Appendix B–8

Hydrology, Dam Failure and Flood Inundation Analyses

The flood inundation maps and tables documenting flood levels and timing included in this EAP were developed by Dubois & King, Inc. and documented in the report titled, “Breach Analyses, East Long Pond Dam, Nichols Pond Dam, and Mackville Pond Dam,” dated August 21, 2012. Refer to that report for additional information regarding the hydrology and hydraulics of the simulated dam breaches.

1.0 INTRODUCTION

This report summarizes the methods, assumptions, and results of a breach and downstream flooding analysis for the East Long Pond Dam (VT# 252.02), Nichols Pond Dam (VT#252.01), and Mackville Pond Dam (#93.02) located in the Towns of Woodbury and Hardwick, Vermont.

1.1 Purpose

This analysis was performed for two primary purposes. First, this report and associated inundation maps (Attachment II-A) are integral components of an Emergency Action Plan (EAP). A copy of the inundation maps can be inserted in the Town's EAP for these dams, and a copy of this report itself can be incorporated into the EAP as an appendix. Second, the results of the analysis presented here—specifically the impacts to downstream roads and structures in the event of breach—provide the technical basis for confirming or determining the hazard classification for these dams.

1.2 Dam Overview

The Town of Hardwick owns the East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam. The Town's Electric Department operates and maintains these structures. The three dams are located in series along Nichols Brook. East Long Pond Dam is located in the headwaters of the Nichols Brook watershed. Nichols Pond Dam is located 1 mile downstream, and Mackville Pond Dam is located an additional 2.6 miles downstream. A map showing the dam locations within the Nichols Brook watershed is included in Attachment I-B. The primary purpose of the three dams is recreational. East Long Pond is also used to augment flows for the Town's hydroelectric facility on the Lamoille River near Portersville, Vermont.

East Long Pond Dam

The dam was reportedly constructed in 1930. The dam was designed and constructed by Trojan Engineering Corporation of New York City. The Vermont Department of Environmental Conservation (DEC) currently classifies the dam as a Class 1, High Hazard Structure.

The dam is an earth embankment with a masonry and concrete outlet structure located near the center of the dam. The dam is approximately 260 feet long including a 14.5-foot (topwidth) by 12.6-foot (bottom width) by 1.8 feet high trapezoidal concrete spillway. There is a 36-inch concrete low-level outlet pipe located below the trapezoidal concrete spillway. Flow to the 36-inch outlet pipe is reportedly controlled by two 2.5-foot by 6-foot hand operated gates. A primary spillway located in the right abutment consists of a 90-foot long reinforced concrete sill that discharges to an outlet channel that in turn connects to Nichols Brook. The outlet channel consists of boulders and rock outcrops with trees along it banks. Photographs of the dam and the downstream floodplain are included in Attachment II-B.

Nichols Pond Dam

The dam was reportedly constructed in the 1900's. In 2004, repair work was performed to provide structural stability to a failing right rock buttress wall. In 2009, reconstruction of the dam's low level outlet pipe, concrete spillway and downstream toe was completed. The Vermont Department of Environmental Conservation (DEC) currently classifies the dam as a Class 1, High Hazard Structure.

The dam is an earth, masonry, and reinforced concrete structure. The dam is approximately 230 feet long (including a 30-foot spillway structure) with a height of 20 feet at maximum section and a 25-foot top width. The dam has concrete cutoff walls in each abutment. The spillway, a rectangular concrete broad-crested weir located in the center of the earth embankment, is 30 feet wide by 3.1 feet high at the entrance and transitions to 15 feet wide by 3.4 feet high at the outlet. A 9-foot wide by 0.5-foot high low flow channel is located in the center of the rectangular concrete broad-crested weir. There is a 16.6-foot drop from the outlet of the concrete spillway to the outlet channel. There is an existing 42-inch steel low-level outlet pipe. Flow control to the 42-inch steel pipe is a slide gate of unknown dimension. Photographs of the dam and the downstream floodplain are included in Attachment II-B.

Mackville Pond Dam

The dam was constructed in the 1900's to provide hydroelectric power for the Town. The dam is longer used for hydropower. In 2001, the dam was reconstructed. The Vermont Department of Environmental Conservation (DEC) currently classifies the dam as a Class 1, High Hazard Structure.

The dam is a reinforced concrete structure with masonry granite blocks located on the downstream side. The dam is approximately 80 feet long (including a 50.3-foot spillway structure and 27-foot concrete left abutment) with a height of 14 feet at maximum section and a 6-foot reinforced concrete top width. The dam has concrete cutoff walls in each abutment. The spillway is 50.3 feet in length. The spillway discharges into Nichols Brook. The channel immediately downstream of the dam is ledge. There is an existing intake structure that is used to control the flow of water to the 3-foot steel outlet pipe. Photographs of the dam and the downstream floodplain are included in Attachment II-B.

2.0 METHODS

2.1 Hydrologic Methods

D&K prepared a rainfall-runoff model for the Nichols Brook watershed above Mackville Pond Dam (the most downstream of the three dams) using the HydroCad computer program. The model was used to calculate the volume and timing of flows into East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam during the 100-year, ½ PMF, and full PMF. It was then used to evaluate the hydraulic capacity of the existing dams. The HydroCad model also includes the information on the 2-year, 10-year, 25-year, 50-year, 200-year and 500-year inflow, though the results are not presented in this report.

The HydroCad program uses the SCS (now NRCS) unit hydrograph method to compute stormwater runoff from a watershed. The method determines runoff discharge rates for a given drainage area over a specified duration of time. The parameters required for this method include the drainage areas, rainfall depth, times of concentration, curve numbers, and dimensions of structures such as dams.

The major inputs for the hydrologic are summarized below. Additional details are included with the attached HydroCad input and output files (Attachment I-A).

<u>Drainage Areas</u>. The drainage areas of the thee ponds were delineated on a digitized 1:24000 USGS topographic map with 6-meter contours using the USGS Streamstats program. A map showing the watersheds is included in Attachment I-B.

- East Long Pond Dam drainage area is 3.6 square miles
- Nichols Pond Dam drainage area is 4.7 square miles
- Mackville Pond Dam drainage area is 10.7 square miles

<u>Times of Concentration</u>. The times of concentration for the dams and their contributing watershed were determined by summing the travel time for sheet flow, shallow concentrated flow, and channel flow along the flow path from the most hydrological distant point within the watershed.

<u>Rainfall</u>. Rainfall values used for the 2-year to the 500-year storms were obtained from the Northeast Regional Climate Center web page for Extremes Precipitation Estimates for Northeastern United States. The total 24-hour precipitation for the 100-year event is 5.33 inches. The NRCS Type II rainfall distribution was used for the 100-year, 24-hour storm.

A center-weighted 24-hour storm distribution based on precipitation values obtained from the National Oceanic and Atmospheric Administration (NOAA) Hydrometeorological Reports No. 51 and No. 52 was used for the ½ and full PMF storms. The full PMP 24-hour precipitation for the Nichols Brook watershed is 27 inches, and the ½ PMP 24-hour precipitation is 13.5 inches. Precipitation documentation is included in Attachment I-C.

<u>Land Cover, Soils, and Curve Numbers</u>. The curve numbers were determined using standard NRCS reference values based on land cover, hydrologic soil group, and professional judgment. Land cover was based on observations during a Spring 2012 site visit and interpretation of the 2009 aerial photography (National Agricultural Imagery Program). The hydrologic soil groups (HSG) for each subwatershed were based on NRCS digital maps. NRCS soils documentation is included in Attachment I-C. A map of the hydrologic soil groups in the watershed and a table summarizing the distribution is included in Attachment I-C.

The land cover for the East Long Pond Dam watershed is approximately 87% forested, 1% meadow, 2% quarry yard, and 10% water. The HSG for this watershed is comprised of approximately 52% relatively well-drained HSG A and B soils, 31% C soils, and the remaining 17% D soils and water.

The land cover for the Nichols Pond Dam watershed is approximately 84% forested, 2% meadows or wood grass combination, 1% quarry yard, and 13% water. The HSG for this watershed is comprised of approximately 54% relatively well-drained HSG A and B soils, 27% C soils, and the remaining 19% D soils and water.

The land cover for the Mackville Pond Dam watershed is approximately 87% forested, 6% meadows or wood grass combination, 0.5% quarry yard, 0.5% roads, and 6% water. The HSG for this watershed is comprised of approximately 40% relatively well-drained HSG A and B soils, 38% C soils, and the remaining 22% D soils and water.

Dam and Pond Dimensions. Plans of the dams were used to determine dam dimensions and are included in Attachment II-A. The East Long Pond Dam plans were obtained from the 1980 Corps of Engineers Phase I Inspection Report. The Nichols Pond Dam dimensions were obtained from the record plans dated 2009. The Mackville Pond Dam dimensions were obtained from the design plans dated 2000. The spillway dimensions were field checked in May 2012. All dam plans were converted to NGVD29 feet vertical datum. The HydroCad model is in the NGVD29 vertical datum.

The stage-surface area data at each dam was based on surface area measurements made using the Cabot, VT, USGS topographic map dated provision edition 1986 with 6-meter contour intervals. The surface area of the lake was then checked using the 2009 aerial photography (National Agricultural Imagery Program). A table summarizing the stage-surface area data is included in the HydroCad input and output files in Attachment I-A.

2.2 Hydrologic Results

The results of the hydrologic analysis are summarized in Table 1. The results are presented for the 100-year rainfall event, the ½ PMF event, and the full PMF. Note that the model was run assuming antecedent moisture condition level 2, which is standard for determining spillway capacity. Detailed HydroCad input and output are included in Attachment I-A.

Table 1. Summary of Computed Inflow to Dams

Event	24-hour Rainfall Depth (in)	Peak Inflow to Dam (cfs)	Unit Discharge (cfs/sq mi)
East Long Pond Dam			
100-year	5.33	1313	366
½ PMF	13.5	6982	1945
Full PMF	27.0	16840	4691
Nichols Pond Dam			
100-year	5.33	539	114
½ PMF	13.5	4489	951
Full PMF	27.0	15764	3340
Mackville Pond Dam			
100-year	5.33	768	72
½ PMF	13.5	5605	522
Full PMF	27.0	17507	1632

The calculated 100-year peak runoff was compared to 100-year flow at 138 stream gages in the Northeast as reported by the USGS. The ½ and full PMF were compared to PMFs previously computed by the U.S. Army Corps of Engineers for flood control dams in the region that they operate. A graph of the results is included in Attachment I-A.

The East Long Pond Dam predicted 100-year runoff is above the best-fit lines through the data for the 100-year discharge developed by the USGS. This is to be expected given the steep slopes and the high percentage of C and D-soils in the contributing watershed. The fact that the computed value is significantly above the USGS best-fit line indicates that the results are likely conservative. The computed PMF is in line with PMFs for Corps dams in the region. At Nichols Pond Dam and Mackville Pond Dam the predicted 100-year runoff is less than the best-fit line showing the attenuation affects of the upstream storage at the upstream dams.

2.3 Hydraulic Results

The results of the hydraulic analysis are summarized in Table 2. HydroCad model printouts are included in Attachment I-A. Table 2 presents the results for the existing spillway configurations at the three dams.

Table 2. Dam Hydraulic Results

Condition	Storm Event	Top of Dam Elev. NGVD29(ft)	Normal Pool Elev. NGVD29(ft)	Inflow (cfs)	Outflow (cfs)	Peak WSEL NGVD29(ft)	Freeboard (ft)
East Long Pond Dam	Primary 90-ft trapezoidal spillway controlled by a concrete sill, crest el. 1202.8 ft. and an auxiliary trapezoidal spillway 14.5-foot topwidth x 12.6-foot bottom width, crest el. 1203.6 ft						
	Q100	1204.8	1202.8	1313	288	1203.9	0.9
	½ PMF	1204.8	1202.8	6982	3391	1206.8	-2.0
	Full PMF	1204.8	1202.8	16840	12009	1209.8	-5.0
Nichols Pond Dam	Rectangular concrete broad-crested weir, 30-foot wide by 3.1 feet high at the entrance and transitions to 15-foot wide by 3.4 feet high at the outlet. A 9-foot wide by 0.5-foot high low flow channel is located in the center of the rectangular concrete broad-crested weir. (crest el. 1128.6 ft)						
	Q100	1131.7	1128.6	539	117	1130.4	1.3
	½ PMF	1131.7	1128.6	4489	2210	1134.0	-2.3
	Full PMF	1131.7	1128.6	15764	8936	1139.3	-7.6
Mackville Pond Dam	50.3-foot spillway, crest el. 924.7 ft. (Assumes flow by-passes the dam and flows down Mackville Road at el. +/- 929.7 ft)						
	Q100	928.3	924.7	768	759	927.5	0.8
	½ PMF	928.3	924.7	5605	5591	932.0	-3.7
	Full PMF	928.3	924.7	17507	17449	937.0	-8.7

2.4 Overview of Breach Conditions

Both sunny-day and storm-day hypothetical dam failures were evaluated. Each is described in the following sections.

2.4.1 Sunny-Day Failure

A sunny-day failure refers to a failure under normal water level conditions associated with fair weather or non-flood conditions. It often results from piping, which is the progressive internal erosion of a soil mass such as an embankment, foundation, or abutment of a dam from uncontrolled seepage carrying soil particles to an unprotected exit that over time creates an erosion cavity or "pipe". Once this happens, a rapid failure of the dam can occur that releases the contents of the reservoir and forms the breach discharge. Piping is the most common cause of sunny-day failures of earth dams and other dams that are constructed on earth foundations or abutments. A sunny-day failure can also result from other causes, such as a sudden failure of a conduit under pressure or a structural component of the dam.

2.4.2 Storm-Day Failure

A storm-day failure is associated with major storm events and floods. During periods of significant rainfall and resulting runoff, the reservoir will rise to relatively high levels. If the storm is severe enough, and the inflow exceeds the hydraulic capacity of the spillway and reservoir storage capacity, overtopping of the embankment can occur. As floodwaters flow over the dam, the erosion of the earth embankment or abutments can occur resulting in a failure of the dam and the formation of the breach discharge as the contents of the reservoir are released. Other dam failure modes such as piping, sudden structural failure, or progressive failure of stone or masonry elements can be a result of high reservoir levels associated with the storm-day type failures.

2.5 Breach Analysis

2.5.1 Overview

Analysis of the hypothetical breach of the dams was conducted using U.S. Army Corps of Engineers HEC-RAS computer model (Version 4.1.0). Input for the HEC-RAS computer model includes a description of the breach geometry and anticipated duration of the breach formation. As the breach develops the breach discharge increases.

For this breach analysis it was first assumed that East Long Pond Dam fails, with subsequent at Nichols Pond Dam then again at Mackville Pond Dam as each downstream dam reaches its maximum water level from the upstream breach flood wave.

2.5.2 Breach Parameters

Breach parameters include the time of formation, size, and shape of the breach. For this evaluation they were based on the Federal Energy Regulatory Commission (FERC) Engineering Guidelines for the Evaluation of Hydropower Projects, Chapter 2, dated October 1993. Total outflow is a combination of flows through the breach and spillway.

All three dams evaluated for this breach analysis are constructed of earth, masonry work and concrete. An average breach width of approximately three times the height of the dam was used at each dam, which is toward the larger range of the recommended width of one to five times the dam height for earthen dams. A breach formation time of 1.0 hour was used for East Long Pond Dam. A breach formation time of 0.5 hour was used for Nichols Pond Dam and Mackville Pond Dam. These values fall within the range of 0.1 to 1.0 hours recommended by FERC for an engineered embankment. These values were developed in consultation with DEC at the start of the project. Additional breach parameter details are provided in Attachment II-C.

2.6 Flood Routing Analysis

2.6.1 Overview

Analysis of downstream flooding resulting from the hypothetical dam breach was also analyzed with the HEC-RAS model. The model was used to route the breach wave through the downstream Nichols Brook, Cooper Brook, and Lamoille River floodplains.

The model was run in the unsteady mode, which employs the dynamic wave method to route the flood wave through the downstream impoundments and valley. Input for the model includes the geometry of three impoundments, geometry of the dams, geometry of the downstream stream valley at selected locations, and hydraulic roughness coefficients for the channel and overbanks.

Two separate HEC-RAS models were used to model the system of ponds and channels. The three dams, Nichols Brook floodplain, and Cooper Brook floodplain were modeled as one HEC-RAS model (Nichols/Cooper Brook model). The Lamoille River was modeled with a second HEC-RAS model. The dam-breach hydrograph at the downstream end of the Nichols/Cooper Brook model was entered into the HEC-RAS model of the Lamoille River at the appropriate location.

2.6.2 Model Extent and Cross Section Locations

The Nichols/Cooper Brook model extent includes 6.4 miles starting approximately 1.1 miles upstream of the East Long Pond Dam and ending at the confluence with Lamoille River. The model includes 1.2 miles of Cooper Brook and 5.2 miles of Nichols Brook. The Lamoille River model extent includes 0.4 miles upstream of the confluence with the Cooper Brook to 2.3 miles downstream of Cooper Brook, corresponding to the location approximately 700 feet downstream of McAllister Farm Road. River Stations (RS) are used to describe cross section locations along the river system.

Cross section locations are shown on the maps in Attachment II-A. The locations were selected based on the topography of the stream valley, the presence of features such as road crossings that have significant potential to affect the flood wave, and the presence of structures such as houses. Existing site plans and sections of East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam are included in Attachment II-A.

2.6.3 Valley and Structure Geometry – Nichols/Cooper Brook Model

The geometry of the river valley and the structures were obtained from a variety of different sources. The base geometry of the East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam impoundments and the valley cross sections for the Nichols Brook and Cooper Brook were developed from 30-meter USGS digital elevation models (DEM) and were manually modified to improve the representation of the floodplain. The manual modifications used are listed below:

- The DEM-based cross sections were modified as needed to incorporate a defined stream channel based on bankfull dimensions developed from the Vermont Regional Hydraulic Geometry Curves, and field observations.
- The DEM-based cross sections at East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam were modified using the site plans included in Attachment II-A.
- The DEM-based cross sections from RS 100 to RS 9121 were modified using the HEC-2 data obtained from the FEMA Engineering Library.
- The DEM-based cross sections located within the dam impoundments were modified based on available bathometry data.

Eight channel crossing structures on Nichols and Cooper Brook (five bridges and three dams) were inspected as part of this study.

All the data for the Nichols/Cooper Brook HEC-RAS model was tied to the NAD 83 horizontal datum and the NGVD 29 vertical datum. Manning's “n” roughness values were assigned to the channel and overbanks on the basis of field observation and standard references.

It is important to note that no effort was made to assess the structural adequacy of the structures located downstream of East Long Pond Dam. During a failure of the East Long Pond Dam, Nichols Pond Dam and Mackville Pond Dam; all are assumed to remain intact.

2.6.4 Valley and Structure Geometry – Lamoille River Model

The geometry of the Lamoille River valley and the structures were obtained from FEMA Engineering Library. The Library provided a copy of the HEC-2 data of Lamoille River from the 2002 Flood Insurance Study for Town and Village of Hardwick. The HEC-2 data provided the base geometry of the Lamoille River valley cross sections. DuBois & King, Inc. converted the HEC-2 data to the HEC-RAS model format.

In the conversion of the HEC-2 data to the HEC-RAS format, all five structures (four bridges and one dam) required some modifications. This is not uncommon in the conversion process. A number of the cross sections required the section be extended vertically utilizing the slope of the land as depicted in the section. No effort was made to assess the structural adequacy of the river crossings located downstream of the dams; during failure of the dams, all crossing structures are assumed to remain intact.

The data for the Lamoille River HEC-RAS model was tied to the NGVD 29 vertical datum. Manning's "n" roughness values were assigned to the channel and overbanks on the basis of field observation and standard references.

2.6.5 Pre-Breach Downstream Flow Conditions

Pre-breach flow (antecedent) conditions upstream and downstream of the dams were coded into HEC-RAS for both sunny-day and storm-day breach events. Additional detail about the flows and locations of input is presented in Attachment II-C.

For sunny-day conditions, baseflows of 1 – 2 cfs per square mile are commonly used to represent typical summer low flow conditions. However, in the Nichols/Cooper Brook model it was necessary to increase the summer base flow to a higher value (2.2 cfs per square mile) at the dam due to computational stability issues within the HEC-RAS model. This increase has no significant impact on the results. The summer flows are added to the sunny-day Nichols/Cooper Brook HEC-RAS model at four locations, RS 6879, RS 14943, RS 25301, and RS 34060 reflecting increased base flow with increased drainage area. The summer flows for the Lamoille River HEC-RAS model are added at two locations, RS 26 and RS 30. The sunny-day dam-breach hydrograph from the Nichols/Cooper model is entered into the Lamoille River model at RS 26.

For storm-day conditions, pre-breach flow was the 100-year storm event. Use of the 100-year flow was established in consultation with DEC at the start of the project. The 100-year inflow hydrographs discussed previously in Section 2.1 were used in the Nichols/Cooper Brook model. The storm-day flows are added to the storm-day Nichols/Cooper Brook HEC-RAS model at five locations, RS 11252, RS 14943, RS 16728, RS 25301 and RS 34060 reflecting increased base flow with increased drainage area. An additional 100-year inflow hydrographs was developed and entered into the Nichols/Cooper model at RS 6879 to represent the inflow from the upper reaches of Cooper Brook at the confluence of Nichols Brook and Cooper Brook. The storm-day dam-breach hydrograph from the Nichols/Cooper model is entered into the Lamoille River model at RS 26.

3.0 RESULTS AND DISCUSSION

Due to the highly unpredictable nature of an actual dam breach and the ensuing sequence of events, the results of this study should not be viewed as exact but as only an approximate quantification of the dam-breach flood potential. For the purposes of analysis, downstream conditions are assumed to remain constant; no allowance is made for possible enlargement or relocation of the river channel due to scour or temporary damming effects, all of which could affect, to some extent, the resulting magnitude and timing of flooding.

3.1 Summary

The bullets below summarize the most significant results of the analysis. Detailed results are included in Attachment II-A (inundation maps), Attachment II-B (annotated photographs), and Attachment II-D (table of results at selected locations).

3.1.1 Sunny-Day Dam Breach

Nichols/Cooper Brook Model

- During a Sunny-Day breach, the peak discharge released from East Long Pond Dam to the downstream channel is 7628 cfs.

- The water surface elevation in the downstream channel increases by five to seven feet due to the breach. The estimated velocity would range from 14 to 20 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water level at Nichols Pond increases by five feet. The dam is overtopped by 2.3 feet. The water level reaches its peak three hours after the East Long Pond Dam breach starts.

- During a Sunny-Day breach, the peak discharge released from Nichols Pond Dam breach to the downstream channel is 14865 cfs.

- The water surface elevation in the channel downstream of Nichols Pond Dam increases by eight to twelve feet due to the breach. The estimated velocity would range from 5 to 22 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water level at Mackville Pond increases by 8.7 feet. The dam is overtopped by 5.3 feet. The water level reaches its peak four hours after the East Long Pond Dam breach starts.

- During a Sunny-Day breach, the peak discharge released from Mackville Pond Dam breach to the downstream channel is 12269 cfs. The flow is reduced by 11% to 10967 cfs by the time it reaches the confluence with the Lamoille River.

- The water surface elevation in the channel downstream of Mackville Pond Dam increases by thirteen to seventeen feet due to the breach. The estimated velocity would range from 3 to 29 feet per sec. At the higher velocities channel erosion and debris can be expected.

- Multiple structures located on Nichols and Cooper Brooks (as shown on Attachment II-A (inundation maps) and Table D-4 Attachment II-D), are impacted by the sunny-day breach.

Lamoille River Model

- During a Sunny-Day breach, the peak discharge released from East Long Pond Dam failure with subsequent failures at Nichols Pond Dam and Mackville Pond Dam releasing dam-breach flows to Nichols and Cooper Brooks results in a peak discharge of 10967 cfs entering the Lamoille River at the confluence of the Cooper Brook and the Lamoille River.

- The water surface elevation in the Lamoille River upstream of the confluence of the Cooper Brook (RS 26 to RS 29) increases by three to nine feet due to the breach. The estimated velocity would range from 3 to 9 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water surface elevation in the Lamoille River downstream of the confluence of the Cooper Brook (RS 20.4 to RS 25) increases by six to ten feet due to the breach. The estimated velocity would range from 3 to 9 feet per second. The water surface elevation in the Lamoille River downstream of the confluence of the Cooper Brook (RS 12 to RS 18) increases by twelve to thirteen feet due to the breach. The estimated velocity would range from 5 to 7 feet per sec. At the higher velocities channel erosion and debris can be expected.

- Multiple structures located on Lamoille River (as shown on Attachment II-A, inundation maps and Table D-4 Attachment II-D), are impacted by the sunny-day breach.

3.1.2 Storm-Day Dam Breach

Nichols/Cooper Brook Model

- During a Storm-Day breach, the peak discharge released from East Long Pond Dam to the downstream channel is 8477 cfs.

- The water surface elevation in the downstream channel increases by five to six feet due to the breach. The estimated velocity would range from 14 to 21 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water level at Nichols Pond increases by four feet. The dam is overtopped by 2.7 feet. The water level reaches its peak three hours after the East Long Pond Dam breach starts.

- During a Storm-Day breach, the peak discharge released from Nichols Pond Dam breach to the downstream channel is 15743 cfs.

- The water surface elevation in the channel downstream of Nichols Pond Dam increases by seven to fourteen feet due to the breach. The estimated velocity would range from 7 to 16 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water level at Mackville Pond increases by 6.2 feet. The dam is overtopped by 5.6 feet. The water level reaches its peak 3.8 hours after the East Long Pond Dam breach starts.

- During a Sunny-Day breach, the peak discharge released from Mackville Pond Dam breach to the downstream channel is 13319 cfs. The flow is reduced by 8% to 12278 cfs by the time it reaches the confluence with the Lamoille River.

- The water surface elevation in the channel downstream of Mackville Pond Dam increases by five to thirteen feet due to the breach. The estimated velocity would range from 3 to 30 feet per sec. At the higher velocities channel erosion and debris can be expected.

- Multiple structures located on the Lamoille River (as shown on Attachment II-A, inundation maps and Table D-4 Attachment II-D), are impacted by the sunny-day breach.

<u>Lamoille River Model</u>

- During a Storm-Day breach, the peak discharge released from East Long Pond Dam failure with subsequent failures at Nichols Pond Dam and Mackville Pond Dam releasing dam-breach flows to Nichols and Cooper Brooks results in a peak discharge of 12278 cfs entering the Lamoille River at the confluence of the Cooper Brook and the Lamoille River.

- The water surface elevation in the Lamoille River upstream of the confluence of the Cooper Brook (RS 26 to RS 28) increases by one to three feet due to the breach. The estimated velocity would range from 5 to 10 feet per sec. At the higher velocities channel erosion and debris can be expected.

- The water surface elevation in the Lamoille River downstream of the confluence of the Cooper Brook (RS 20.4 to RS 25) increases by one to three feet due to the breach. The estimated velocity would range from 5 to 9 feet per sec. The water surface elevation in the Lamoille River downstream of the confluence of the Cooper Brook (RS 12 to RS 18) increases by four feet due to the breach. The estimated velocity would range from 5 to 8 feet per sec. At the higher velocities channel erosion and debris can be expected.

- Multiple structures located on Lamoille River (as shown on Attachment II-A, inundation maps and Table D-4 Attachment II-D), are impacted by the sunny-day breach.

3.2 Implications for Hazard Classification

The DEC classifies dams following the U.S. Army Corps of Engineers classification guidelines (ER1110-2-106), which is based on the potential for loss of life and property downstream of the dam were the dam to fail. Table 3 summarizes the classification system.

Table 3. Summary of Hazard Classification System

Class	Hazard Category	Potential Loss of Life	Potential Economic Loss
3	Low	None Expected (no permanent structures for human habitation)	Minimal (undeveloped to occasional structures or agriculture)
2	Significant	Few (no urban developments and no more than a small number of inhabitable structures)	Appreciable (notable agriculture, industry, or structures)
1	High	More than a few	Excessive (extensive community, industry, or agriculture)

The East Long Pond Dam, Nichols Pond Dam, and Mackville Pond Dam are currently classified as a Class 1 High Hazard structures. The technical basis for that classification is not known.

Based on the results of the breach analysis—specifically the overtopping of multiple local roads during sunny-day and storm-day breaches and the inundation of multiple residential and commercial structures the appropriate hazard classification for the dams is indeed **Class 1 High Hazard**. It is possible that a more detailed breach analysis of the individual dams, as opposed to the assumption of serial breaches used in this analysis, would justify something less than a High Hazard classification. In the absence of such an analysis, it is prudent to consider each High Hazard.

Basic EAP Data

Purpose

The purpose of this EAP is to reduce the risk of human life loss and injury and minimize property damage during an unusual or emergency event at Nichols Pond Dam, located in Washington County, Woodbury, Vermont.

Potential Impacted Area

See the *Inundation Maps* (Appendix B–4) and *Residents/Businesses/Roads* tab (Appendix B–5) for the locations and contact information of residents and roads that may be flooded if the dam should fail and the estimated time for the flood wave to travel from the dam to these locations. A dam breach (triggered by a breach of East Long Pond Dam upstream and or subsequent breaches of a downstream dam) may impact over 200 properties, 20 roads, and two downstream dams (Mackville Pond Dam and Hardwick Lake Dam) in the downstream area of Nichols Pond Dam along Nichols Brook, Cooper Brook, and the Lamoille River.

Nichols Pond Dam is the middle dam of three high hazard dams in series, including East Long Pond Dam located upstream approximately 1 mile in Woodbury and Mackville Pond Dam, which is located approximately 2 miles downstream in Hardwick. A failure of East Long Pond Dam could trigger a failure of Nichols Pond Dam. Similarly, a failure of Nichols Pond Dam could trigger a failure of Mackville Pond Dam, increasing flooding, damage downstream, and risk to people and property. Hardwick Lake Dam, a low hazard dam is also located in the downstream floodway along the Lamoille River to the west of Hardwick.

Accordingly, the potential impacted area includes areas of Woodbury as well as portions of the Town of Hardwick, Caledonia County, Vermont.

Dam Description

Height: 18 ft.
Built: 1900
Legal Description: Not available
Latitude: 44.4626   Longitude: -72.3446
National Inventory of Dams No.: VT00184

Drainage Area: 4.56 mi.^{2}
Hazard Classification: HIGH
Dam Operator: Hardwick Electric Department
Major Property Owner: Hardwick Electric Dept.
Dam Designer: Unknown/Dubois & King, Inc.

See the Dam Data in *Appendix B* for more information.

Directions to dam (See *Location*; Appendix B–2.)

The following directions are provided from the Hardwick Electric Department headquarters at 123 North Main Street, Hardwick, VT. The dam is located in a rural area of Woodbury accessed using gravel roads. The access roads to the dam are seasonally maintained. During certain times of the year and weather conditions, four wheel drive vehicles, all-terrain vehicles, or in the winter months, snow mobiles may be required to access the dam.

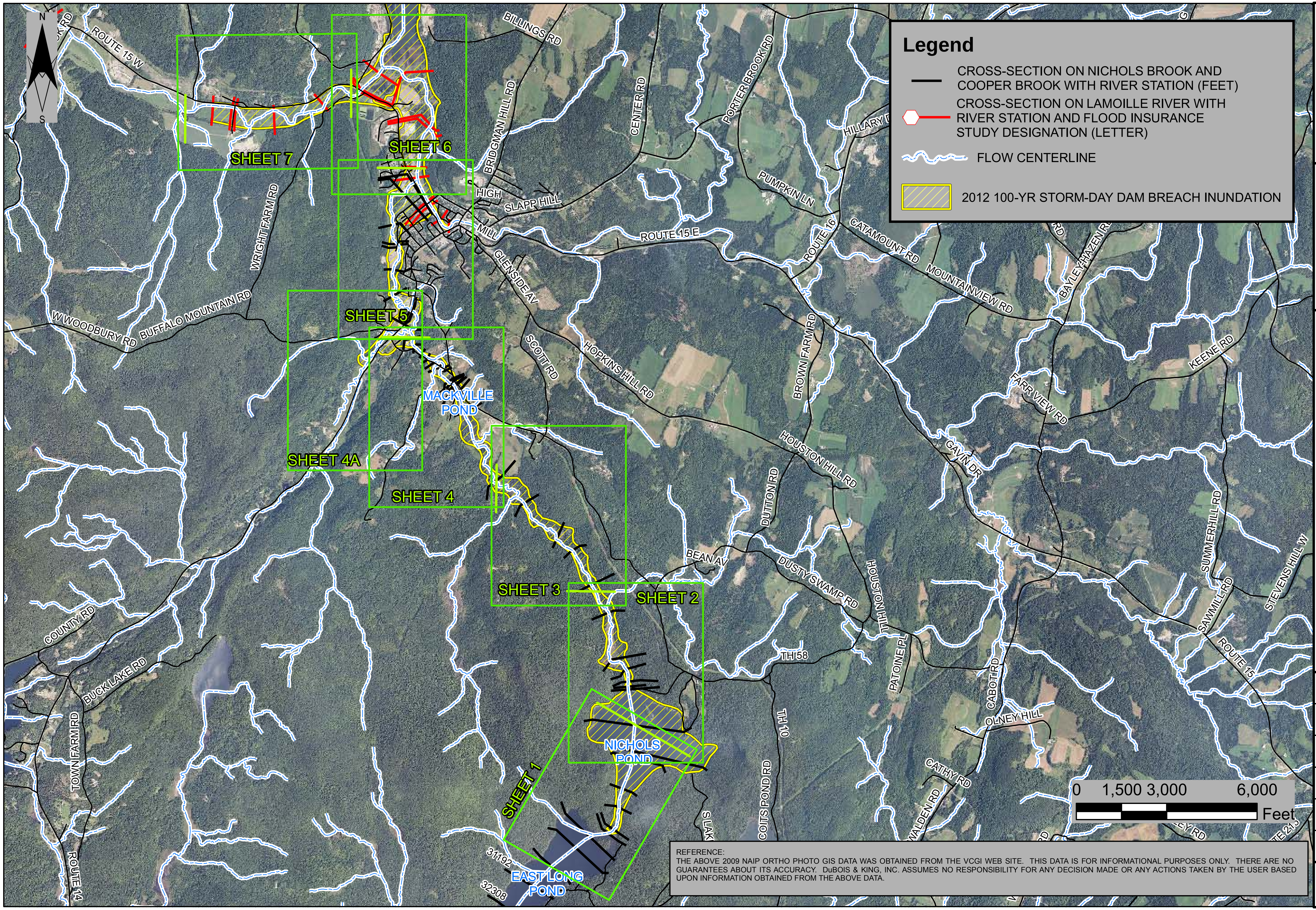
<u>FASTEST ROUTE (Approximately 4 miles and 12 minutes)</u>

- Head southwest on North Main Street toward Church Street for 0.1 miles
- Turn right onto VT 15 East for 0.1 miles.
- Turn right onto Glenside Avenue for 0.6 miles
- Turn right onto Scott Road for 0.8 miles.
- Turn left onto Nichols Pond Road for 1.9 miles.
- Turn right onto Nichols Dam Road for approximately 0.3 miles. You will arrive at the right abutment of the dam.

ALT. ROUTE DUE TO POSSIBLE FLOODING (Approx. 6 miles and 15 minutes)

- Head southwest on North Main Street toward Church Street for 0.1 miles
- Turn right onto VT 15 East for 2.6 miles.
- Turn right onto Brown Farm Road for 0.9 miles.
- Turn right onto Houston Hill Road for approximately 100 feet.
- Turn left onto Dutton Road for 0.7 miles.
- Turn right onto Dutton Road/Town Road 45 for 0.7 miles.
- Turn left onto Nichols Pond Road for 0.6 miles.
- Turn right onto Nichols Dam Road for approximately 0.3 miles. You will arrive at the right abutment of the dam.

Appendix B–4
Inundation Maps



REFERENCE:
THE ABOVE 2009 NAIP ORTHO PHOTO GIS DATA WAS OBTAINED FROM THE VCGI WEB SITE. THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. DuBOIS & KING, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

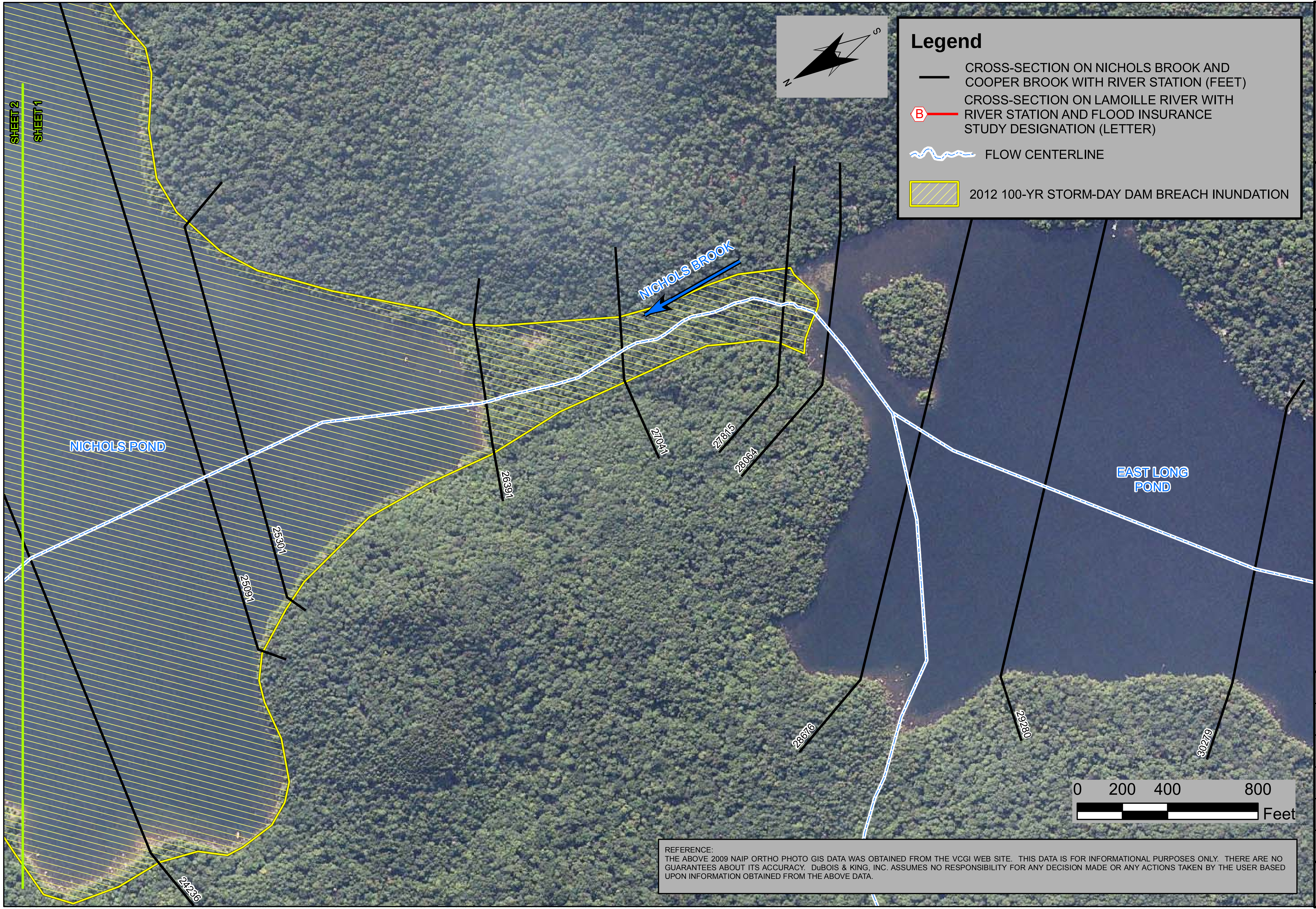
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	INDX



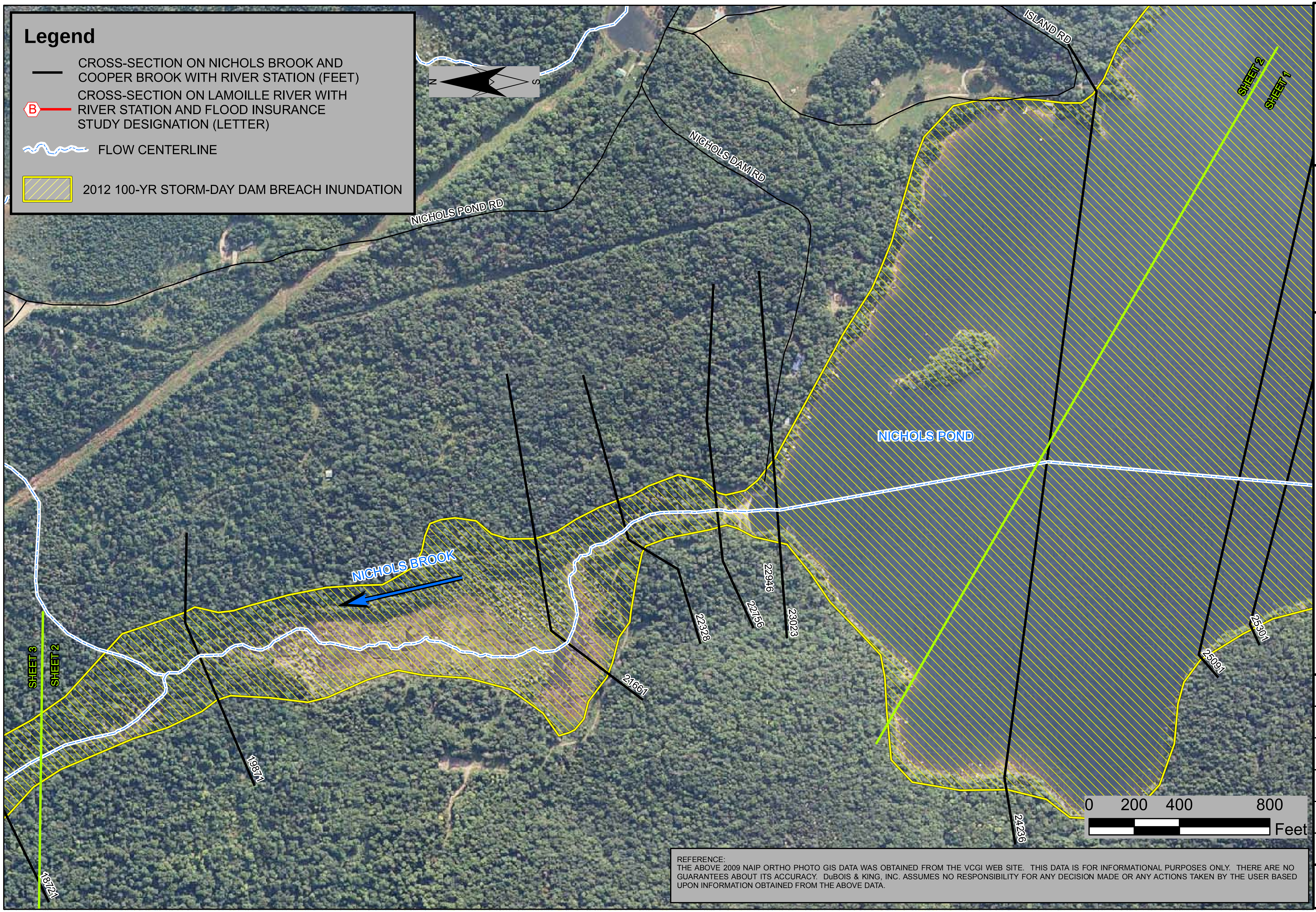
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	1 OF 7



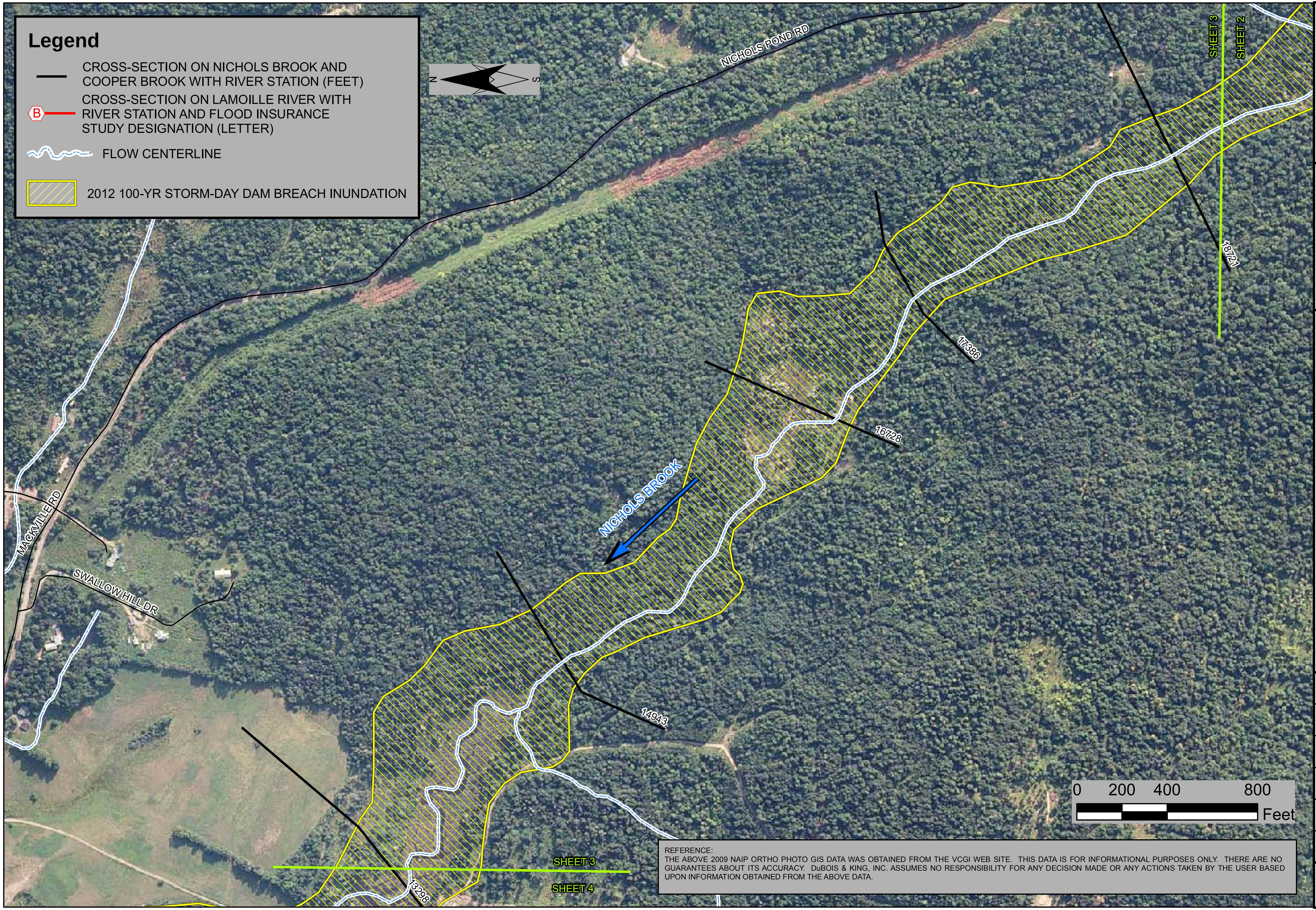
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS
INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	2 OF 7

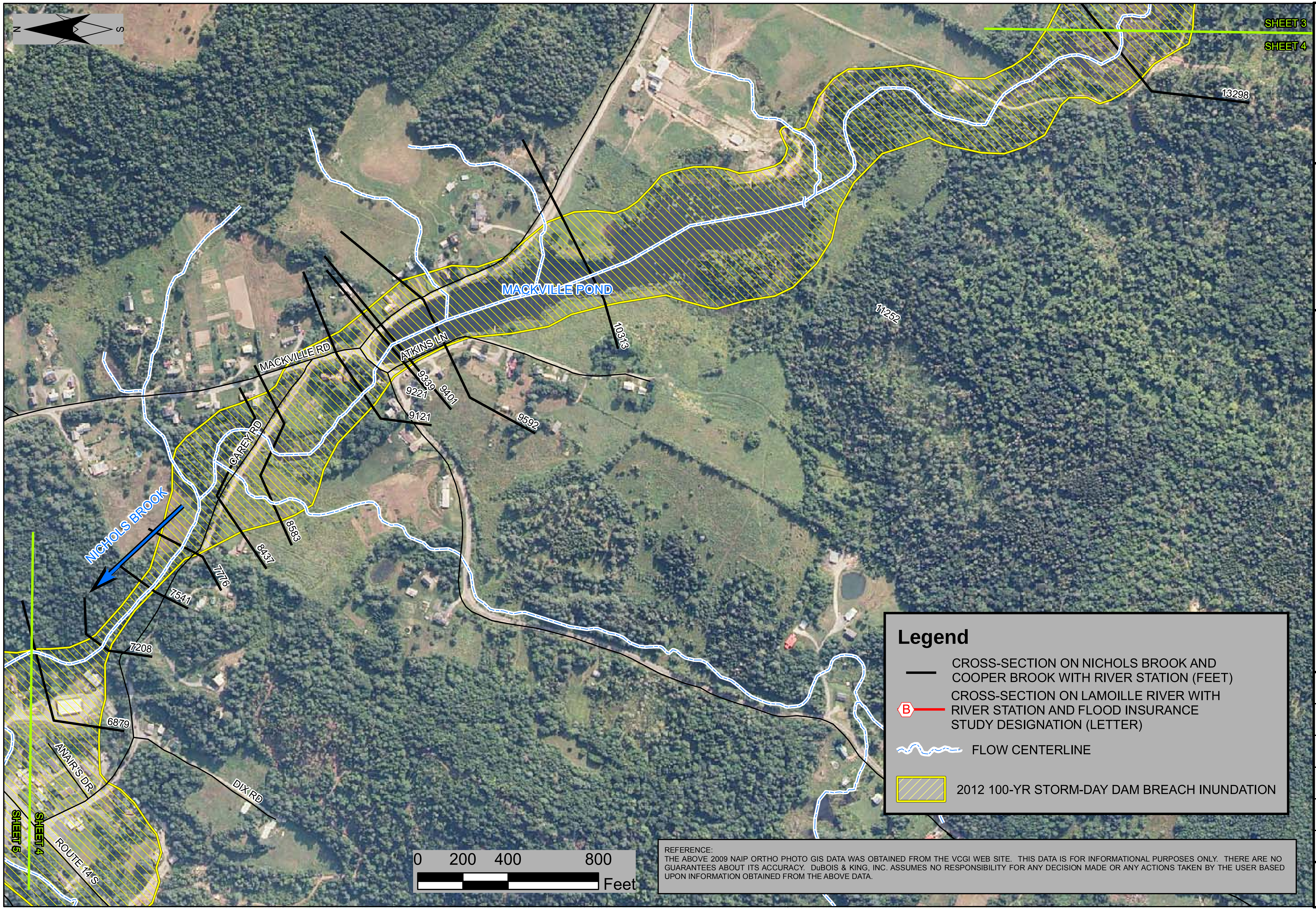


CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS
INUNDATION MAP
MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	**3 OF 7**



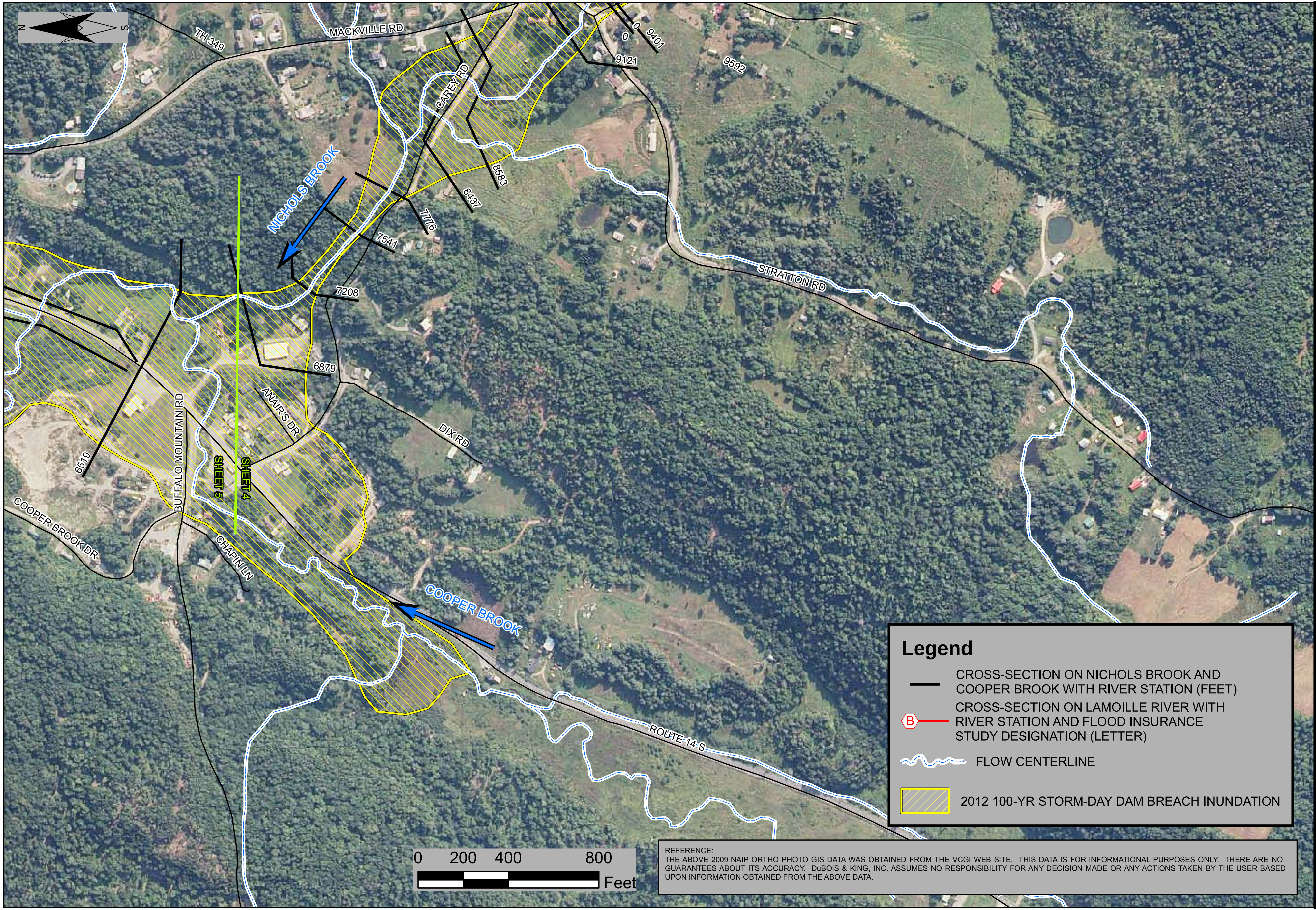
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY: CJK
APPROVED BY:
DRAWN BY: ZDC
CHECKED BY: CJK
PROJECT NO: 120832
DATE: 08/31/12
SHEET NO: 4 OF 7



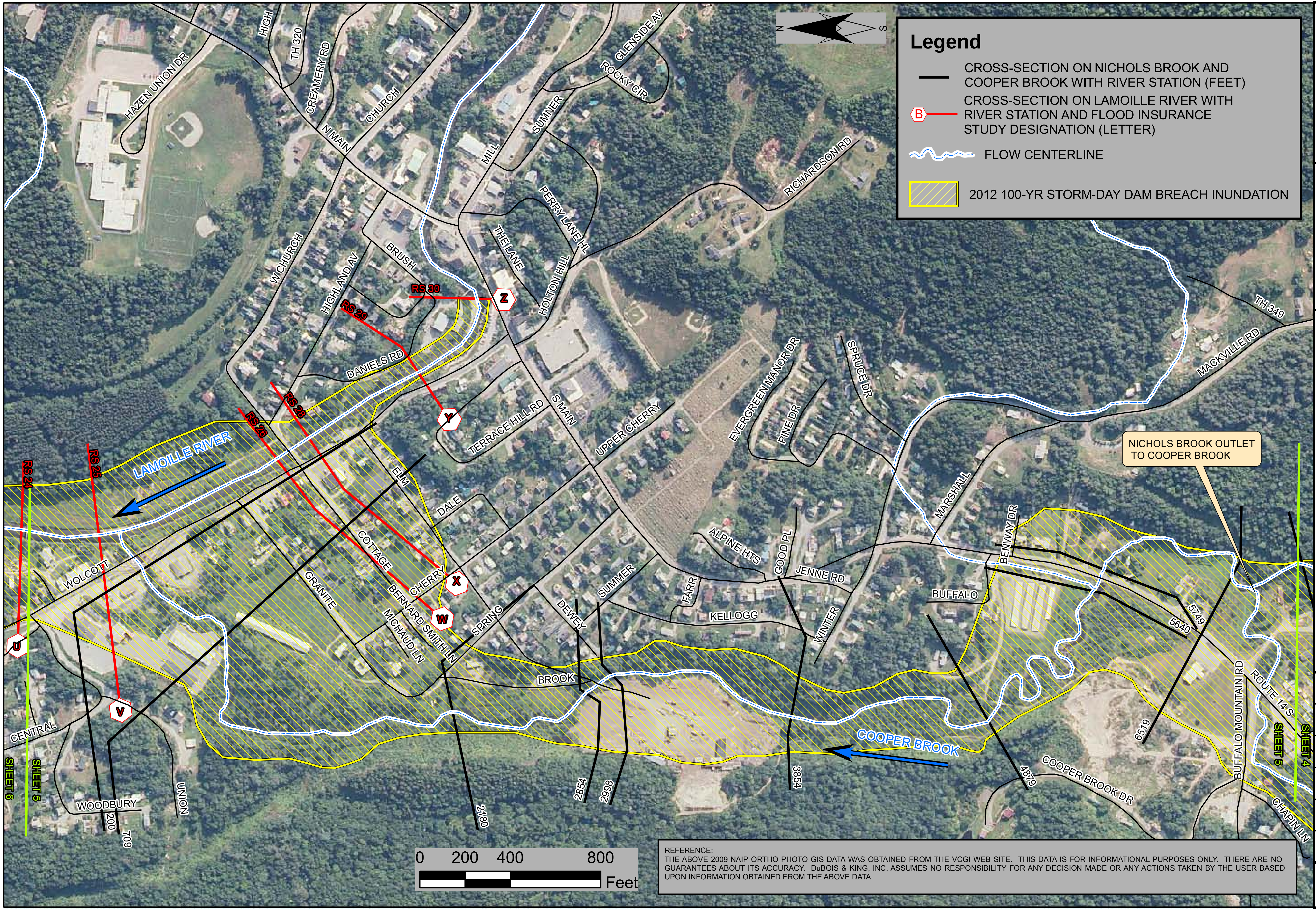
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS
INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	4A OF 7



CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY: CJK

APPROVED BY:

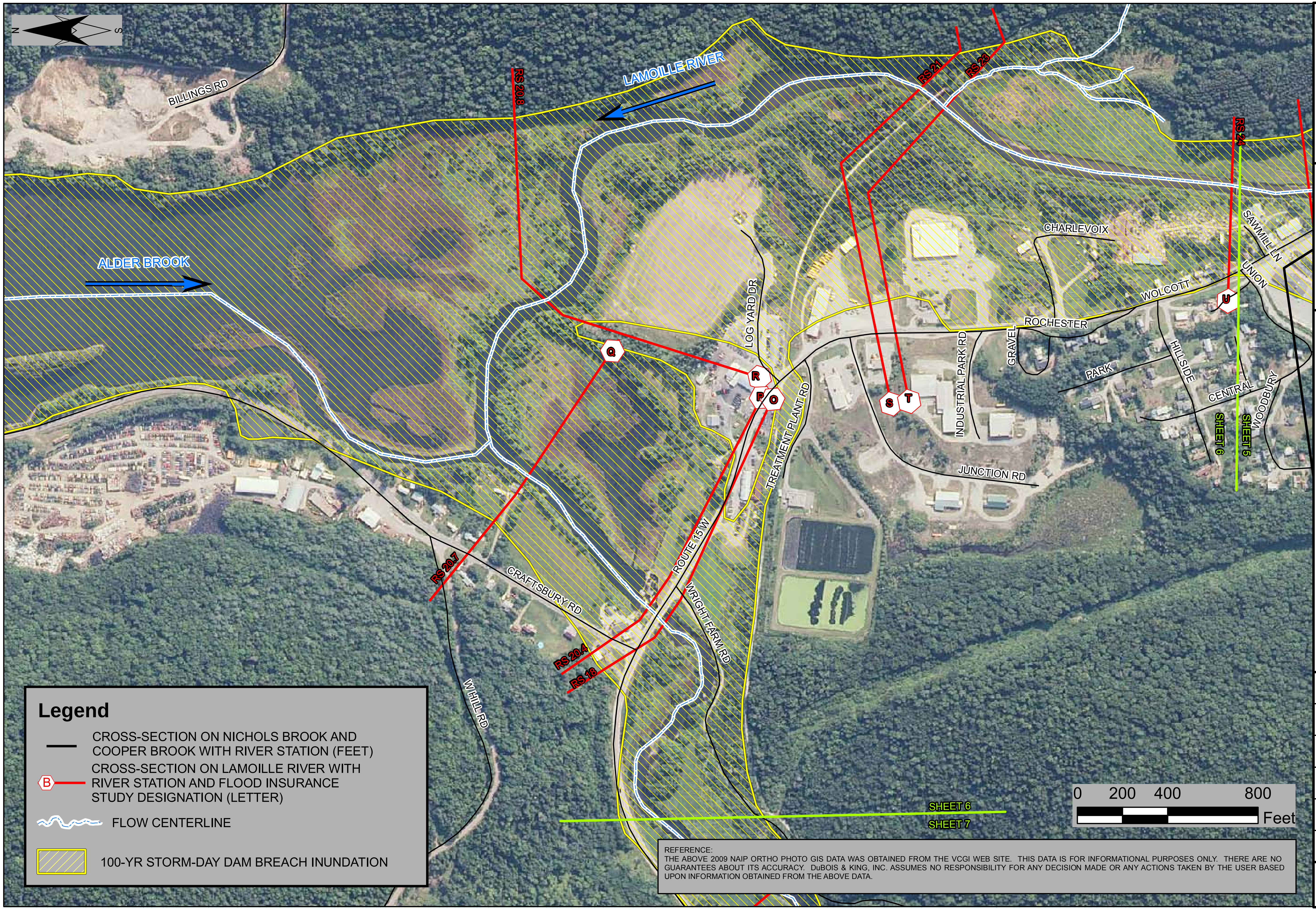
DRAWN BY: ZDC

CHECKED BY: CJK

PROJECT NO: 120832

DATE: 08/31/12

SHEET NO: **5 OF 7**



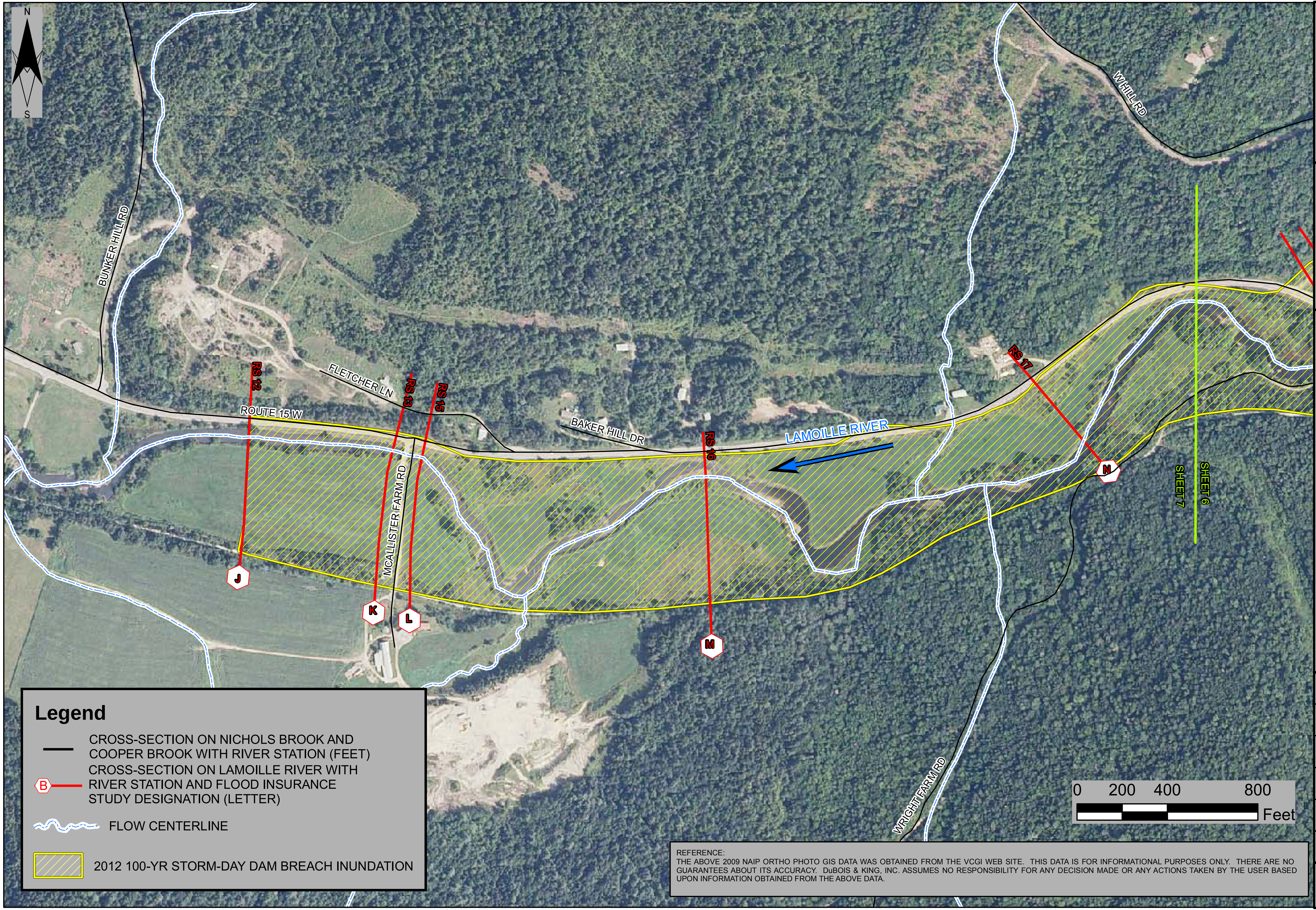
CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY: CJK
APPROVED BY:
DRAWN BY: ZDC
CHECKED BY: CJK
PROJECT NO: 120832
DATE: 08/31/12



Legend

- CROSS-SECTION ON NICHOLS BROOK AND COOPER BROOK WITH RIVER STATION (FEET)
- (B) CROSS-SECTION ON LAMOILLE RIVER WITH RIVER STATION AND FLOOD INSURANCE STUDY DESIGNATION (LETTER)
- FLOW CENTERLINE
- 2012 100-YR STORM-DAY DAM BREACH INUNDATION

REFERENCE:
THE ABOVE 2009 NAIP ORTHO PHOTO GIS DATA WAS OBTAINED FROM THE VCGI WEB SITE. THIS DATA IS FOR INFORMATIONAL PURPOSES ONLY. THERE ARE NO GUARANTEES ABOUT ITS ACCURACY. DuBOIS & KING, INC. ASSUMES NO RESPONSIBILITY FOR ANY DECISION MADE OR ANY ACTIONS TAKEN BY THE USER BASED UPON INFORMATION OBTAINED FROM THE ABOVE DATA.

CLIENT:
VTDEC - DAM SAFETY
FACILITIES ENG. DIV.
103 SOUTH MAIN ST.
WATERBURY, VT 05671

DuBois & King inc.
ENGINEERING • PLANNING
MANAGEMENT • DEVELOPMENT

DAM BREACH FLOOD ANALYSIS INUNDATION MAP

MACKVILLE POND, NICHOLS POND AND EAST LONG POND DAMS
TOWNS OF HARDWICK AND WOODBURY, VERMONT
CALEDONIA AND WASHINGTON COUNTY

DESIGNED BY:	CJK
APPROVED BY:	
DRAWN BY:	ZDC
CHECKED BY:	CJK
PROJECT NO:	120832
DATE:	08/31/12
SHEET NO:	7 OF 7

Appendix B–5
Residents/Businesses/Roads at Risk

A major flood caused by a sudden breach of the dam could cause subsequent failure of Mackville Pond Dam that could greatly increase flooding. Flooding caused by failure of the dam (or dams) is estimated to inundate or cut off approximately 200 properties (homes, businesses, and out buildings) downstream of Nichols Pond Dam with others at high risk for damage and/or in the immediate vicinity of the predicted flood extents. It should be noted that additional properties may not be directly inundated, but will be near the estimated flood limits and may become isolated as a result of flood and dam breach flows. In the event that East Long Pond Dam located upstream of Nichols Pond Dam were to fail, it may trigger a failure of Nichols Pond Dam and could also cause flooding of properties around Nichols Pond.

The following list of properties could be impacted by a breach of the dam (or dams) and was compiled by Weston & Sampson following a review of the existing inundation maps and comparison with the Vermont Agency of Natural Resources (VT ANR) Atlas database and the E911 Buildings/Address Layer. ESITEIDs are consistent with the State of Vermont's GIS database "E911 Sites" to facilitate emergency response. Weston & Sampson makes no guarantee about the accuracy of the information. Names, addresses, and telephone numbers should be compiled and reviewed yearly by the Dam Owner and or the Incident Commander.

Refer to tables D-1, D-2, and D-3, below, taken from the 2012 Breach Analyses Report by Dubois & King for information regarding estimated flooding depths and timing at select downstream locations.

Nichols Pond Dam to Mackville Pond Dam

No.	Site ID	Address	Type	Town	Location
1	301477	1580 Nichols Pond Rd	Camp	Woodbury	East of Nichols Brook
2	301475	1581 Nichols Pond Rd	Camp	Woodbury	East of Nichols Brook
3	446960	1002 Nichols Pond Rd	Home	Hardwick	Northeast of Nichols Brook
4	119828	952 Mackville Rd	Public Gathering	Hardwick	East of Mackville Pond
5	119838	230 Atkins Ln	Home	Hardwick	West of Mackville Pond
6	119891	156 Atkins Ln	Home	Hardwick	West of Mackville Pond
7	119823	116 Atkins Ln	Home	Hardwick	West of Mackville Pond
8	119822	184 Atkins Ln	Camp	Hardwick	West of Mackville Pond
9	119821	66 Atkins Ln	Home	Hardwick	West of Mackville Pond
10	119816	20 Atkins Ln	Home	Hardwick	West of Mackville Pond
11	119818	849 Mackville Rd	Home	Hardwick	East of Mackville Pond
12	119813	813 Mackville Rd	Home	Hardwick	East of Mackville Pond
13	119810	787 Mackville Rd	Home	Hardwick	East of Mackville Pond
14	119806	755 Mackville Rd	Home	Hardwick	East of Mackville Pond
15	119815	63 Stratton Rd	Home	Hardwick	West of Mackville Pond
16	119812	64 Stratton Rd	Home	Hardwick	West of Mackville Pond

Mackville Pond Dam to Termination of Inundation Maps

No.	Site ID	Address	Type	Town	Location
17	119805	736 Mackville Rd	Home	Hardwick	North of Mackville Pond
18	119799	661 Mackville Rd	Home	Hardwick	North of Mackville Pond
19	119794	652 Mackville Rd	Mobile Home	Hardwick	North of Mackville Pond
20	119793	629 Mackville Rd	Home	Hardwick	North of Mackville Pond
21	119951	616 Mackville Rd	Mobile Home	Hardwick	North of Mackville Pond
22	119788	613 Mackville Rd	Home	Hardwick	North of Mackville Pond
23	119787	582 Mackville Rd	Home	Hardwick	North of Mackville Pond
24	119779	553 Mackville Rd	Home	Hardwick	North of Mackville Pond
25	119772	482 Mackville Rd	Home	Hardwick	North of Mackville Pond
26	119792	387 Carey Rd	Mobile Home	Hardwick	Northwest of Mackville Pond
27	119791	302 Carey Rd	Mobile Home	Hardwick	Northwest of Mackville Pond
28	119789	244 Carey Rd	Home	Hardwick	Northwest of Mackville Pond
29	119781	216 Carey Rd	Mobile Home	Hardwick	Northwest of Mackville Pond
30	120060	42 Carey Rd	Mobile Home	Hardwick	Northwest of Mackville Pond
31	119775	72 Carey Rd	Home	Hardwick	Northwest of Mackville Pond
32	119784	415 VT Route 14S	Home	Hardwick	Northwest of Mackville Pond
33	449940	393 VT Route 14S	Retail	Hardwick	Northwest of Mackville Pond
34	119768	333 VT Route 14S	Commercial	Hardwick	Northwest of Mackville Pond
35	119770	368 VT Route 14S	Mobile Home	Hardwick	Cooper Brook
36	119761	320 VT Route 14S	Public Telephone	Hardwick	Cooper Brook
37	119759	308 VT Route 14S	Commercial	Hardwick	Cooper Brook
38	119758	277 VT Route 14S	Mobile Home	Hardwick	Northwest of Mackville Pond
39	307343	32 Carey Dr	Home	Hardwick	Northwest of Mackville Pond
40	119767	36 Anairs Dr	Home	Hardwick	Northwest of Mackville Pond
41	119989	29 Anairs Dr	Home	Hardwick	Northwest of Mackville Pond
42	307344	35 Anairs Dr	Home	Hardwick	Northwest of Mackville Pond
43	119766	41 Anairs Dr	Home	Hardwick	Northwest of Mackville Pond
44	119769	239 VT Route 14S	Industrial	Hardwick	Northwest of Mackville Pond
45	119757	223 VT Route 14S	Mobile Home	Hardwick	Northwest of Mackville Pond
46	119797	584 VT Route 14S	Home	Hardwick	Cooper Brook
47	119911	42 Chapin Ln	Home	Hardwick	Cooper Brook
48	119910	36 Chapin Ln	Home	Hardwick	Cooper Brook
49	119752	38 Buffalo Mountain Rd	Public gathering	Hardwick	Cooper Brook
50	119754	60 Buffalo Mountain Rd	Commercial	Hardwick	Cooper Brook
51	119756	85 Buffalo Mountain Rd	Home	Hardwick	Cooper Brook
52	119753	114 Buffalo Mountain Rd	Commercial	Hardwick	Cooper Brook
53	119749	77 Cooper Brook Dr	Mobile Home	Hardwick	Cooper Brook
54	119746	206 VT Route 14S	Public Gathering	Hardwick	Cooper Brook
55	119748	181 VT Route 14S	Home	Hardwick	Cooper Brook
56	119745	161 VT Route 14S	Home	Hardwick	Cooper Brook

57	120051	151 VT Route 14S	Camp	Hardwick	Cooper Brook
58	119739	115 VT Route 14S	Camp	Hardwick	Cooper Brook
59	119737	81 VT Route 14S	Home	Hardwick	Cooper Brook
60	119735	65 VT Route 14S	Mobile Home	Hardwick	Cooper Brook
61	119733	57 VT Route 14S	Mobile Home	Hardwick	Cooper Brook
62	119728	16 Benway Dr	Mobile Home	Hardwick	Cooper Brook
63	119731	32 Benway Dr	Mobile Home	Hardwick	Cooper Brook
64	119727	15 Benway Dr	Home	Hardwick	Cooper Brook
65	119732	17 Buffalo St	Storage Units	Hardwick	Cooper Brook
66	119721	8 Buffalo St	Home	Hardwick	Cooper Brook
67	119714	67 Buffalo st	Home	Hardwick	Cooper Brook
68	119722	45 Buffalo St	Home	Hardwick	Cooper Brook
69	119923	180 Brook St	Commercial	Hardwick	Cooper Brook
70	119555	75 Dewey St	Home	Hardwick	Cooper Brook
71	119551	76 Dewey St	Home	Hardwick	Cooper Brook
72	119511	85 Brook St	Home	Hardwick	Cooper Brook
73	119450	27 Brook St	Home	Hardwick	Cooper Brook
74	119486	220 Elm St	Home	Hardwick	Cooper Brook
75	119477	206 Elm St	Home	Hardwick	Cooper Brook
76	119468	153 Spring St	Home	Hardwick	Cooper Brook
77	119448	160 Spring St	Home	Hardwick	Cooper Brook
78	119441	170 Spring St	Home	Hardwick	Cooper Brook
79	119459	184 Elm St	Home	Hardwick	Cooper Brook
80	119439	152 Elm St	Home	Hardwick	Cooper Brook
81	119426	153 Cherry St	House of Worship	Hardwick	Cooper Brook
82	119412	171 Cherry St	Home	Hardwick	Cooper Brook
83	119405	181 Cherry St	Home	Hardwick	Cooper Brook
84	119402	187 Cherry St	Home	Hardwick	Cooper Brook
85	119396	22 Bernard Smith Ln	Home	Hardwick	Cooper Brook
86	119395	29 Michaud Ln	Home	Hardwick	Cooper Brook
87	119381	19 Michaud Ln	Home	Hardwick	Cooper Brook
88	119382	199 Cherry St	Home	Hardwick	Cooper Brook
89	119373	203 Cherry St	Home	Hardwick	Cooper Brook
90	119354	187 Granite St	Home	Hardwick	Cooper Brook
91	119348	227 Cherry St	Home	Hardwick	Cooper Brook
92	119417	124 Elm St	Home	Hardwick	Cooper Brook
93	119406	104 Elm St	Home	Hardwick	Cooper Brook
94	119399	98 Elm St	Home	Hardwick	Cooper Brook
95	119377	76 Elm St	Multi-Home	Hardwick	Cooper Brook
96	119366	60 Elm St	Commercial	Hardwick	Cooper Brook
97	119429	117 Elm St	Home	Hardwick	Cooper Brook
98	119430	24 Dale St	Home	Hardwick	Cooper Brook
99	119418	17 Dale St	Home	Hardwick	Cooper Brook

100	119404	83 Elm St	Home	Hardwick	Cooper Brook
101	119392	63 Elm St	Home	Hardwick	Cooper Brook
102	119376	47 Elm St	Commercial	Hardwick	Cooper Brook
103	119367	37 Elm St	Multi-Home	Hardwick	Cooper Brook
104	119347	13 Elm St	Multi-Home	Hardwick	Cooper Brook
105	119320	163 Wolcott St	Commercial	Hardwick	Lamoille River
106	119333	22 Elm St	Home	Hardwick	Cooper Brook
107	119302	191 Wolcott St	Commercial	Hardwick	Lamoille River
108	119310	41 Cottage St	Home	Hardwick	Cooper Brook
109	119319	53 Cottage St	Home	Hardwick	Cooper Brook
110	119330	69 Cottage St	Home	Hardwick	Cooper Brook
111	119339	79 Cottage St	Home	Hardwick	Cooper Brook
112	119350	91 Cottage St	Home	Hardwick	Cooper Brook
113	119301	38 Cottage St	Home	Hardwick	Cooper Brook
114	119300	46 Cottage St	Home	Hardwick	Cooper Brook
115	119312	60 Cottage St	Home	Hardwick	Cooper Brook
116	119318	76 Cottage St	Home	Hardwick	Cooper Brook
117	119327	86 Cottage St	Home	Hardwick	Cooper Brook
118	119331	98 Cottage St	Multi-Home	Hardwick	Cooper Brook
119	119346	110 Cottage St	Home	Hardwick	Cooper Brook
120	119352	118 Cottage St	Home	Hardwick	Cooper Brook
121	119259	231 Wolcott St	Camp	Hardwick	Lamoille River
122	119247	241 Wolcott St	Commercial	Hardwick	Lamoille River
123	119271	57 Granite St	Multi-Home	Hardwick	Cooper Brook
124	119285	73 Granite St	Home	Hardwick	Cooper Brook
125	119290	79 Granite St	Multi-Home	Hardwick	Cooper Brook
126	119299	101 Granite St	Home	Hardwick	Cooper Brook
127	119343	180 Granite St	Other	Hardwick	Cooper Brook
128	119315	150 granite St	Other	Hardwick	Cooper Brook
129	119243	40 Granite St	Home	Hardwick	Cooper Brook
130	119229	48 Granite St	Home	Hardwick	Cooper Brook
131	119231	18 Granite St	Home	Hardwick	Lamoille River
132	119221	283 Wolcott St	Home	Hardwick	Lamoille River
133	119208	307 Wolcott St	Home	Hardwick	Lamoille River
134	119195	333 Wolcott St	Fire Station	Hardwick	Lamoille River
135	119313	166 Wolcott St	Commercial	Hardwick	Lamoille River
136	119394	54 Terrace Hill Rd	Mobile Home	Hardwick	Lamoille River
137	119416	71 Wolcott St	Commercial	Hardwick	Lamoille River
138	119440	49 Wolcott St	Multi-Home	Hardwick	Lamoille River
139	119296	209 Highland Ave	Home	Hardwick	Lamoille River
140	119198	171 Union St	Home	Hardwick	Lamoille River
141	119190	99 Union St	Home	Hardwick	Lamoille River
142	119168	387 Wolcott St	Commercial	Hardwick	Lamoille River

143	119165	401 Wolcott St	Commercial	Hardwick	Lamoille River
144	119150	439 Wolcott St	Commercial	Hardwick	Lamoille River
145	119167	376 Wolcott St	Home	Hardwick	Lamoille River
146	119158	404 Wolcott St	Commercial	Hardwick	Lamoille River
147	119153	420 Wolcott St	Commercial	Hardwick	Lamoille River
148	119144	24 Sawmill Ln	Mobile Home	Hardwick	Lamoille River
149	119143	5 Sawmill Ln	Home	Hardwick	Lamoille River
150	119140	444 Wolcott St	Home	Hardwick	Lamoille River
151	119121	490 Wolcott St	Home	Hardwick	Lamoille River
152	119112	502 Wolcott St	Multi-Home	Hardwick	Lamoille River
153	119104	528 Wolcott St	Home	Hardwick	Lamoille River
154	119094	550 Wolcott St	Home	Hardwick	Lamoille River
155	119099	141 Charlevoix St	Commercial	Hardwick	Lamoille River
156	119088	132 Charlevoix St	Multi-Home	Hardwick	Lamoille River
157	119086	24 Charlevoix St	Home	Hardwick	Lamoille River
158	119075	67 Charlevoix St	Industrial	Hardwick	Lamoille River
159	119077	632 Wolcott St	Public Telephone	Hardwick	Lamoille River
160	119078	630 Wolcott St	Abandoned	Hardwick	Lamoille River
161	119072	18 VT Route 15W	Other	Hardwick	Lamoille River
162	119061	84 VT Route 15W	Commercial	Hardwick	Lamoille River
163	119062	82 VT Route 15W	Commercial	Hardwick	Lamoille River
164	119052	120 VT Route 15W	Commercial	Hardwick	Lamoille River
165	119045	154 VT Route 15W	Commercial	Hardwick	Lamoille River
166	119024	135 Log Yard Dr	Industrial	Hardwick	Lamoille River
167	120044	77 Log Yard Dr	Commercial	Hardwick	Lamoille River
168	119030	222 VT Route 15W	Commercial	Hardwick	Lamoille River
169	119019	294 VT Route 15W	Home	Hardwick	Lamoille River
170	118910	259 Craftsbury Rd	Home	Hardwick	Hardwick Lake
171	118928	231 Craftsbury Rd	Commercial	Hardwick	Hardwick Lake
172	118948	216 Craftsbury Rd	Home	Hardwick	Hardwick Lake
173	118957	198 Craftsbury Rd	Home	Hardwick	Hardwick Lake
174	118961	172 Craftsbury Rd	Mobile Home	Hardwick	Lamoille River
175	118967	164 Craftsbury Rd	Mobile Home	Hardwick	Lamoille River
176	118964	153 Craftsbury Rd	Mobile Home	Hardwick	Lamoille River
177	118974	133 Craftsbury Rd	Home	Hardwick	Lamoille River
178	118979	138 Craftsbury Rd	Mobile Home	Hardwick	Lamoille River
179	118976	111 Craftsbury Rd	Home	Hardwick	Lamoille River
180	118981	83 Craftsbury Rd	Home	Hardwick	Lamoille River
181	118994	47 Craftsbury Rd	Home	Hardwick	Lamoille River
182	118998	17 Craftsbury Rd	Commercial	Hardwick	Lamoille River
183	119004	454 VT Route 15W	Commercial	Hardwick	Lamoille River
184	119005	452 VT Route 15W	Public Telephone	Hardwick	Lamoille River
185	119023	281 VT Route 15W	Commercial	Hardwick	Lamoille River
186	454964	18 Treatment Plant Rd	Information Center	Hardwick	Lamoille River

187	119039	107 Treatment Plant Rd	Wastewater Plant	Hardwick	Lamoille River
188	119014	730 VT Route 15W	Mobile Home	Hardwick	Lamoille River
189	119021	828 VT Route 15W	Home	Hardwick	Lamoille River
190	119022	944 VT Route 15W	Mobile Home	Hardwick	Lamoille River
191	119027	18 Baker Hill Dr	Mobile Home	Hardwick	Lamoille River
192	119033	42 Baker Hill Dr	Home	Hardwick	Lamoille River
193	119029	74 Baker Hill Dr	Home	Hardwick	Lamoille River
194	119032	29 Fletcher Ln	Home	Hardwick	Lamoille River
195	119026	67 Fletcher Ln	Mobile Home	Hardwick	Lamoille River
196	119065	175 McAllister Farm Rd	Mobile Home	Hardwick	Lamoille River
197	119068	168 McAllister Farm Rd	Home	Hardwick	Lamoille River
198	119991	1396 VT Route 15W	Mobile Home	Hardwick	Lamoille River