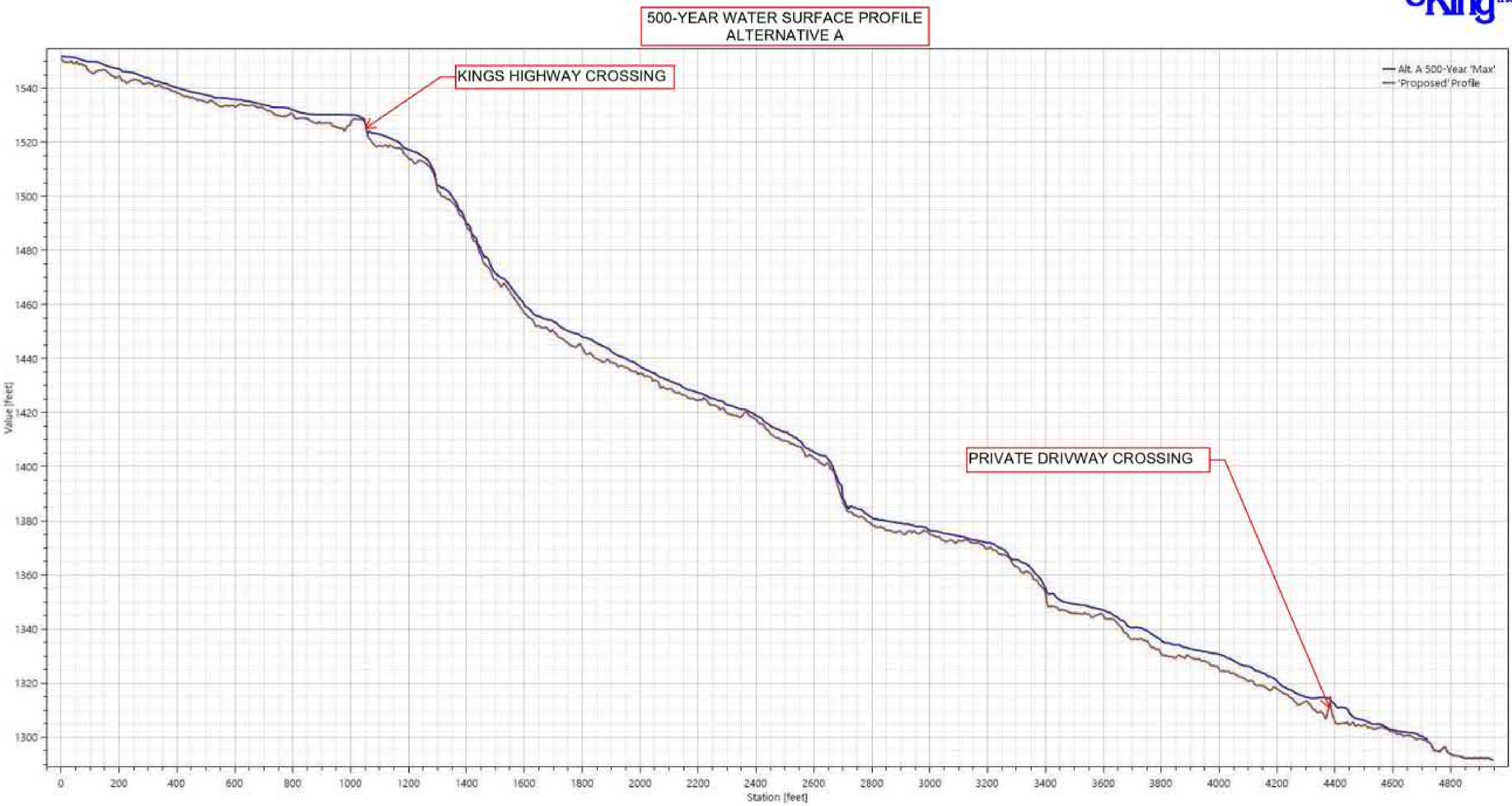
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE A



100-YEAR WATER SURFACE DEPTH
ALTERNATIVE A

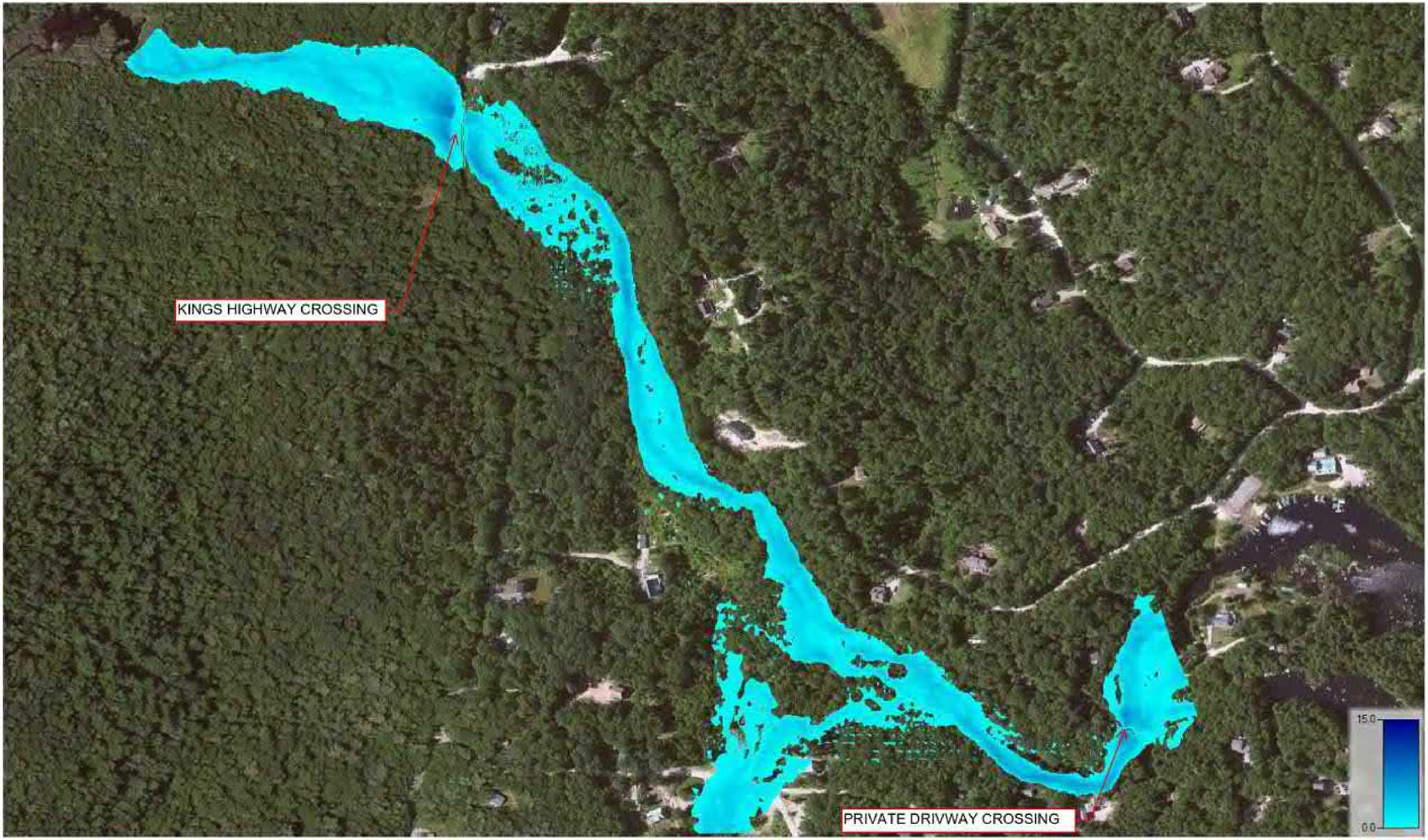


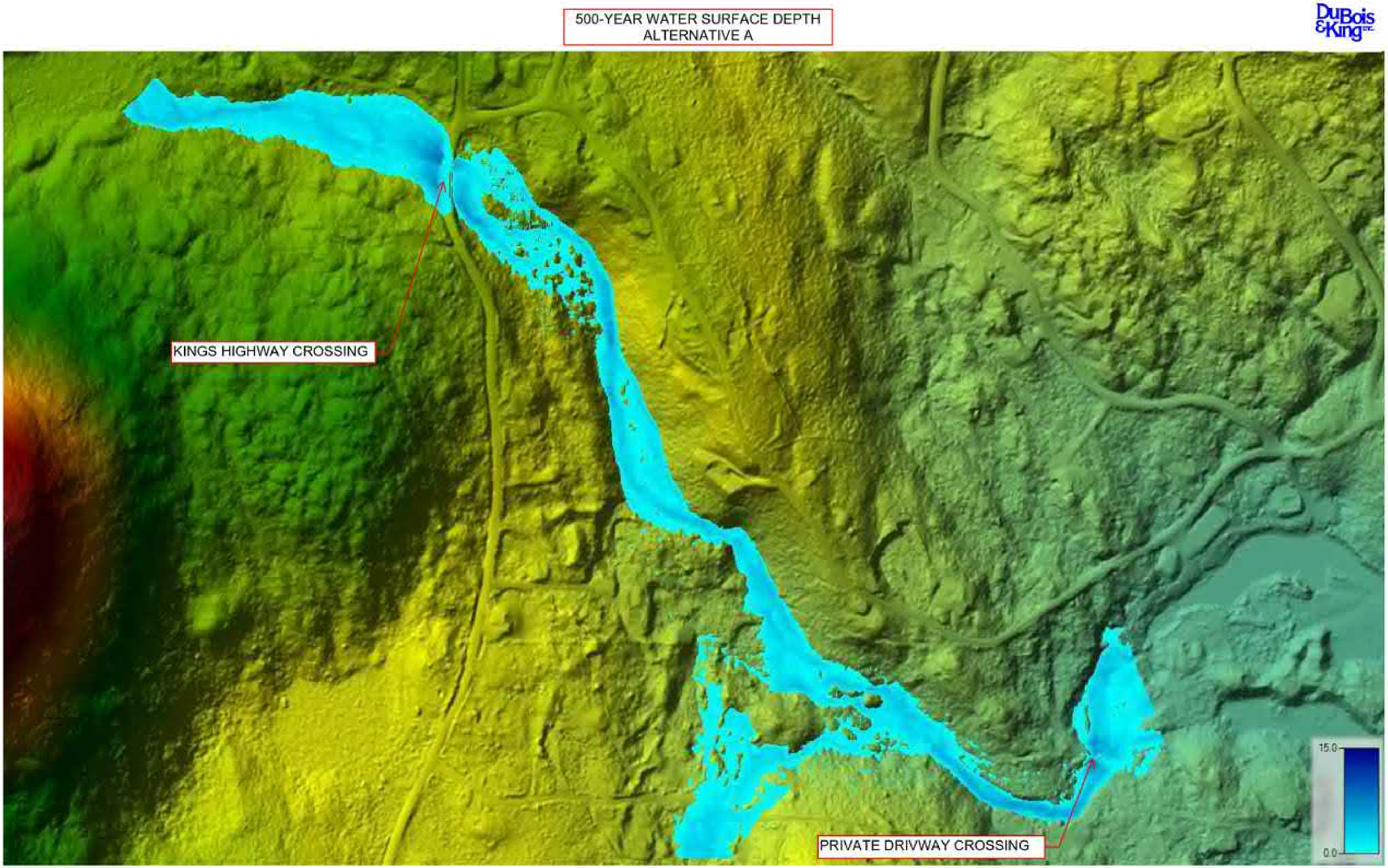

100-YEAR WATER VELOCITIES
ALTERNATIVE A
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
15.0
10.0
8.0
6.0
4.0
2.0
0.0



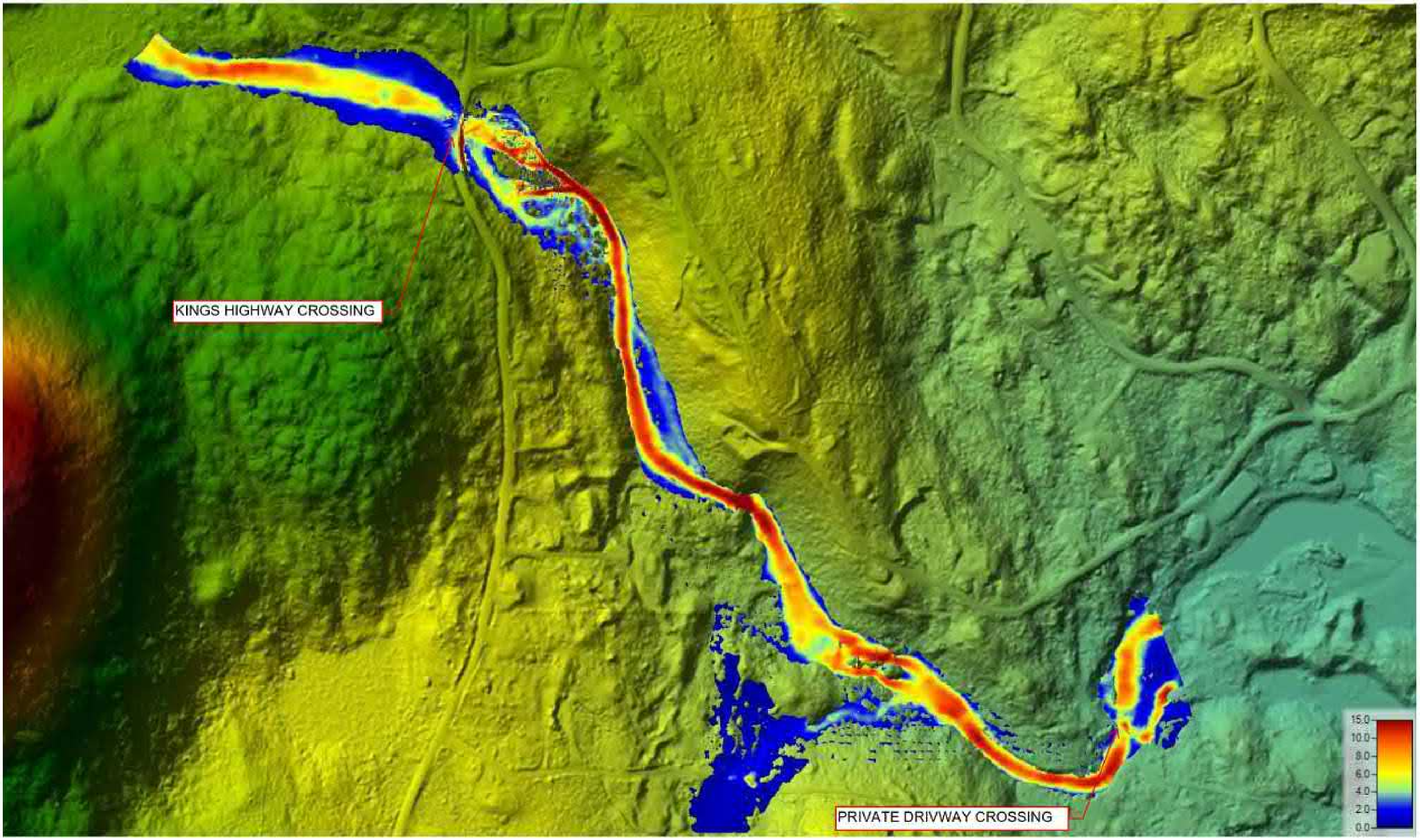
500-YEAR WATER SURFACE PROFILE
ALTERNATIVE A
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. A 500-Year 'Max'
'Proposed' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

500-YEAR WATER SURFACE DEPTH
ALTERNATIVE A




500-YEAR WATER SURFACE DEPTH
ALTERNATIVE A
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
15.0
0.0

500-YEAR WATER VELOCITIES
ALTERNATIVE A



APPENDIX L

King's Highway Over Kennedy Brook - Stoddard, NH

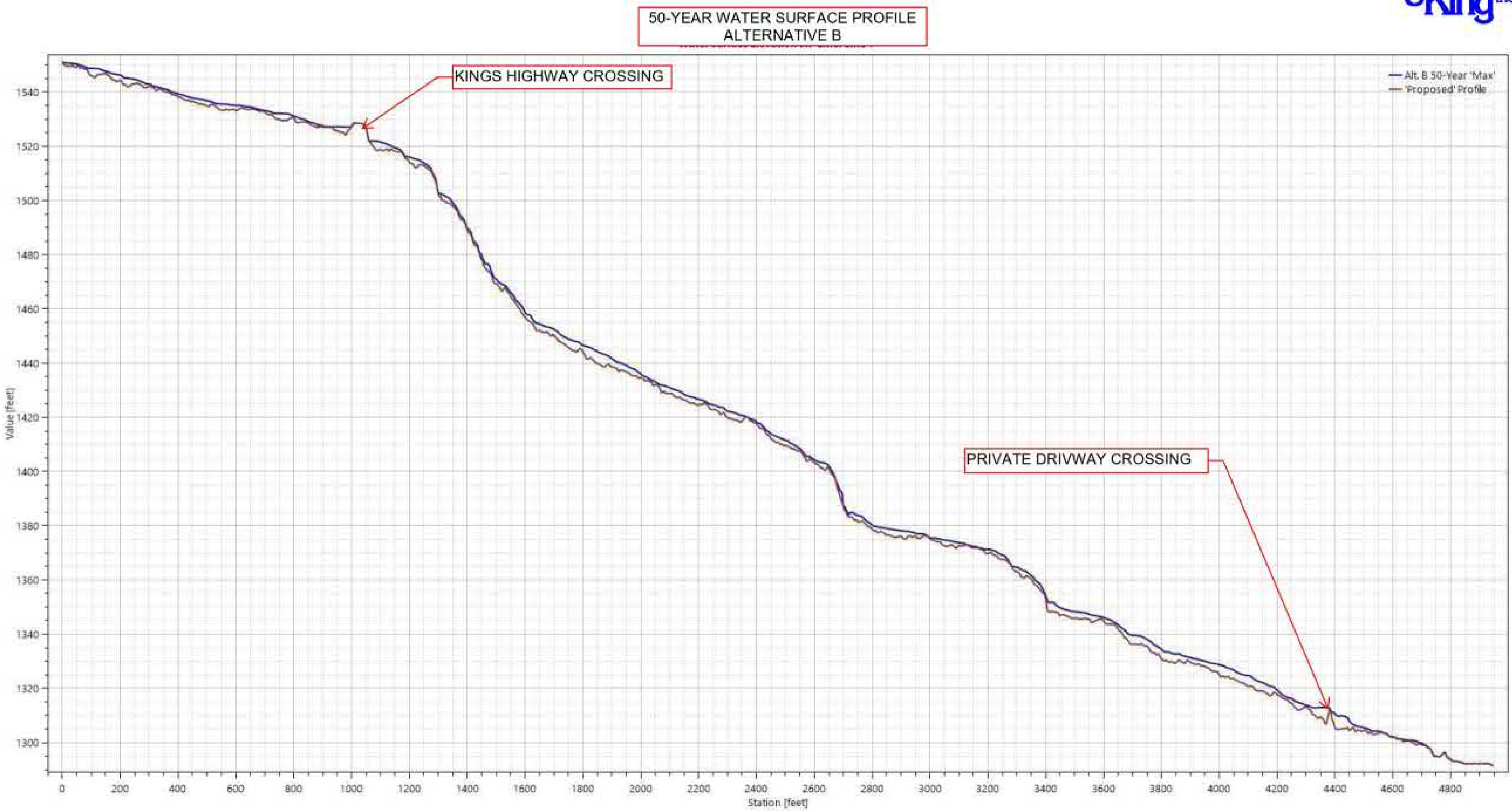
2D HEC-RAS Model Output (From Select Locations, See Figures)
Alternative B

DuBois & King inc.

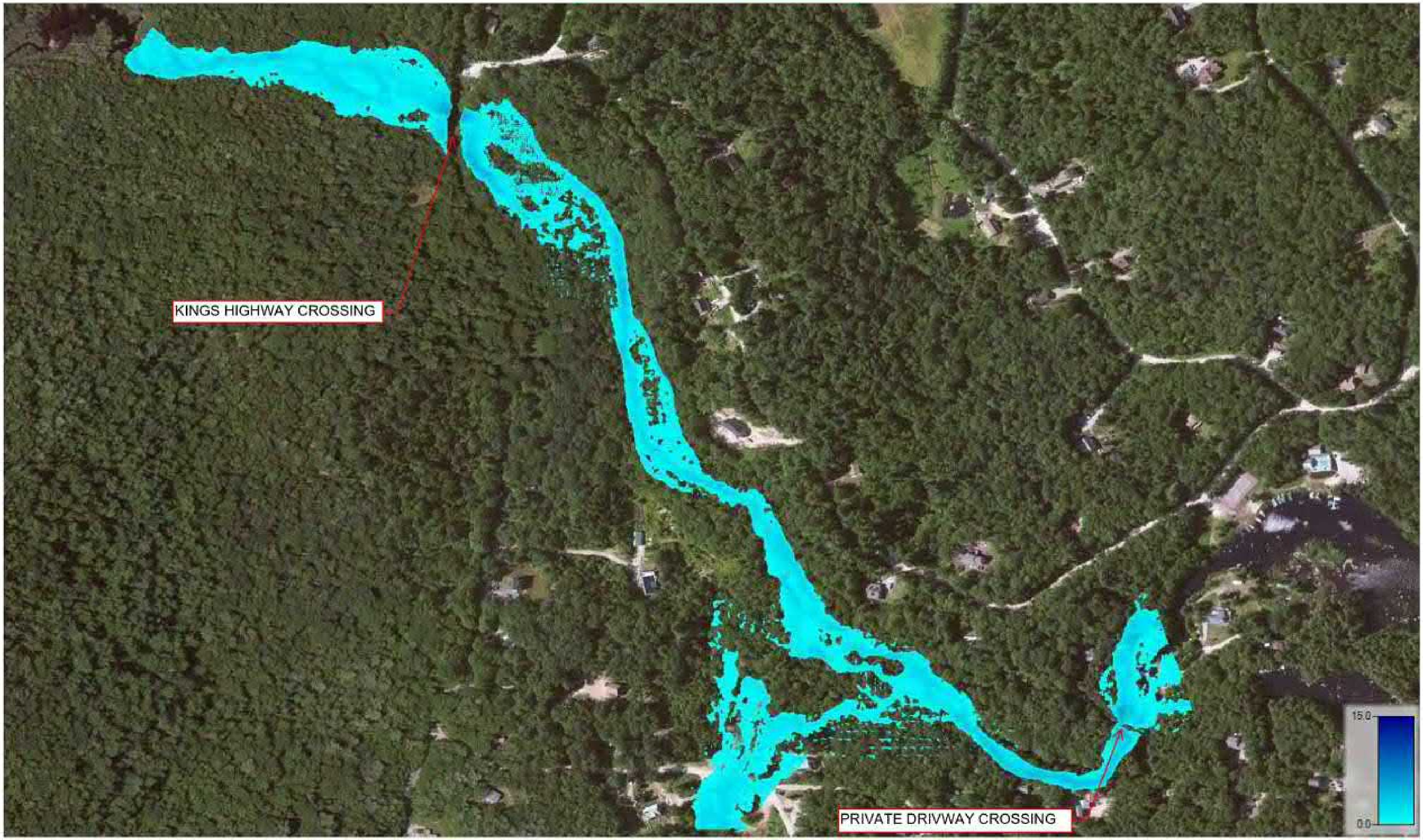
Profile Line / Location	50-YR MAX Water Surface Elevation	100-YR MAX Water Surface Elevation	500-YR MAX Water Surface Elevation
XS 1	1537.76	1537.94	1538.46
XS 2	1531.93	1532.14	1532.71
XS 3	1527.22	1528.28	1530.02
XS 4	N/A	N/A	1530.04
XS 5	1525.10	1525.61	1525.90
XS 6	1512.04	1512.13	1512.46
XS 7	1313.46	1313.96	1315.13
XS 8	1310.82	1310.89	1311.75

Profile Line / Location	50-YR MAX Depth (feet)	100-YR MAX Depth (feet)	500-YR MAX Depth (feet)
XS 1	2.15	2.32	2.82
XS 2	2.01	2.19	2.76
XS 3	4.45	4.48	7.23
XS 4	N/A	N/A	1.15
XS 5	4.42	4.72	6.07
XS 6	2.36	2.76	3.43
XS 7	6.31	6.84	8.00
XS 8	4.94	5.30	6.12

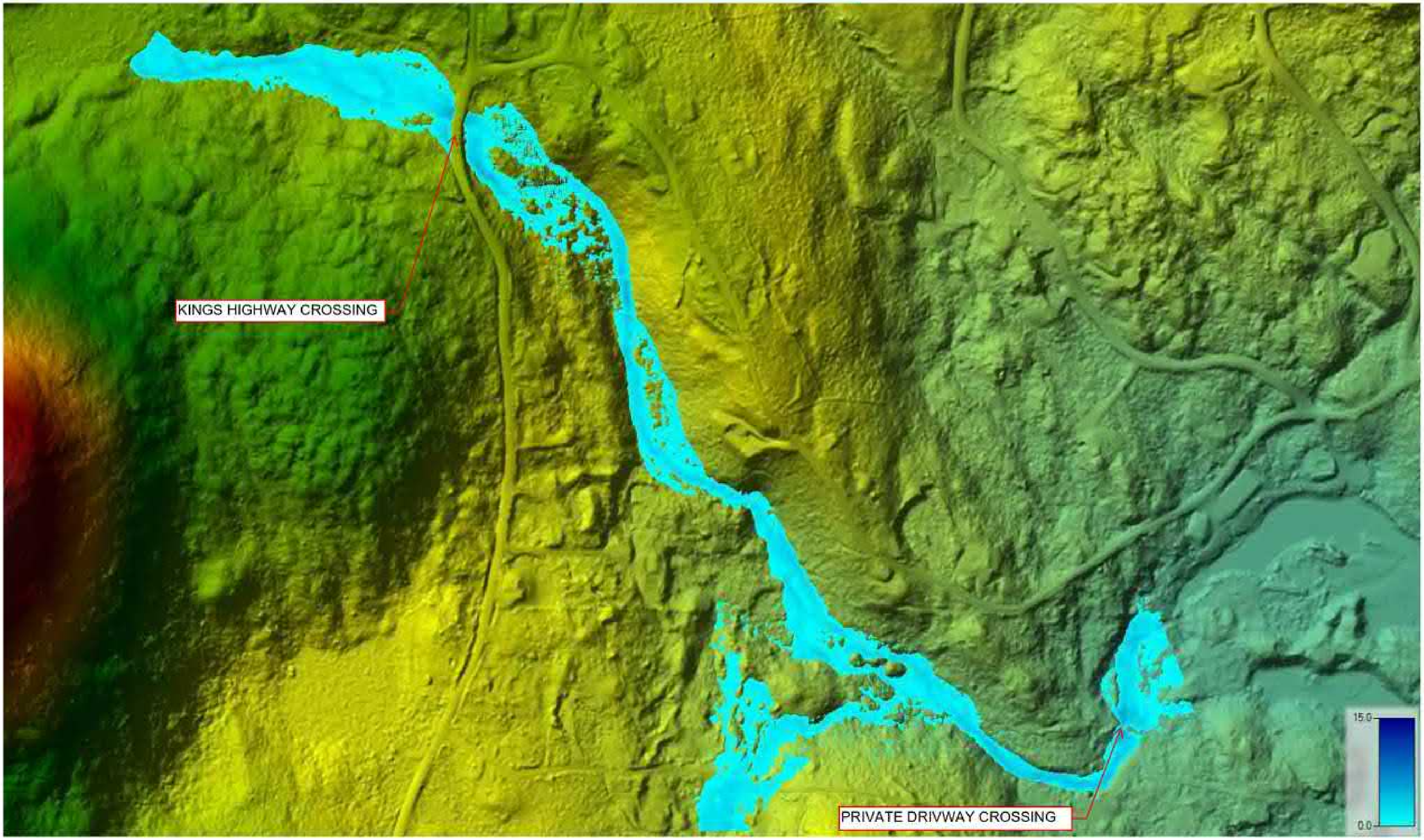
Profile Line / Location	50-YR MAX Velocity (ft/s)	100-YR MAX Velocity (ft/s)	500-YR MAX Velocity (ft/s)
XS 1	6.26	6.91	8.43
XS 2	5.56	5.97	6.82
XS 3	5.78	5.80	5.87
XS 4	N/A	N/A	4.36
XS 5	8.04	8.71	9.44
XS 6	8.54	9.27	10.29
XS 7	8.59	8.43	7.79
XS 8	4.75	4.94	5.47

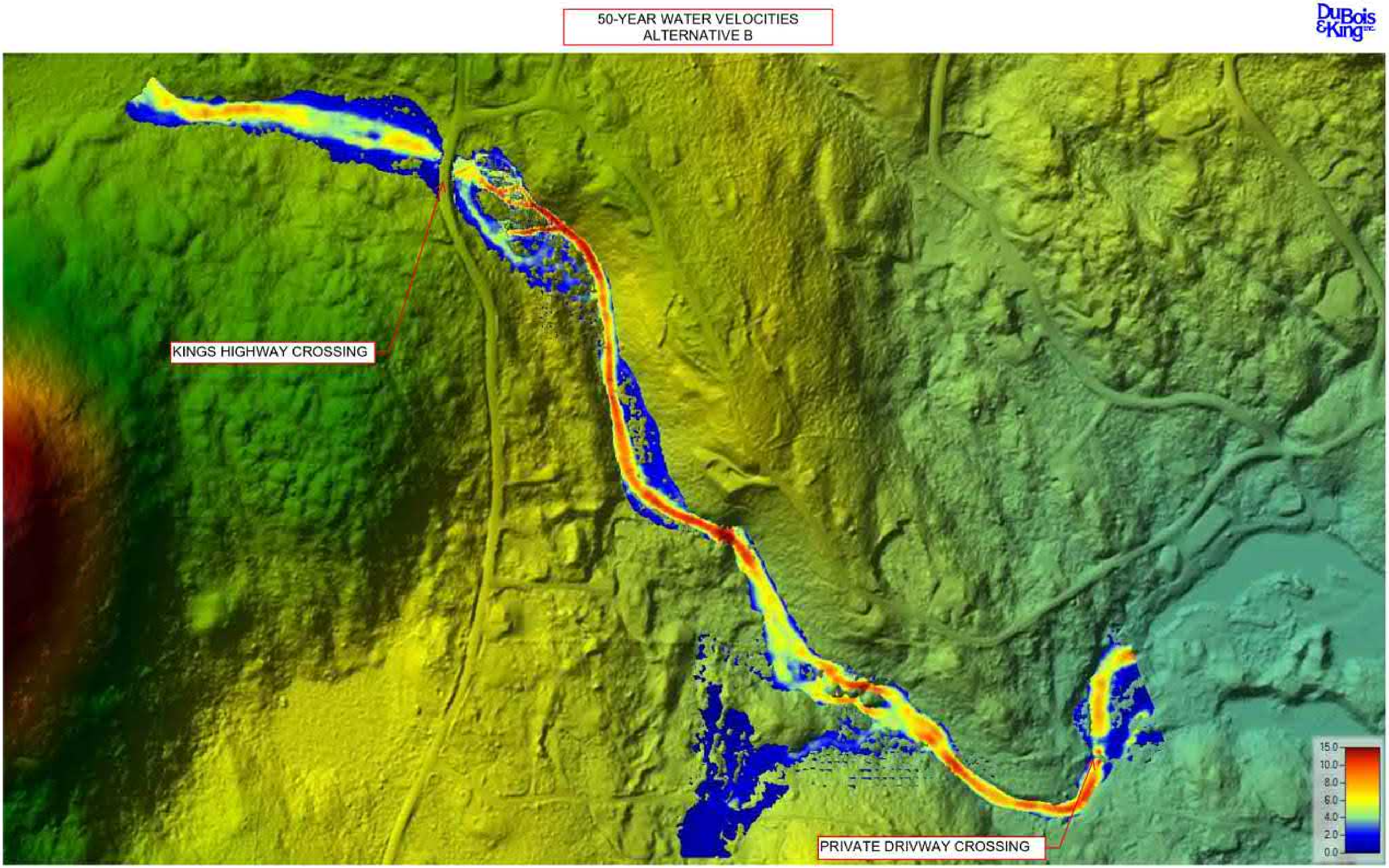

50-YEAR WATER SURFACE PROFILE
ALTERNATIVE B
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. B 50-Year 'Max'
'Proposed' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

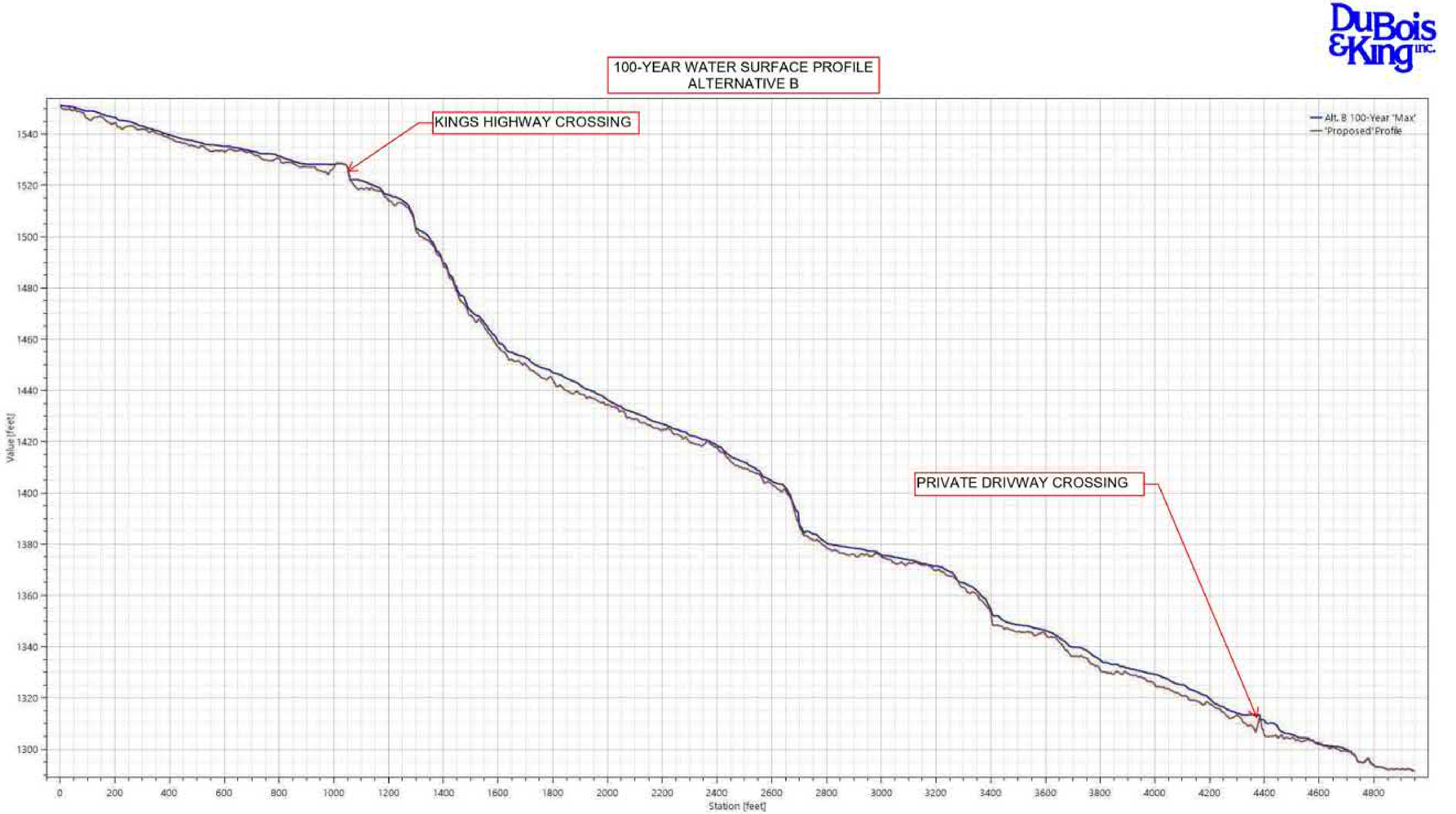
50-YEAR WATER SURFACE DEPTH
ALTERNATIVE B



50-YEAR WATER SURFACE DEPTH
ALTERNATIVE B

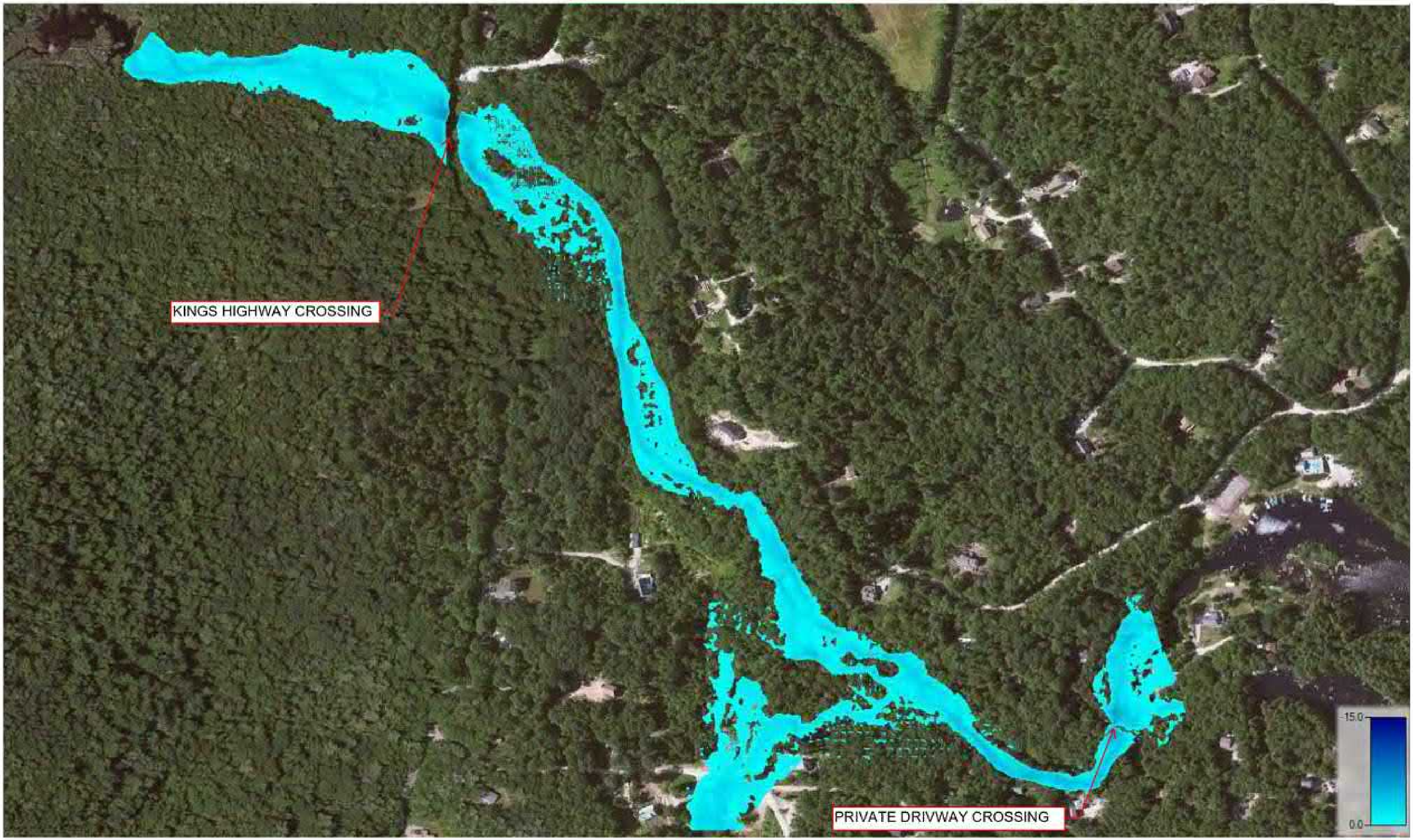



50-YEAR WATER VELOCITIES
ALTERNATIVE B
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
15.0
10.0
8.0
6.0
4.0
2.0
0.0

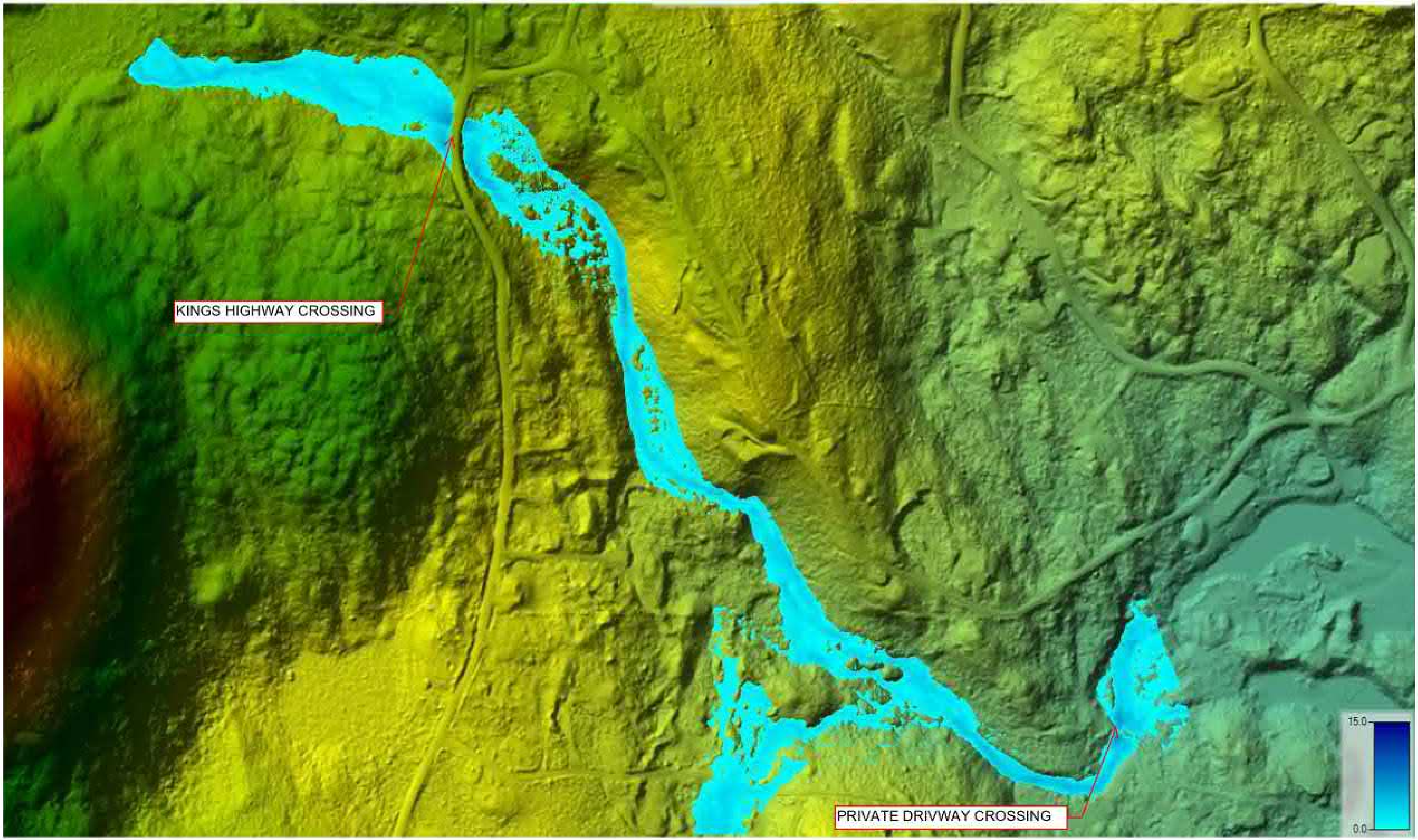


DuBois & King inc.
100-YEAR WATER SURFACE PROFILE
ALTERNATIVE B
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. B 100-Year 'Max'
'Proposed' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

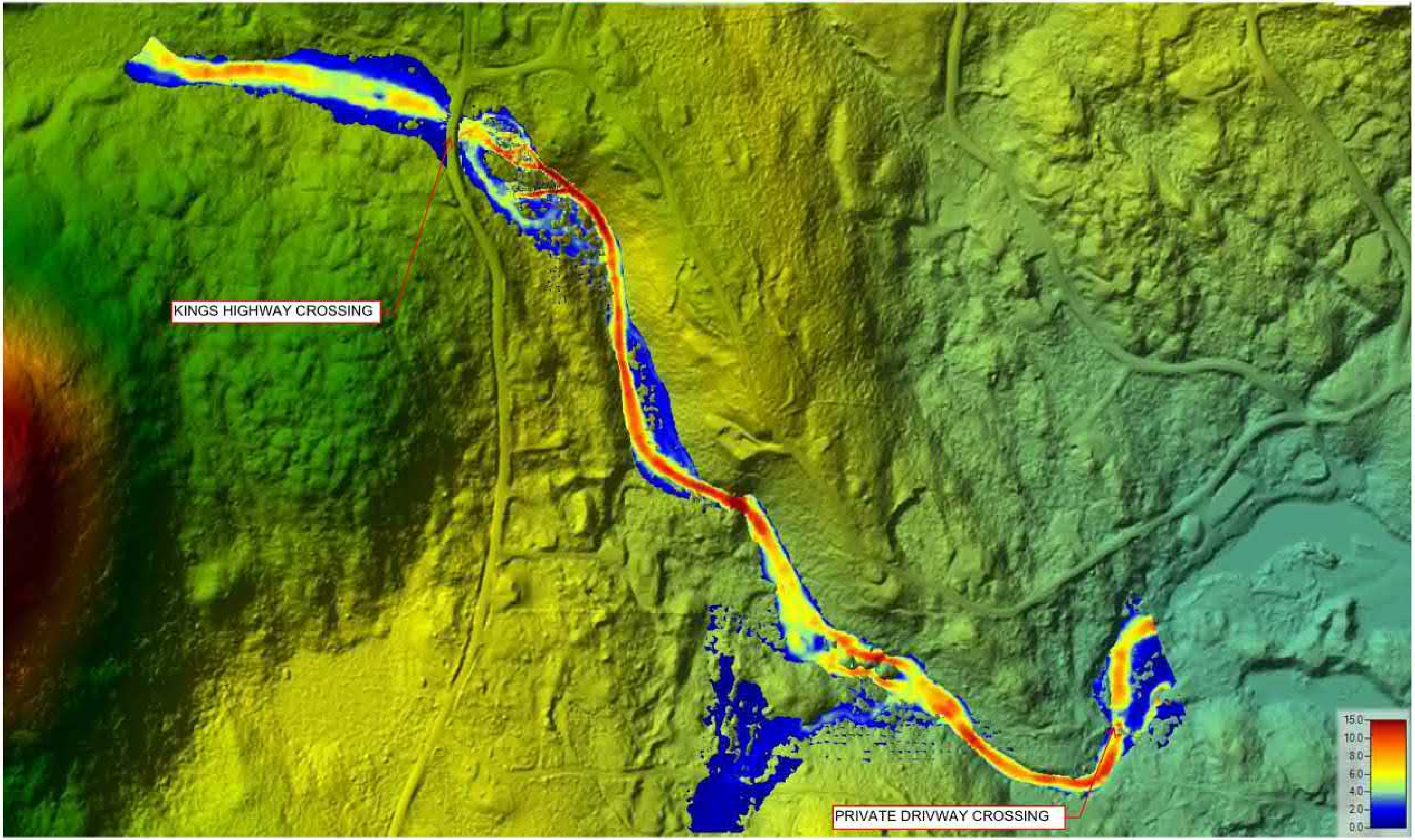
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE B

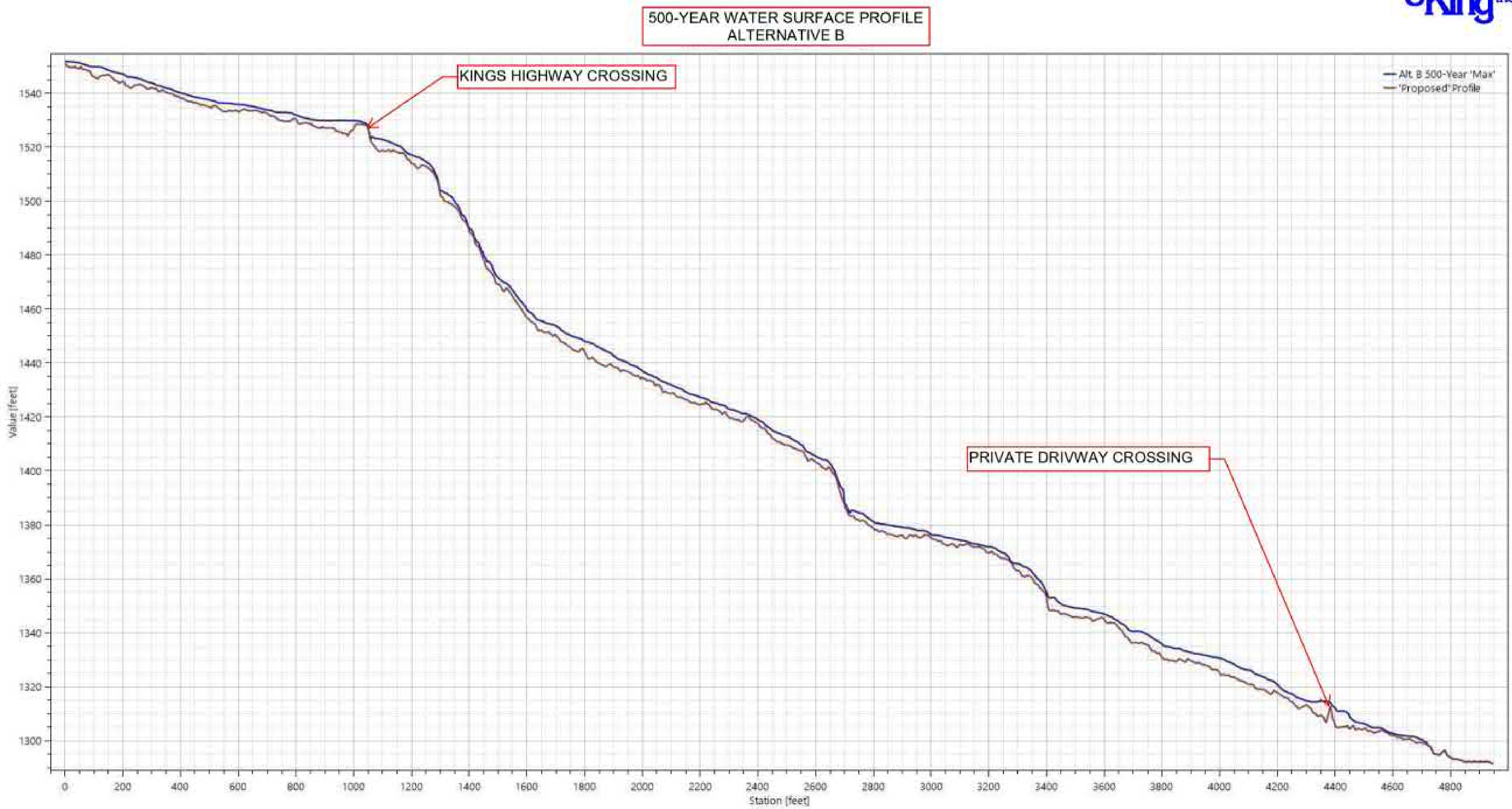


100-YEAR WATER SURFACE DEPTH
ALTERNATIVE B



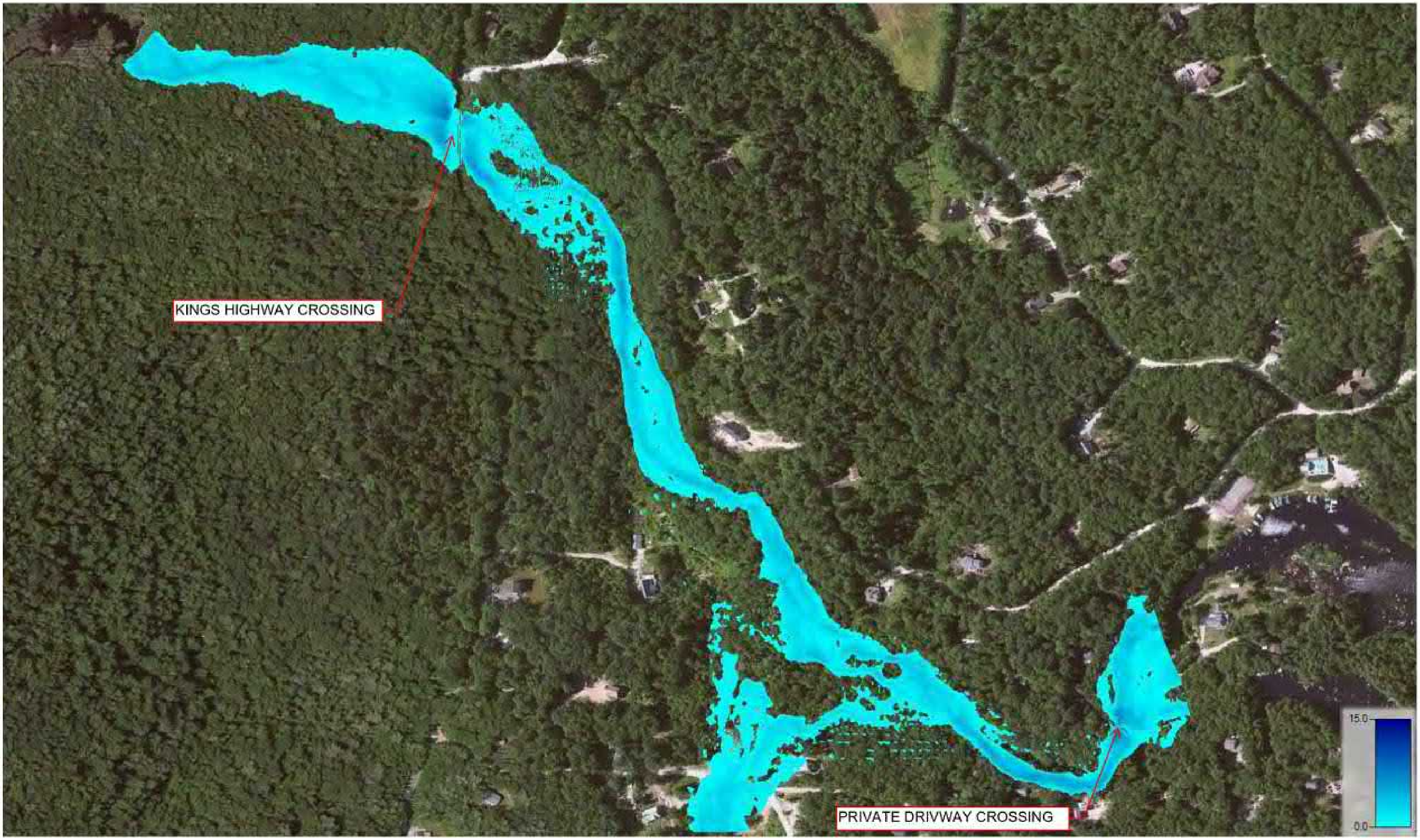
100-YEAR WATER VELOCITIES
ALTERNATIVE B



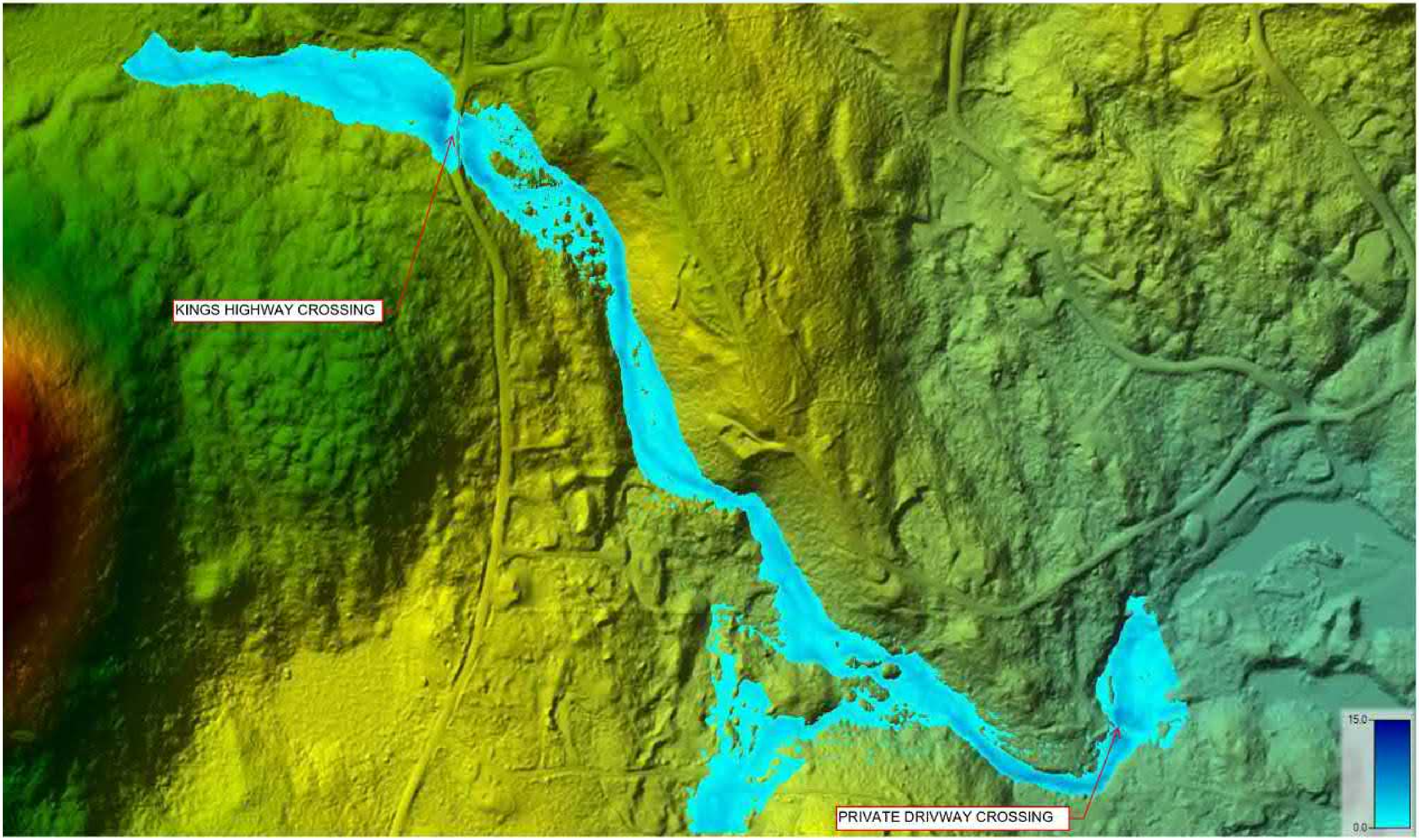


500-YEAR WATER SURFACE PROFILE
ALTERNATIVE B
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. B 500-Year 'Max'
'Proposed' Profile
Value [feet]
Station [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

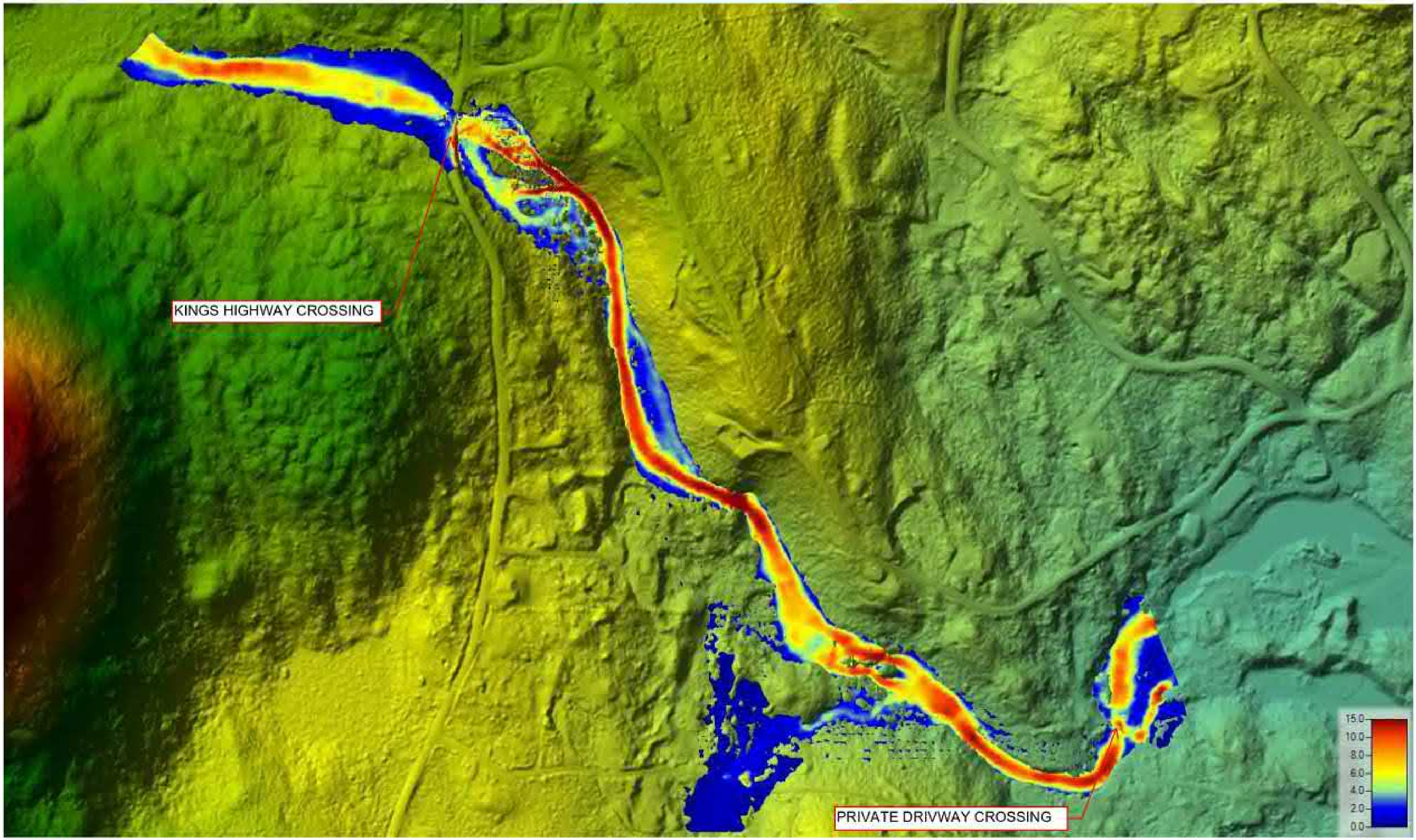
500-YEAR WATER SURFACE DEPTH
ALTERNATIVE B



500-YEAR WATER SURFACE DEPTH
ALTERNATIVE B



500-YEAR WATER VELOCITIES
ALTERNATIVE B



APPENDIX M

King's Highway Over Kennedy Brook - Stoddard, NH

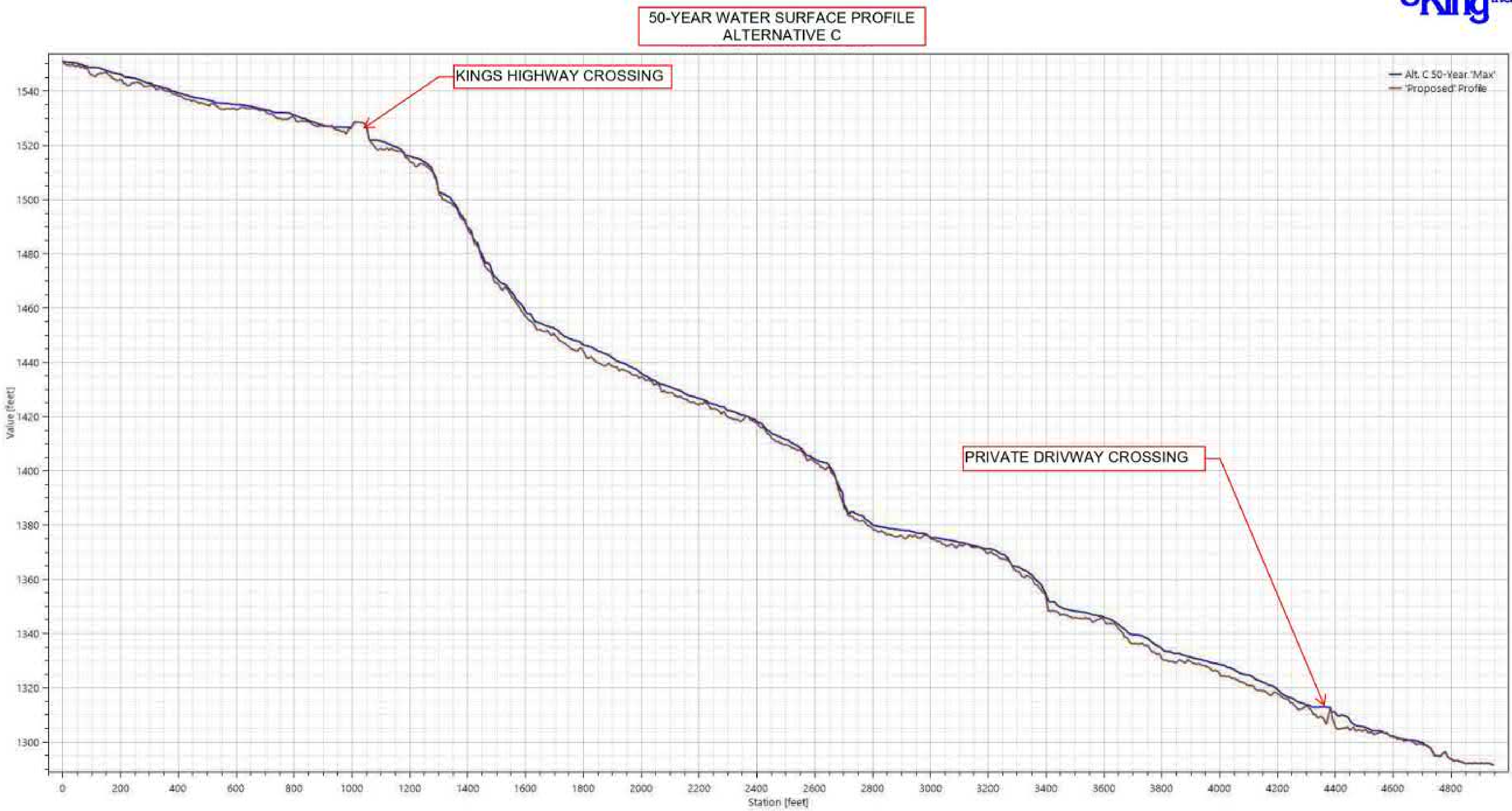
2D HEC-RAS Model Output (From Select Locations, See Figures)

Alternative C

Profile Line / Location	50-YR MAX Water Surface Elevation	100-YR MAX Water Surface Elevation	500-YR MAX Water Surface Elevation
XS 1	1537.76	1537.94	1538.46
XS 2	1531.93	1532.14	1532.71
XS 3	1526.79	1527.58	1529.73
XS 4	N/A	N/A	1529.70
XS 5	1525.02	1525.33	1526.29
XS 6	1512.04	1512.13	1512.42
XS 7	1313.46	1313.96	1315.13
XS 8	1310.82	1310.92	1311.75

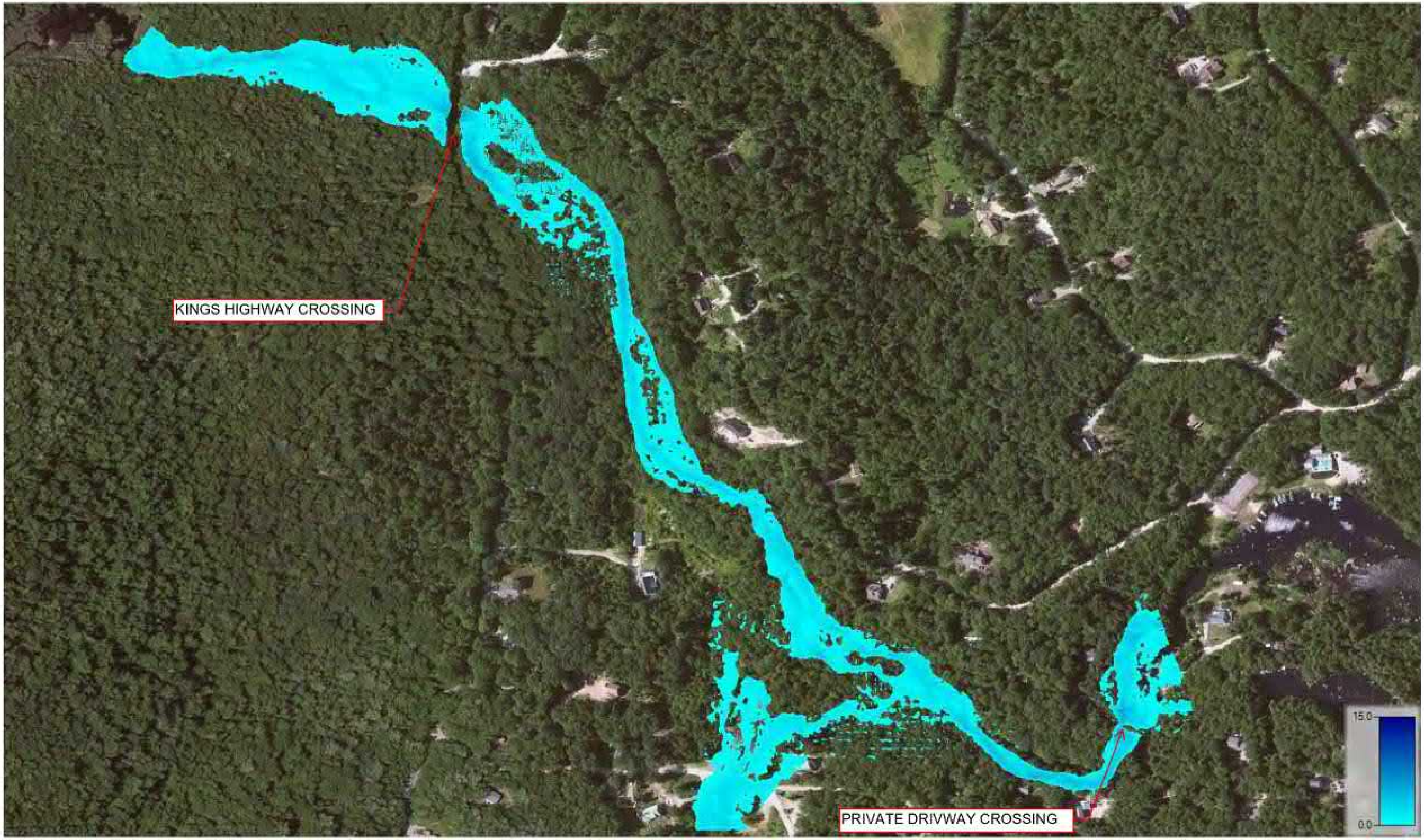
Profile Line / Location	50-YR MAX Depth (feet)	100-YR MAX Depth (feet)	500-YR MAX Depth (feet)
XS 1	2.15	2.32	2.82
XS 2	2.01	2.19	2.75
XS 3	3.96	4.80	6.93
XS 4	N/A	N/A	0.94
XS 5	4.42	4.71	5.75
XS 6	2.36	2.76	3.53
XS 7	6.31	6.84	8.00
XS 8	4.94	5.30	6.12

Profile Line / Location	50-YR MAX Velocity (ft/s)	100-YR MAX Velocity (ft/s)	500-YR MAX Velocity (ft/s)
XS 1	6.26	6.91	8.43
XS 2	5.56	5.97	6.84
XS 3	6.29	6.32	6.36
XS 4	N/A	N/A	3.66
XS 5	8.00	8.63	9.79
XS 6	8.54	9.27	10.50
XS 7	15.10	8.09	9.28
XS 8	4.66	4.92	5.47

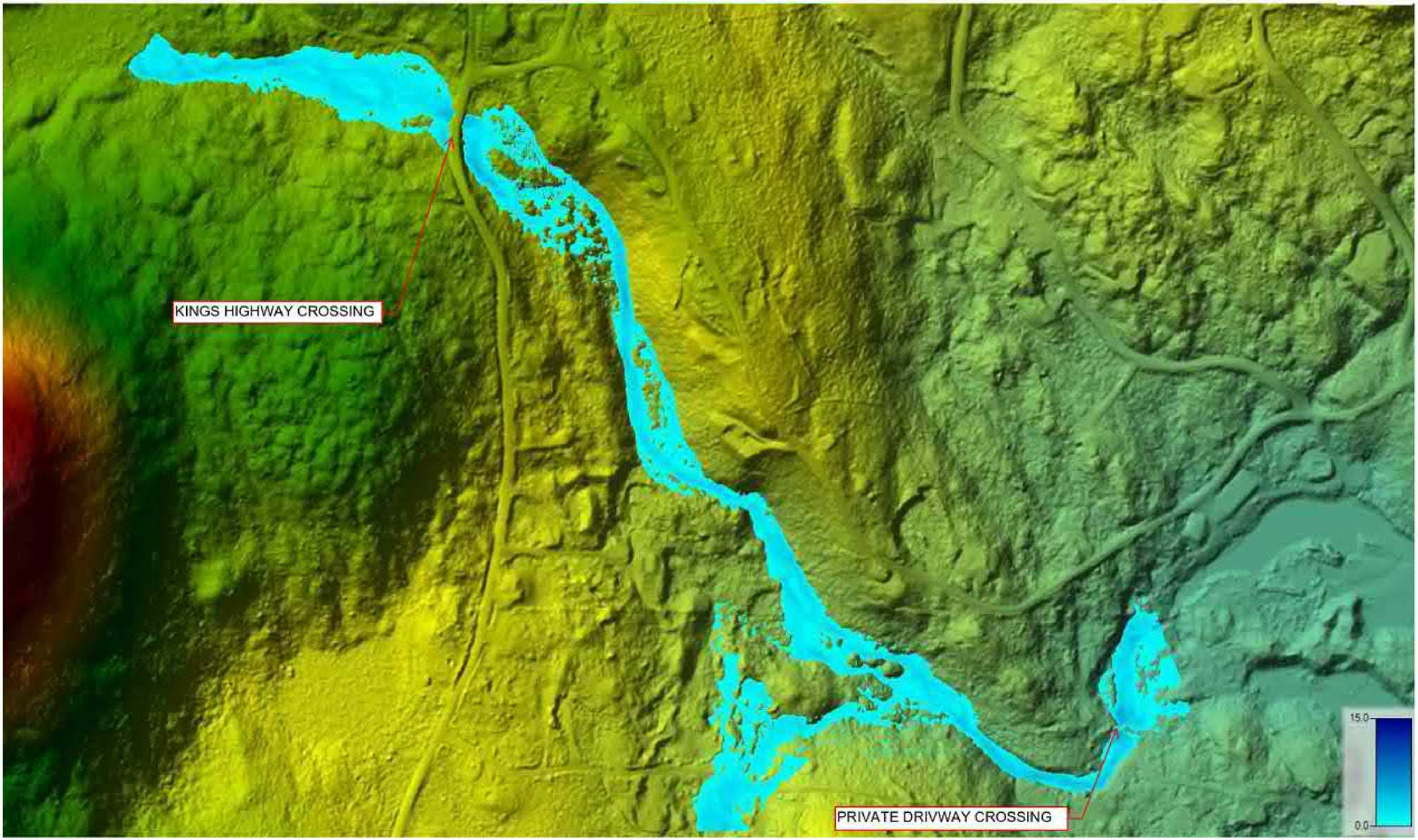


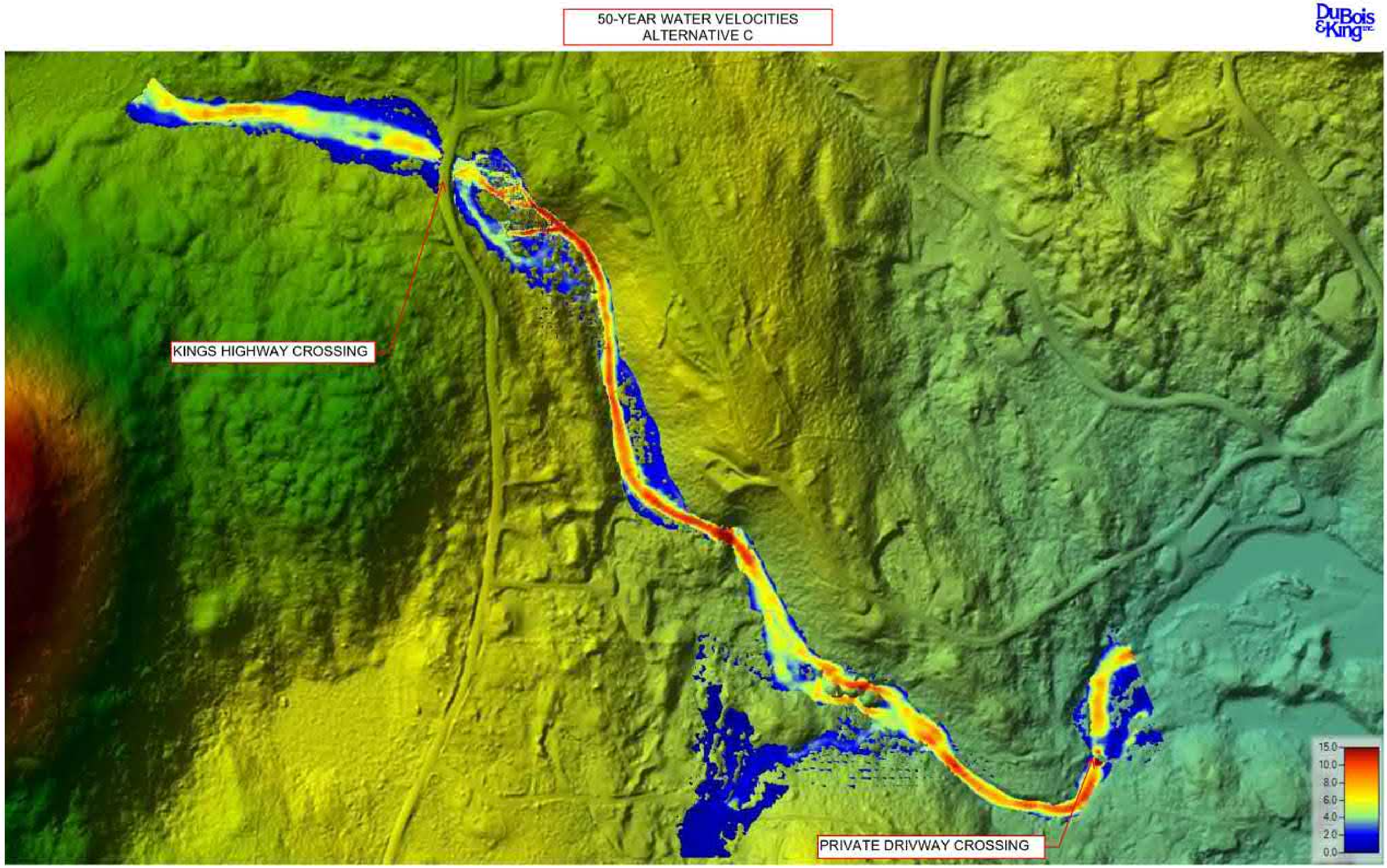
50-YEAR WATER SURFACE PROFILE
ALTERNATIVE C
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. C 50-Year 'Max'
'Proposed' Profile
Value [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
Station [feet]
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

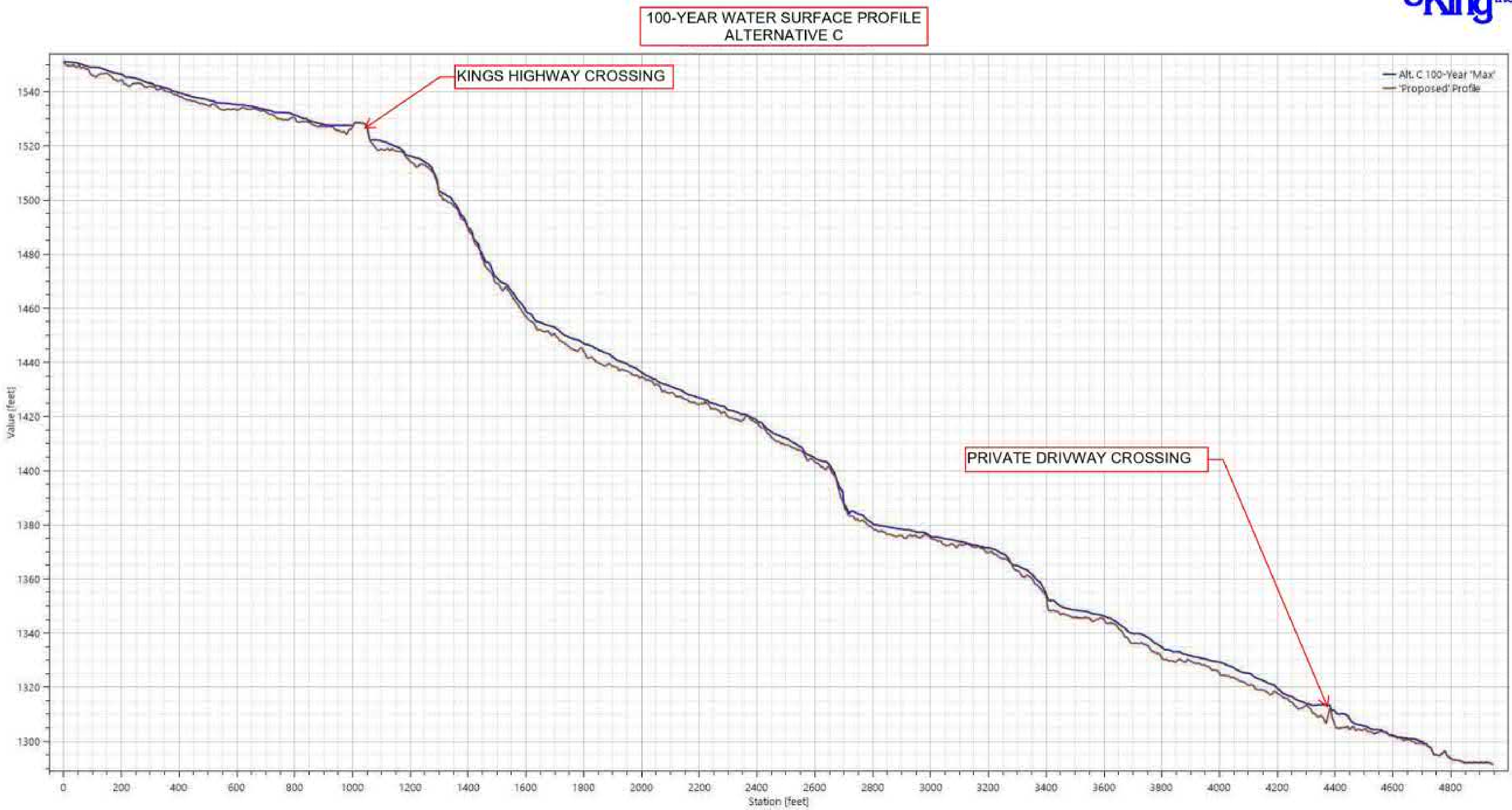
50-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



50-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



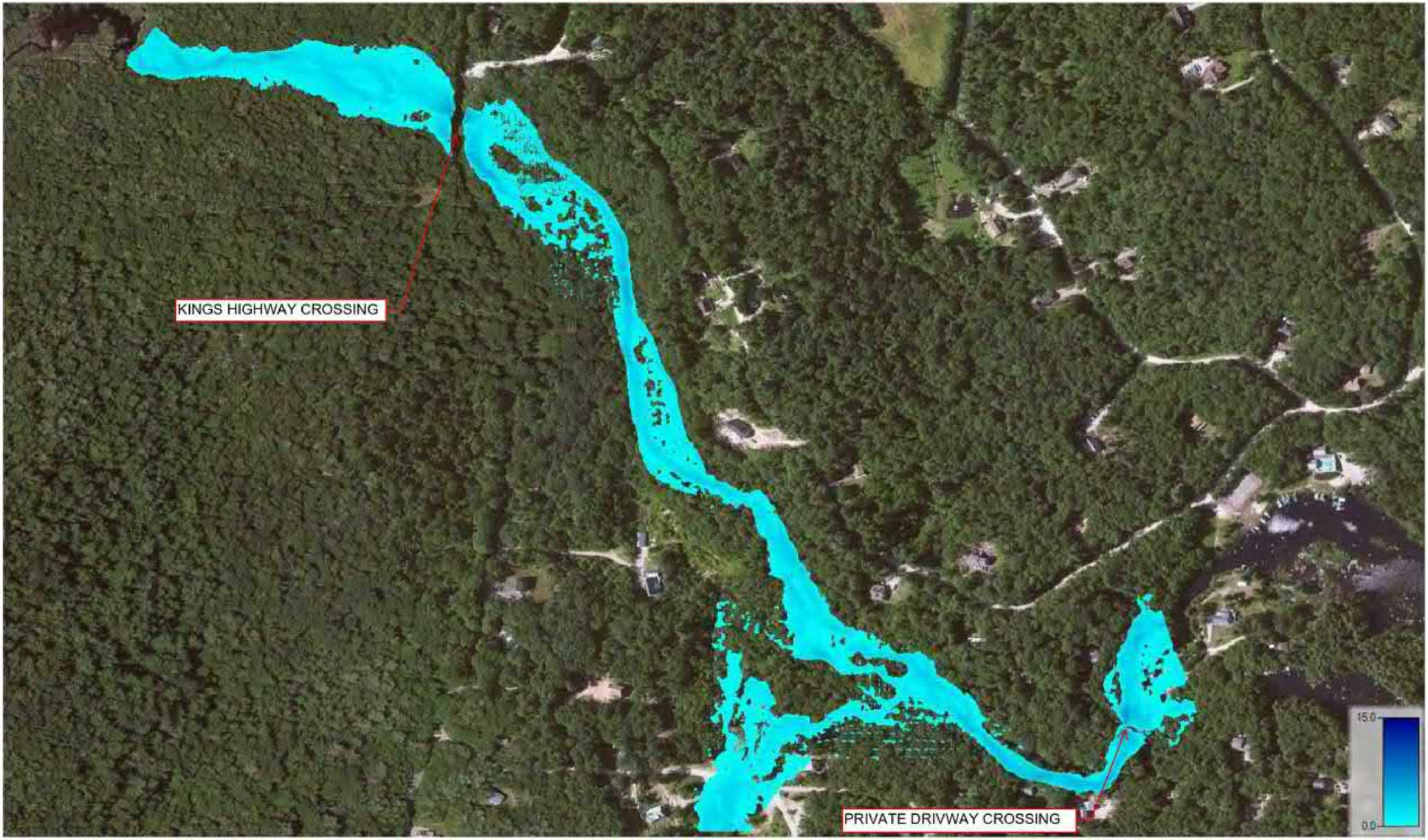

50-YEAR WATER VELOCITIES
ALTERNATIVE C
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
15.0
10.0
8.0
6.0
4.0
2.0
0.0



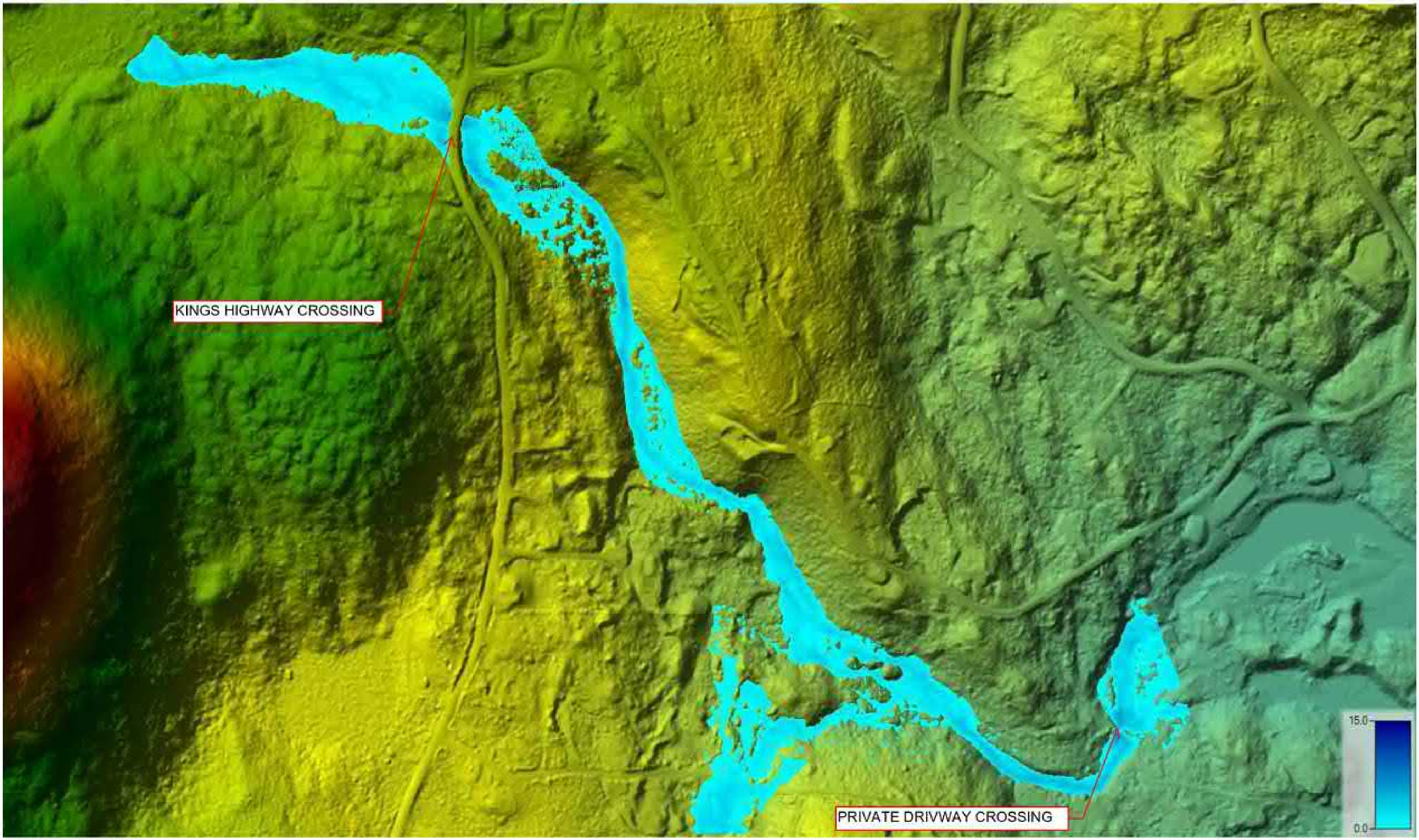
100-YEAR WATER SURFACE PROFILE
ALTERNATIVE C
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. C 100-Year 'Max'
'Proposed' Profile
Value (feet)
Station (feet)

DuBois & King inc.

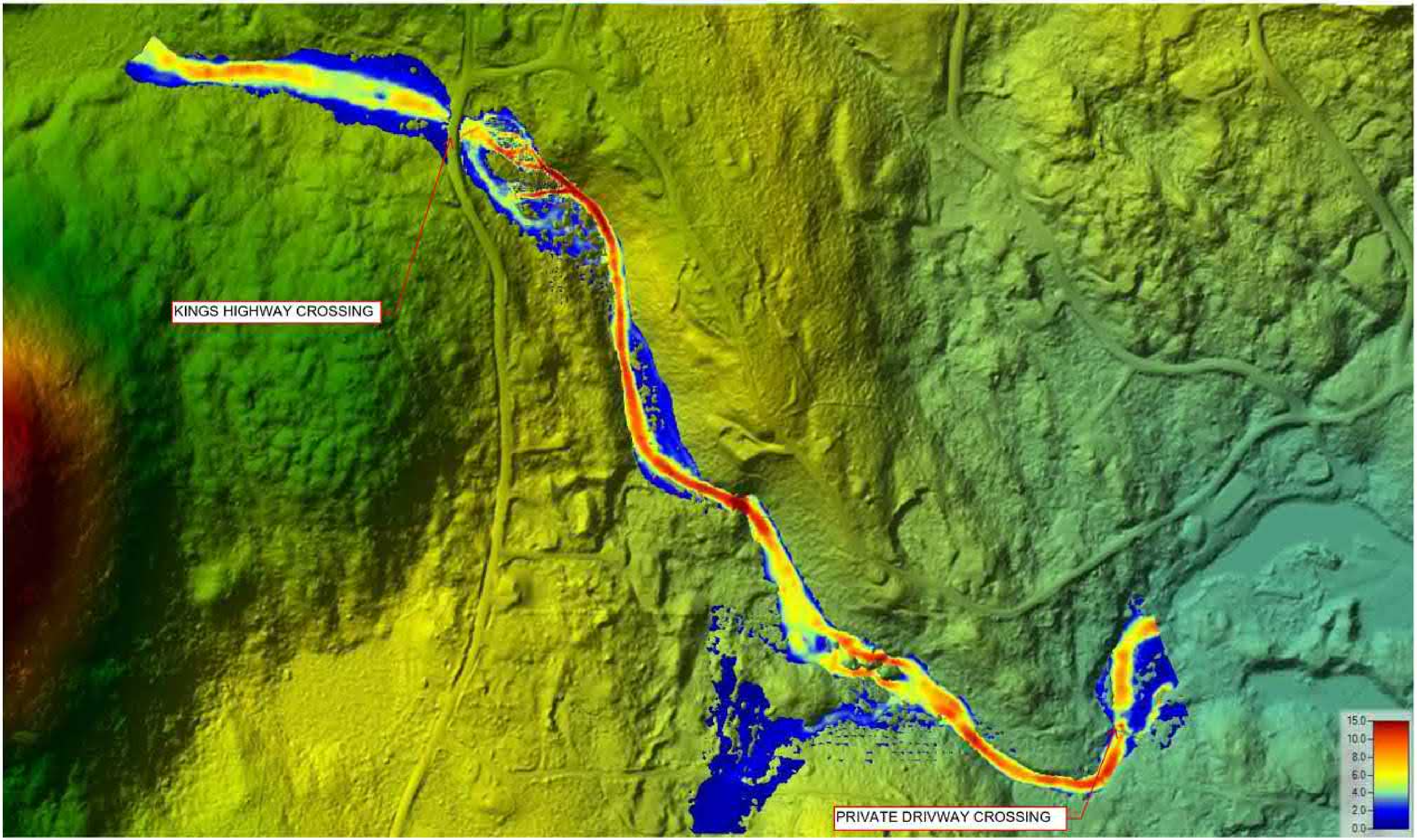
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



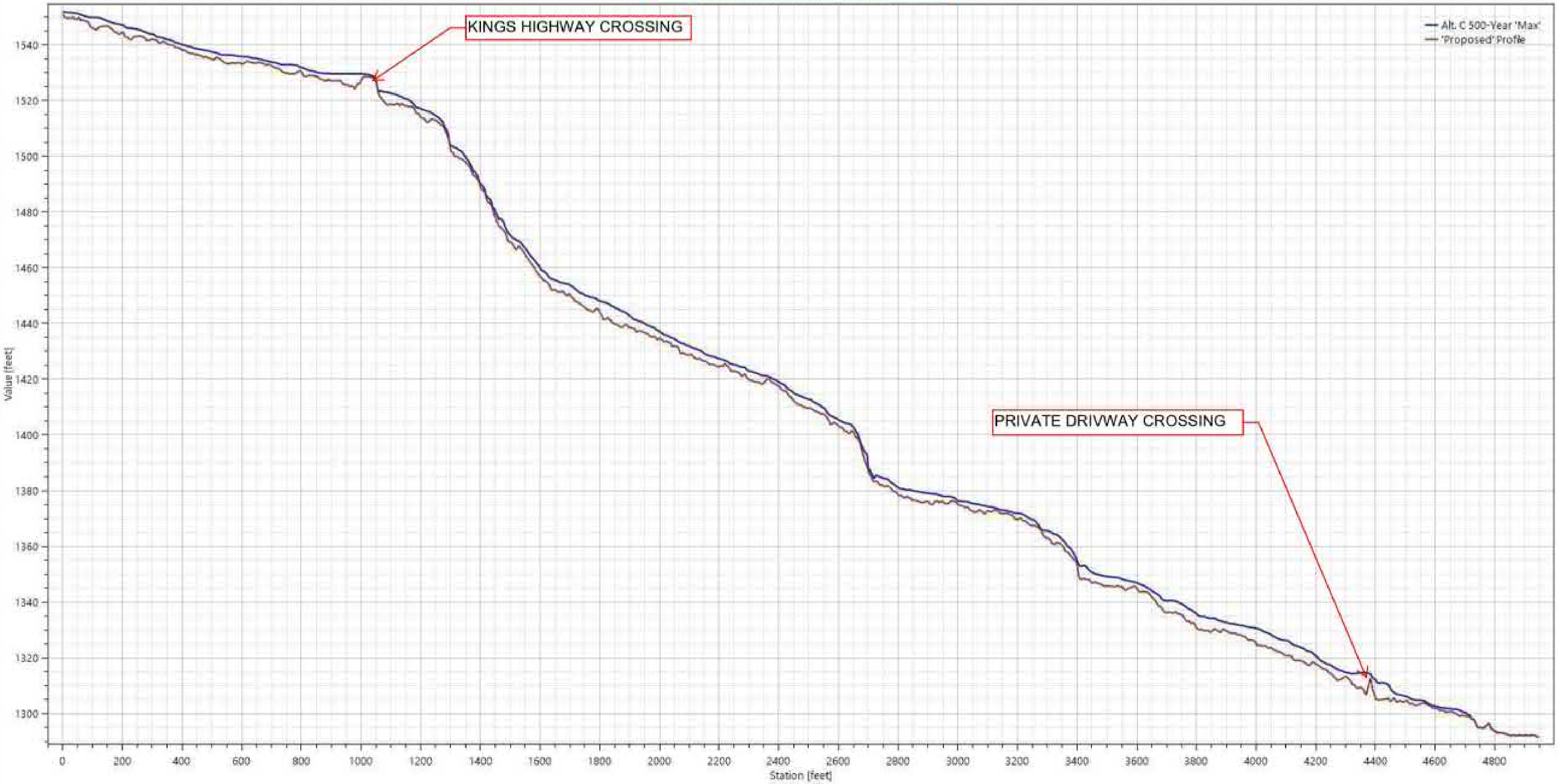
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



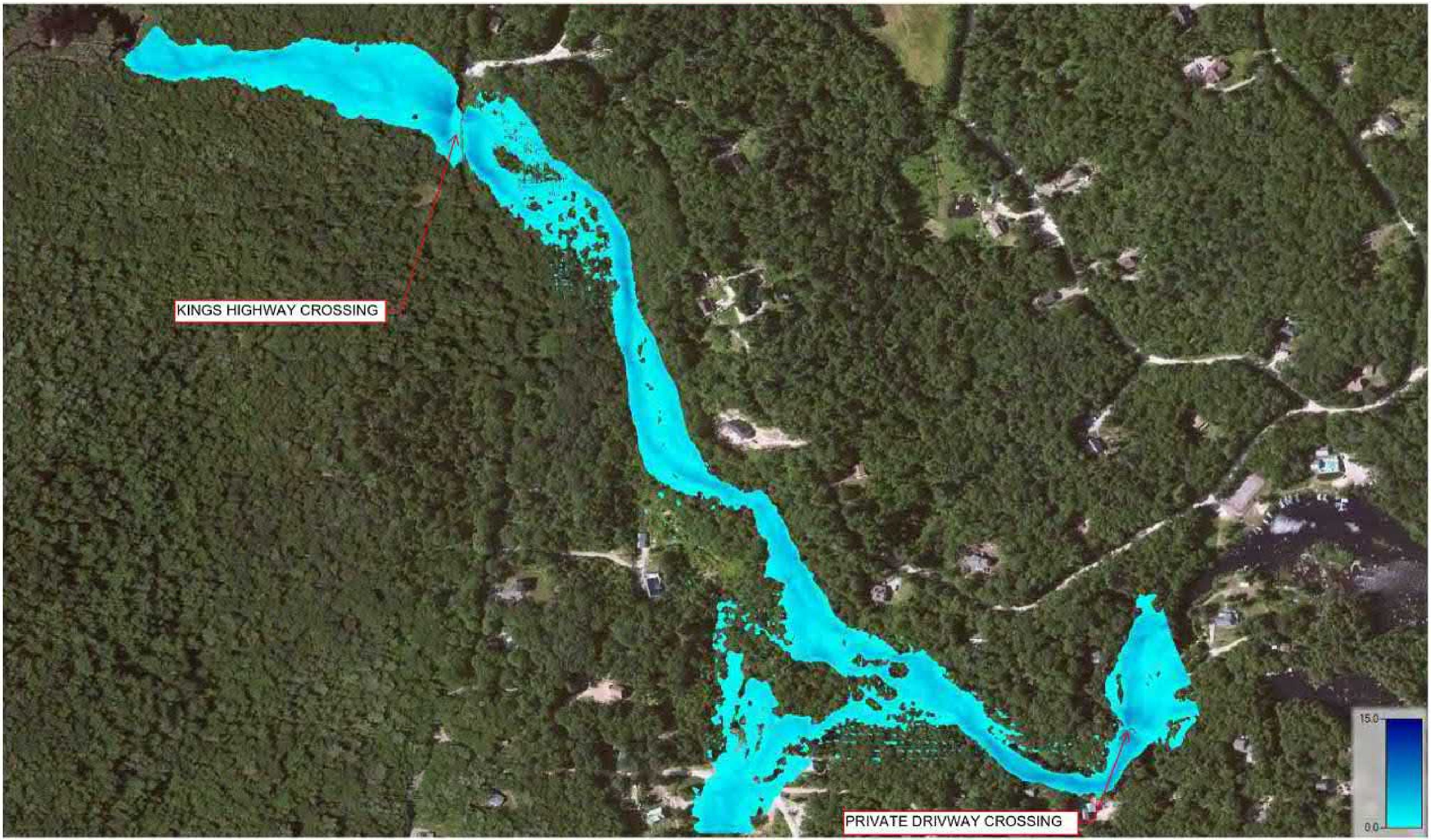
100-YEAR WATER VELOCITIES
ALTERNATIVE C



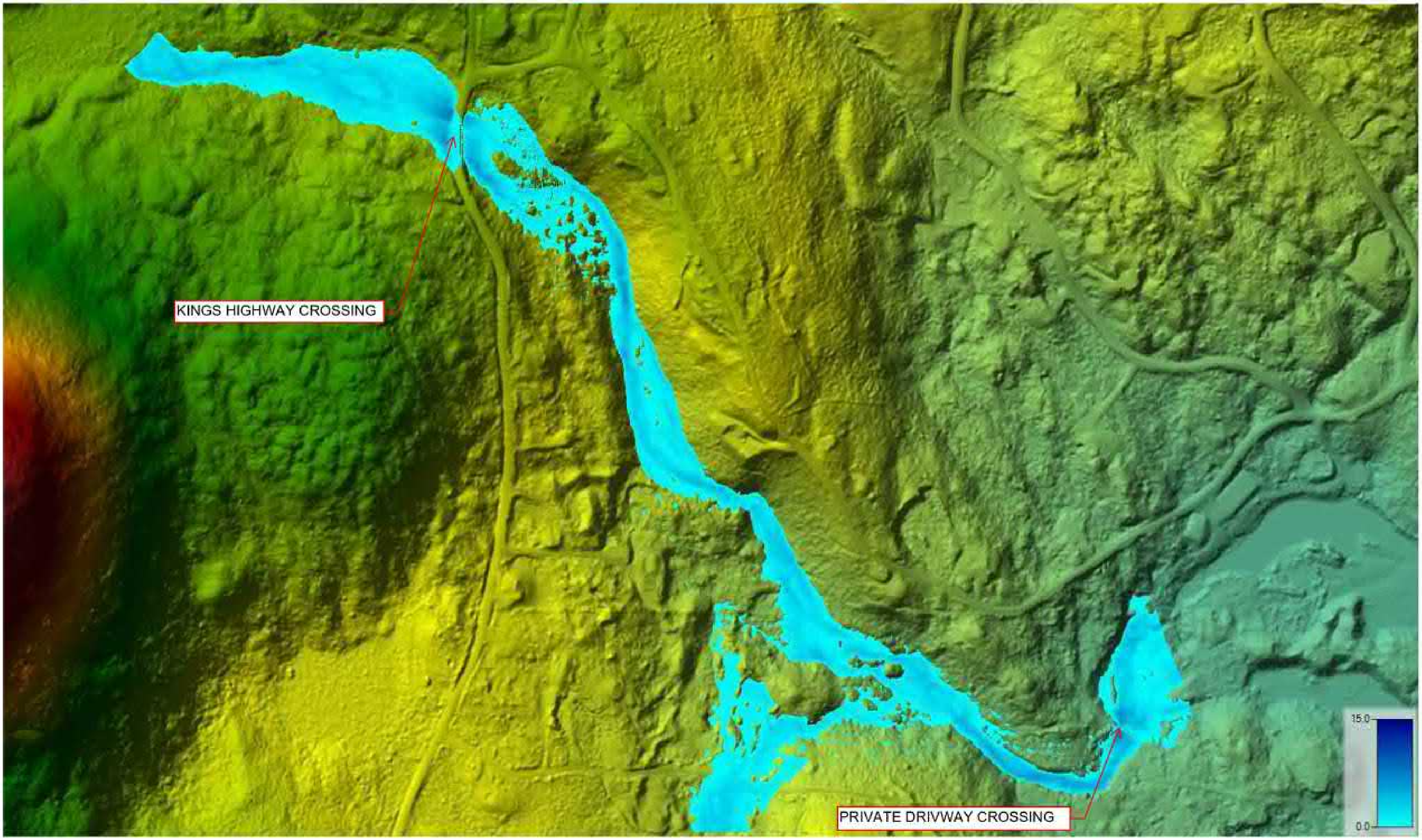
500-YEAR WATER SURFACE PROFILE
ALTERNATIVE C



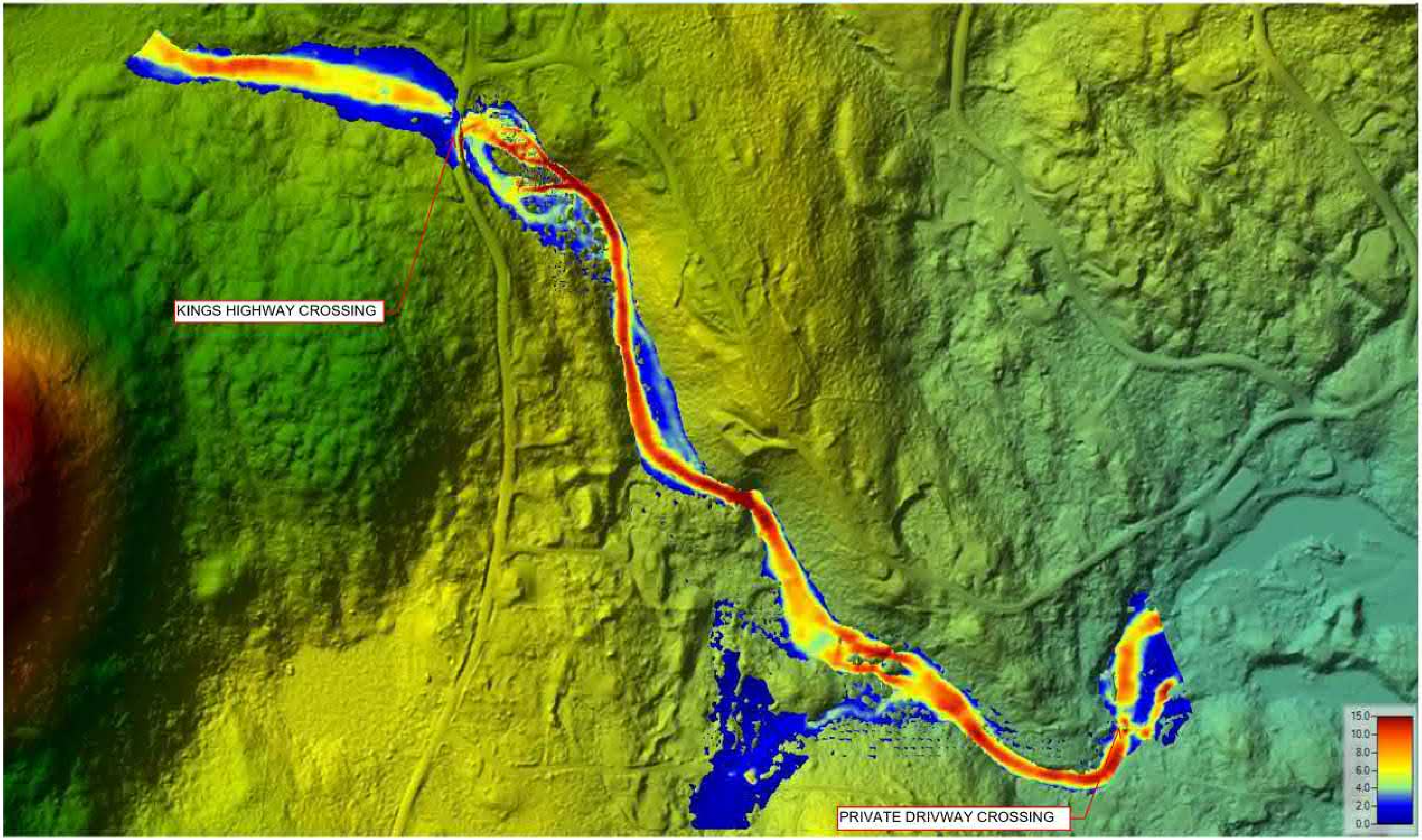
500-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



500-YEAR WATER SURFACE DEPTH
ALTERNATIVE C



500-YEAR WATER VELOCITIES
ALTERNATIVE C



APPENDIX N

King's Highway Over Kennedy Brook - Stoddard, NH

2D HEC-RAS Model Output (From Select Locations, See Figures)

Alternative D

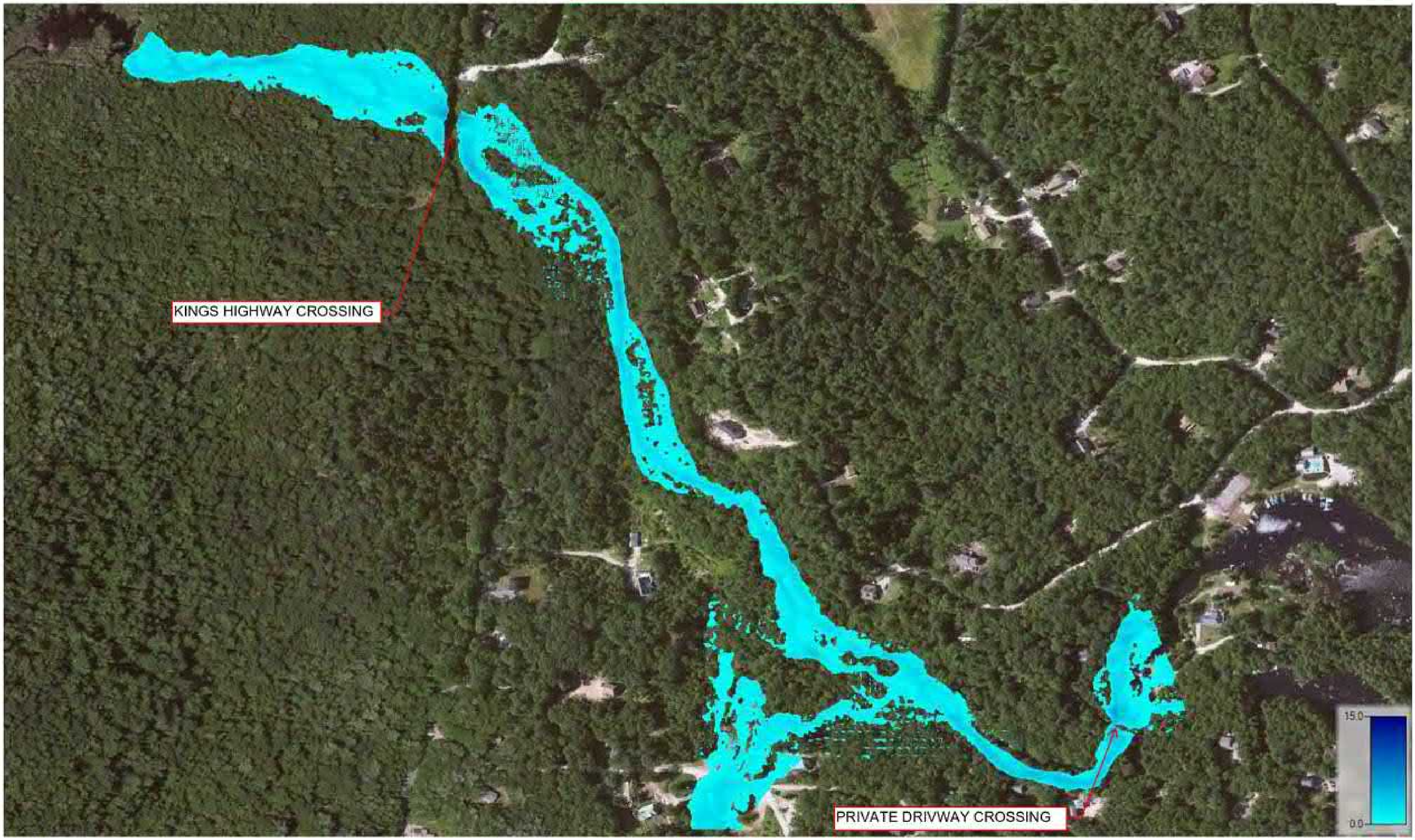
Profile Line / Location	50-YR MAX Water Surface Elevation	100-YR MAX Water Surface Elevation	500-YR MAX Water Surface Elevation
XS 1	1537.76	1537.94	1538.46
XS 2	1531.93	1532.14	1532.71
XS 3	1527.22	1528.11	1529.71
XS 4	N/A	N/A	1529.62
XS 5	1525.10	1525.44	1526.40
XS 6	1512.04	1512.13	1512.42
XS 7	1313.47	1313.96	1315.13
XS 8	1310.82	1310.90	1311.75

Profile Line / Location	50-YR MAX Depth (feet)	100-YR MAX Depth (feet)	500-YR MAX Depth (feet)
XS 1	2.15	2.32	2.82
XS 2	2.01	2.19	2.75
XS 3	4.44	5.34	6.90
XS 4	N/A	N/A	0.92
XS 5	4.42	4.72	5.73
XS 6	2.36	2.76	3.53
XS 7	6.31	6.84	8.00
XS 8	4.94	5.30	6.12

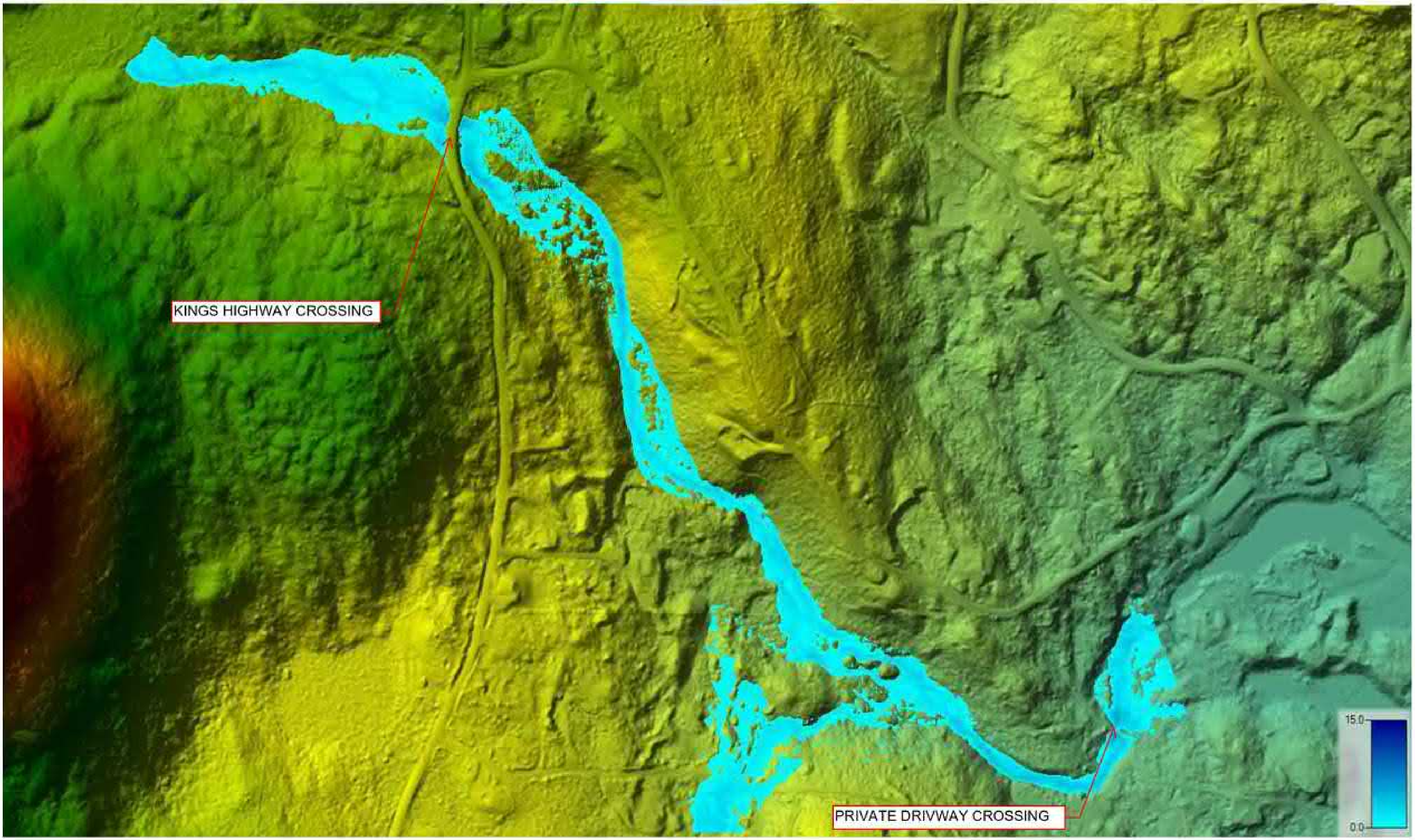
Profile Line / Location	50-YR MAX Velocity (ft/s)	100-YR MAX Velocity (ft/s)	500-YR MAX Velocity (ft/s)
XS 1	6.26	6.91	8.43
XS 2	5.56	5.97	6.84
XS 3	5.79	5.81	5.96
XS 4	N/A	N/A	3.61
XS 5	8.03	8.71	9.88
XS 6	8.54	9.27	10.50
XS 7	8.48	7.42	7.56
XS 8	4.66	4.93	5.47

50-YEAR WATER SURFACE PROFILE
ALTERNATIVE D

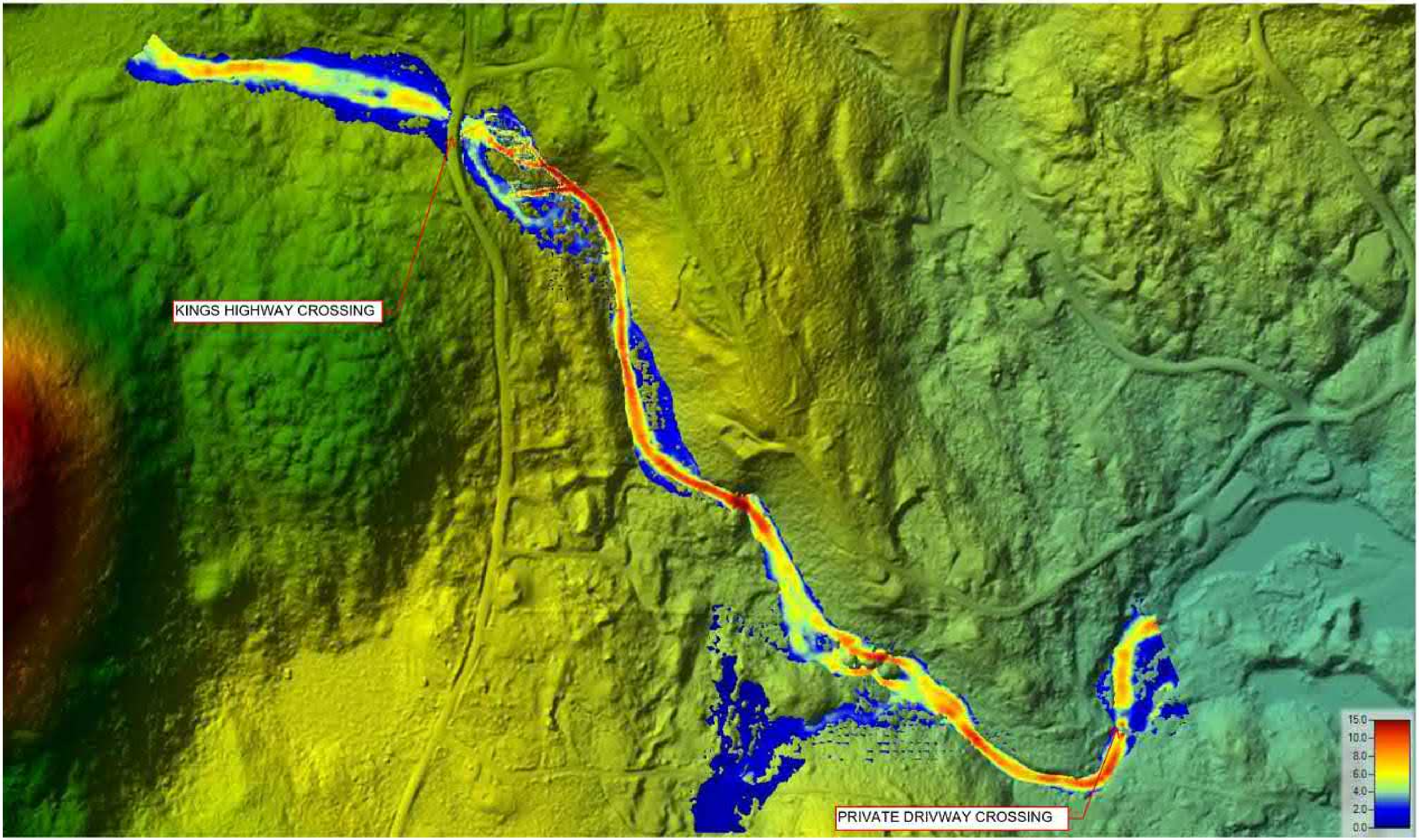
50-YEAR WATER SURFACE DEPTH
ALTERNATIVE D



50-YEAR WATER SURFACE DEPTH
ALTERNATIVE D

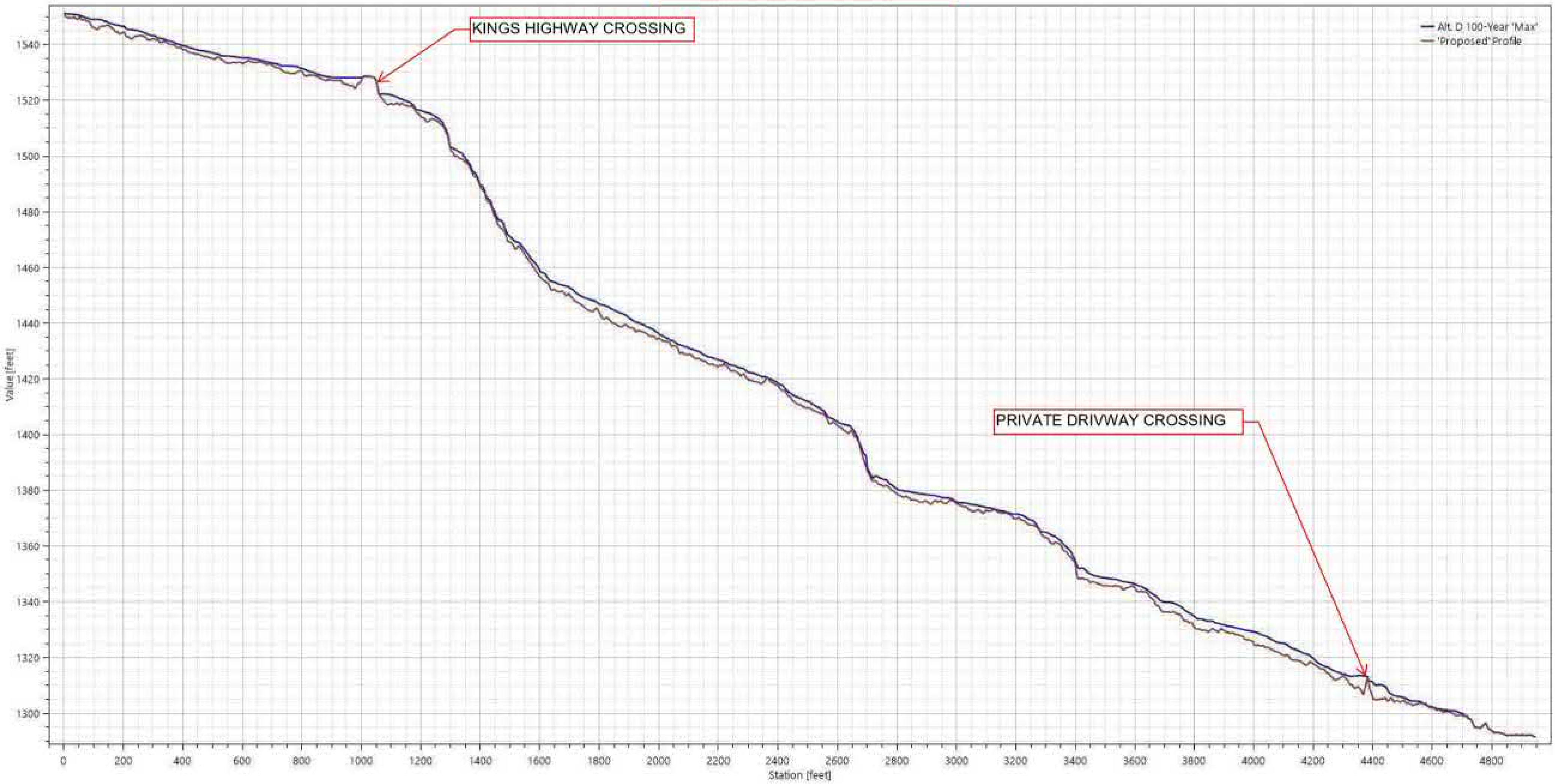


50-YEAR WATER VELOCITIES
ALTERNATIVE D



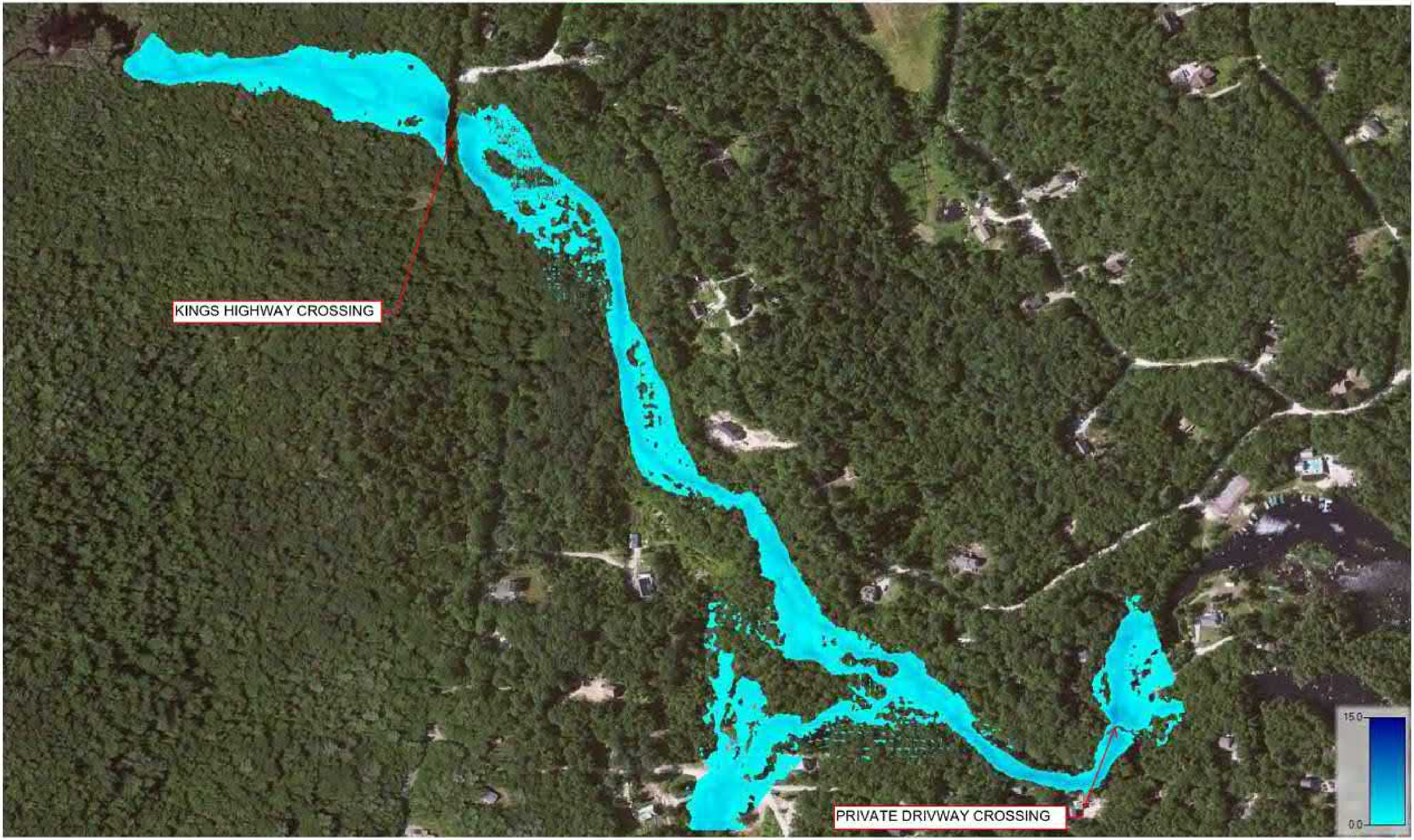
DuBois & King inc.

100-YEAR WATER SURFACE PROFILE
ALTERNATIVE D



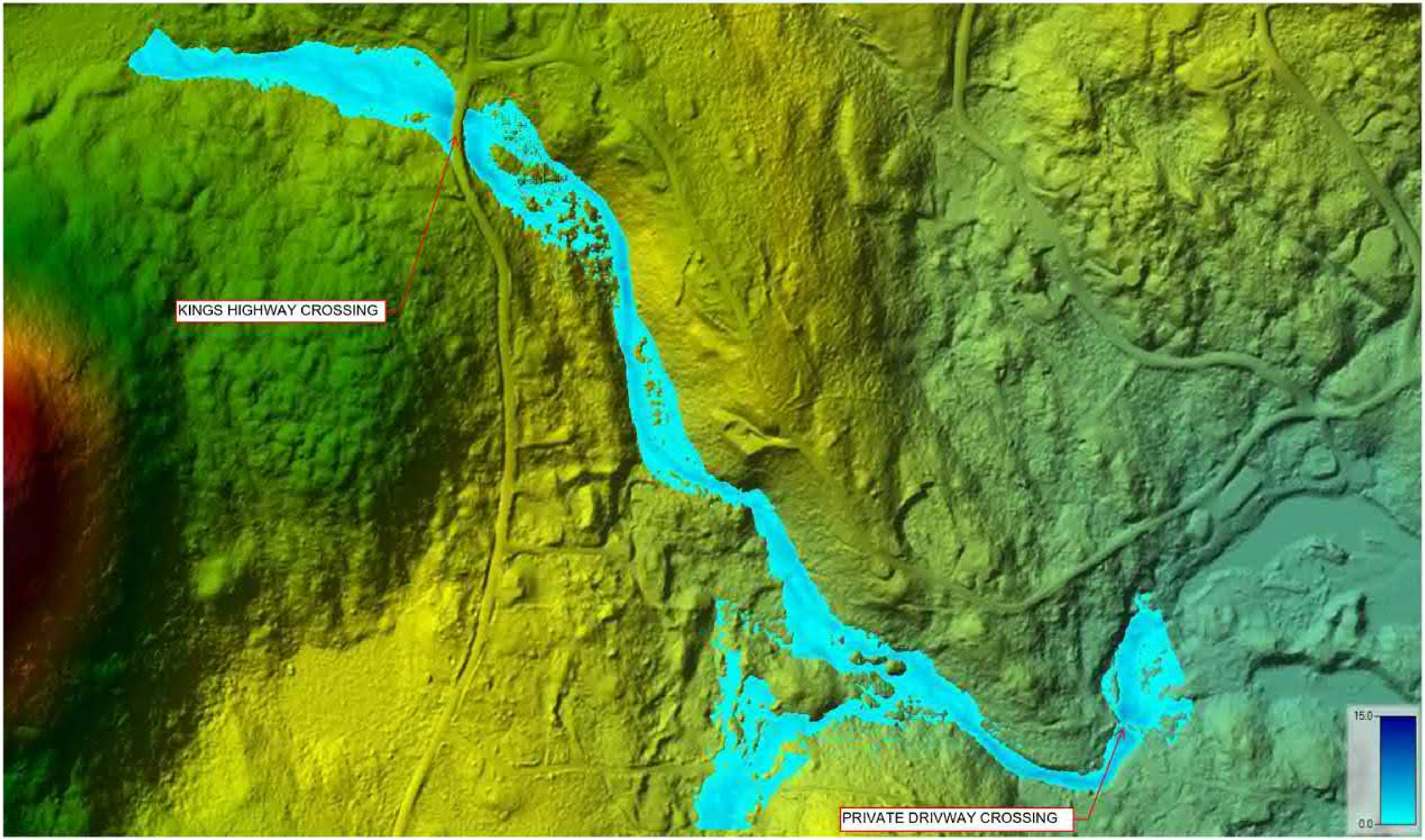
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE D

DuBois & King inc.

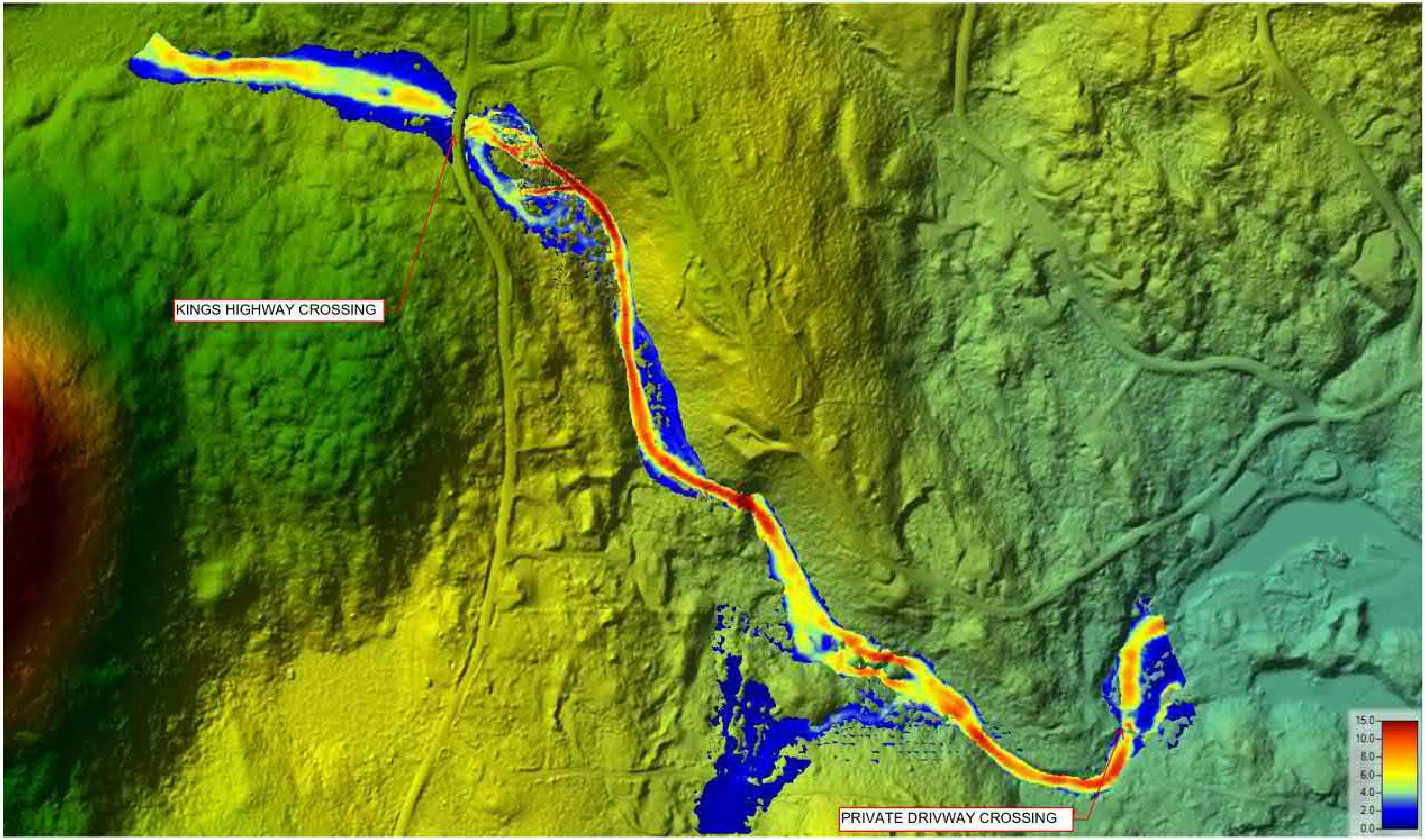


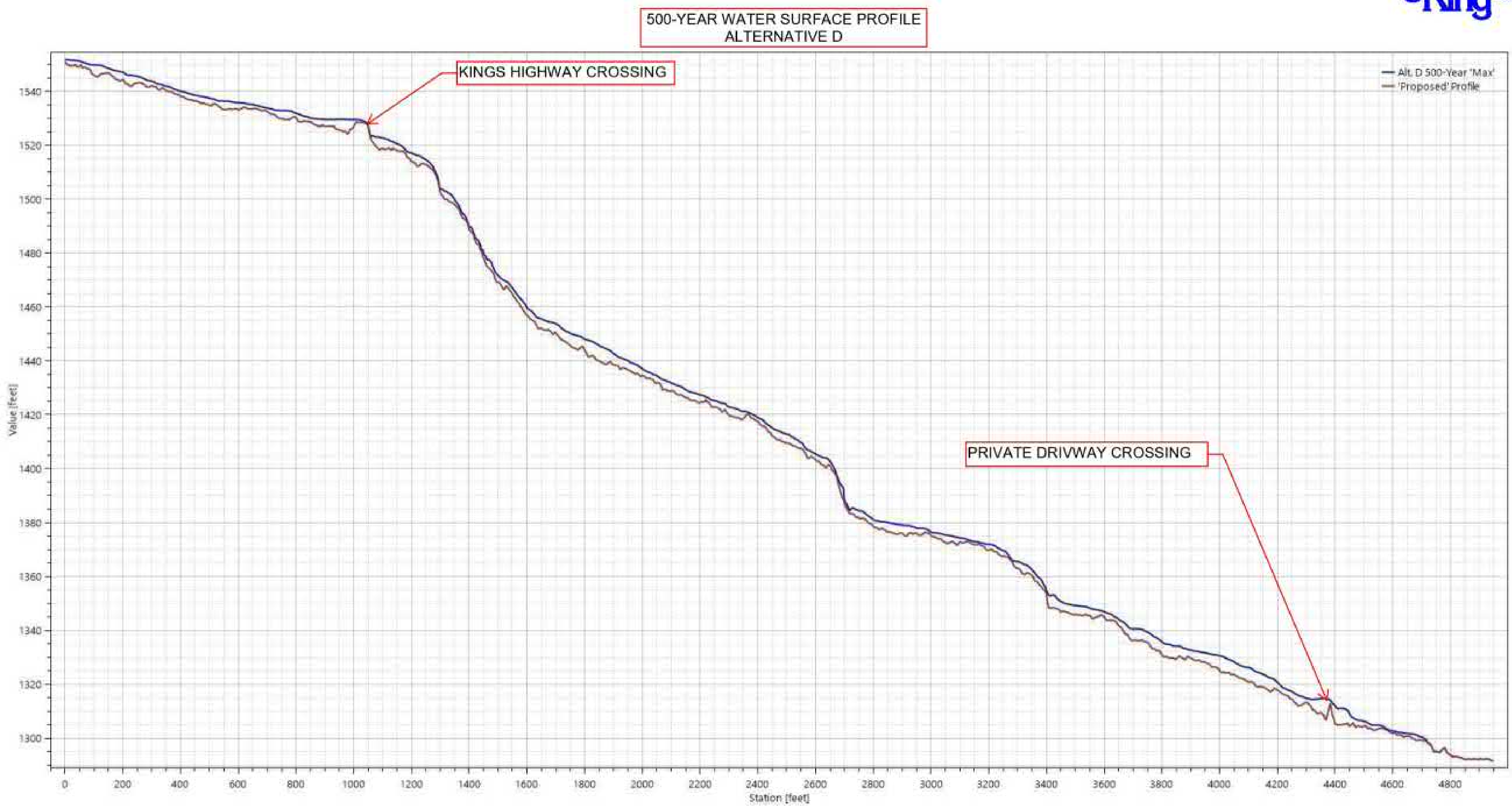
100-YEAR WATER SURFACE DEPTH
ALTERNATIVE D

DuBois & King inc.



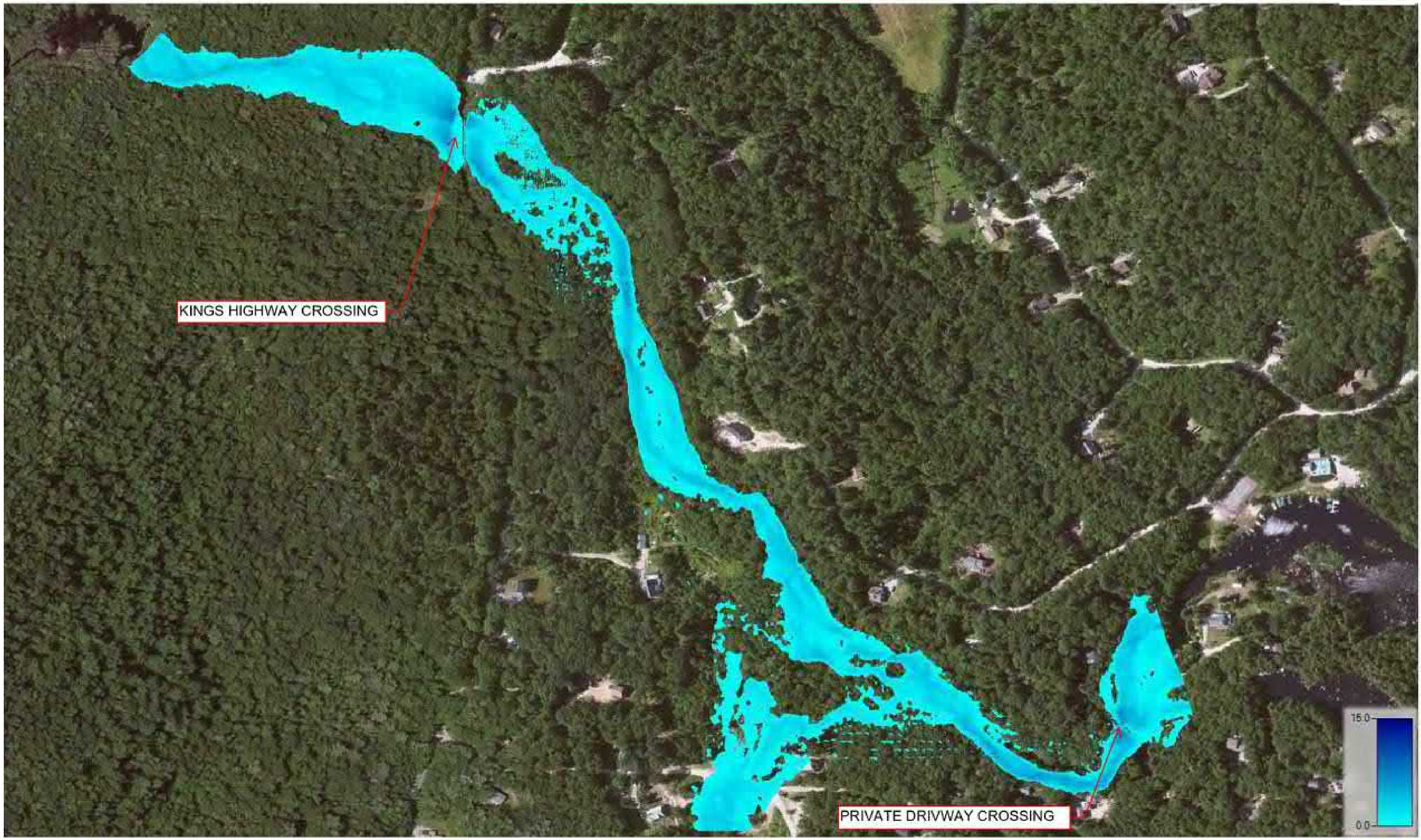
100-YEAR WATER VELOCITIES
ALTERNATIVE D



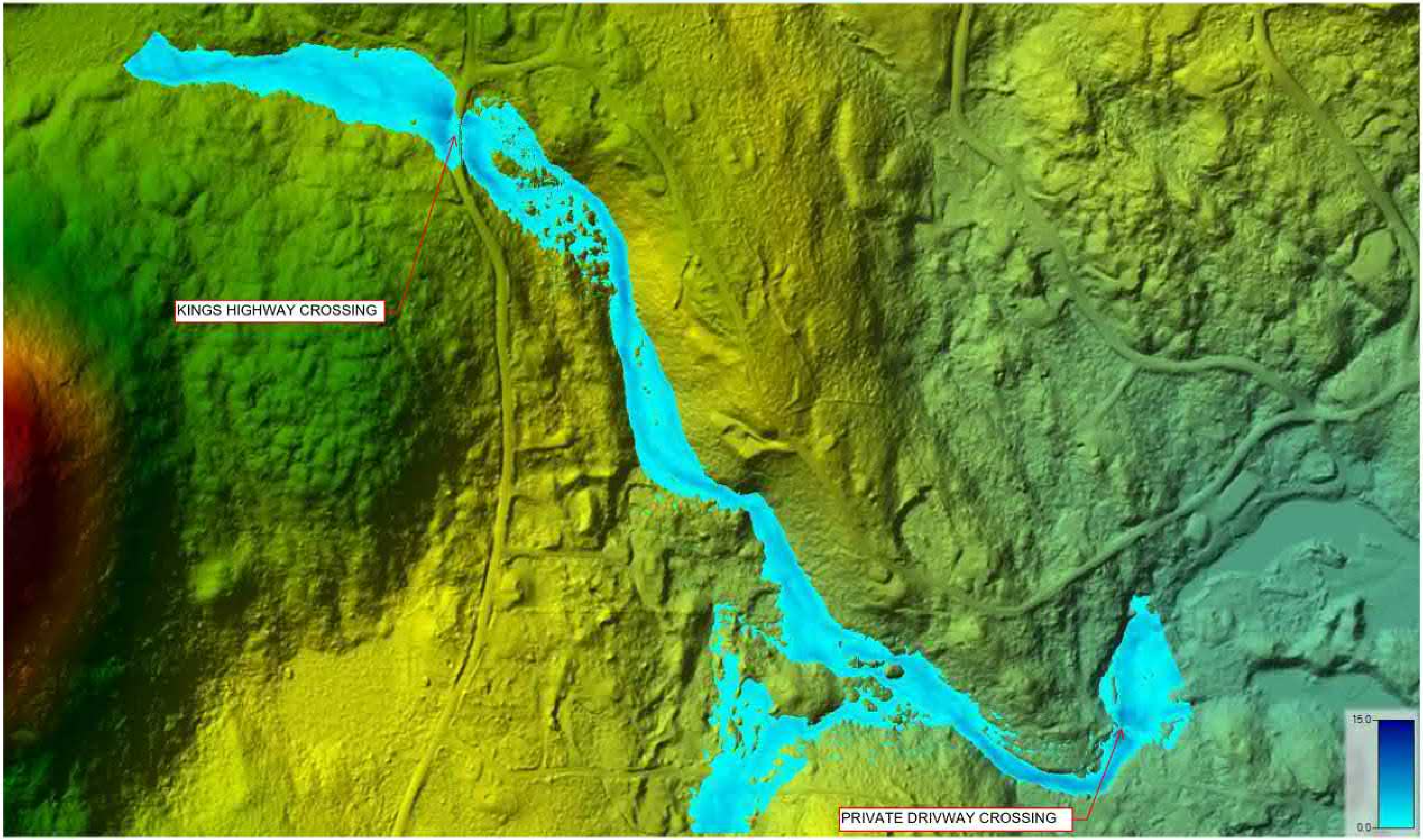


500-YEAR WATER SURFACE PROFILE
ALTERNATIVE D
KINGS HIGHWAY CROSSING
PRIVATE DRIVWAY CROSSING
Alt. D 500-Year 'Max'
'Proposed' Profile
Value [feet]
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
Station [feet]
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
4800

500-YEAR WATER SURFACE DEPTH
ALTERNATIVE D



500-YEAR WATER SURFACE DEPTH
ALTERNATIVE D



500-YEAR WATER VELOCITIES
ALTERNATIVE D