Appendix A

Water Resources Development Act 2000, Section 542 – Lake Champlain Water Shed, and New York State Canal Corp. Letter of Support

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. 2796

One Hundred Sixth Congress of the United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Monday, the twenty-fourth day of January, two thousand

An Act

To provide for the conservation and development of water and related resources, to authorize the Secretary of the Army to construct various projects for improvements to rivers and harbors of the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Water Resources Development Act of 2000".

(b) TABLE OF CONTENTS.—

Sec. 1. Short title; table of contents.
Sec. 2. Definition of Secretary.

TITLE I—WATER RESOURCES PROJECTS

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Sec. 102. Small projects for flood damage reduction.
Sec. 103. Small projects for emergency streambank protection.
Sec. 104. Small projects for navigation.
Sec. 105. Small projects for improvement of the quality of the environment.
Sec. 106. Small projects for aquatic ecosystem restoration.
Sec. 107. Small projects for shoreline protection.
Sec. 108. Small projects for snagging and sediment removal.
Sec. 109. Small project for mitigation of shore damage.
Sec. 110. Beneficial uses of dredged material.
Sec. 111. Disposal of dredged material on beaches.
Sec. 112. Petaluma River, Petaluma, California.

TITLE II—GENERAL PROVISIONS

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Sec. 204. Ability to pay.
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Sec. 206. National recreation reservation service.
Sec. 207. Interagency and international support authority.
Sec. 208. Reburial and conveyance authority.
Sec. 209. Floodplain management requirements.
Sec. 210. Nonprofit entities.
Sec. 211. Performance of specialized or technical services.
Sec. 212. Hydroelectric power project funding.
Sec. 213. Assistance programs.
Sec. 214. Funding to process permits.
Sec. 215. Dredged material marketing and recycling.
Sec. 216. National academy of sciences study.
Sec. 217. Rehabilitation of Federal flood control levees.
Sec. 218. Maximum program expenditures for small flood control projects.
Sec. 219. Engineering consulting services.
Sec. 220. Beach recreation.
Sec. 221. Design-build contracting.
Sec. 222. Enhanced public participation.
Sec. 223. Monitoring.
Sec. 224. Fish and wildlife mitigation.

Sec. 225. Feasibility studies and planning, engineering, and design.
Sec. 226. Administrative costs of land conveyances.
Sec. 227. Flood mitigation and riverine restoration.

TITLE III—PROJECT-RELATED PROVISIONS

Sec. 301. Tennessee-Tombigbee Waterway Wildlife Mitigation Project, Alabama and Mississippi.
Sec. 302. Nogales Wash and tributaries, Nogales, Arizona.
Sec. 303. Boydsville, Arkansas.
Sec. 304. White River Basin, Arkansas and Missouri.
Sec. 305. Sacramento Deep Water Ship Channel, California.
Sec. 306. Delaware River Mainstem and Channel Deepening, Delaware, New Jersey, and Pennsylvania.
Sec. 307. Rehoboth Beach and Dewey Beach, Delaware.
Sec. 308. Fernandina Harbor, Florida.
Sec. 309. Gasparilla and Estero Islands, Florida.
Sec. 310. East Saint Louis and vicinity, Illinois.
Sec. 311. Kaskaskia River, Kaskaskia, Illinois.
Sec. 312. Waukegan Harbor, Illinois.
Sec. 313. Upper Des Plaines River and tributaries, Illinois.
Sec. 314. Cumberland, Kentucky.
Sec. 315. Atchafalaya Basin, Louisiana.
Sec. 316. Red River Waterway, Louisiana.
Sec. 317. Thomaston Harbor, Georges River, Maine.
Sec. 318. Poplar Island, Maryland.
Sec. 319. William Jennings Randolph Lake, Maryland.
Sec. 320. Breckenridge, Minnesota.
Sec. 321. Duluth Harbor, Minnesota.
Sec. 322. Little Falls, Minnesota.
Sec. 323. New Madrid County, Missouri.
Sec. 324. Pemiscot County Harbor, Missouri.
Sec. 325. Fort Peck fish hatchery, Montana.
Sec. 326. Sagamore Creek, New Hampshire.
Sec. 327. Passaic River basin flood management, New Jersey.
Sec. 328. Times Beach Nature Preserve, Buffalo, New York.
Sec. 329. Rockaway Inlet to Norton Point, New York.
Sec. 330. Garrison Dam, North Dakota.
Sec. 331. Duck Creek, Ohio.
Sec. 332. John Day Pool, Oregon and Washington.
Sec. 333. Fox Point hurricane barrier, Providence, Rhode Island.
Sec. 334. Nonconnah Creek, Tennessee and Mississippi.
Sec. 335. San Antonio Channel, San Antonio, Texas.
Sec. 336. Buchanan and Dickenson Counties, Virginia.
Sec. 337. Buchanan, Dickenson, and Russell Counties, Virginia.
Sec. 338. Sandbridge Beach, Virginia Beach, Virginia.
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Sec. 340. Lower Mud River, Milton, West Virginia.
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Sec. 430. Boeuf and Black, Louisiana.
Sec. 431. Iberia Port, Louisiana.
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Sec. 436. Portsmouth Harbor and Piscataqua River, Maine and New Hampshire.
Sec. 437. Merrimack River basin, Massachusetts and New Hampshire.
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Sec. 439. Port of Gulfport, Mississippi.
Sec. 440. Las Vegas Valley, Nevada.
Sec. 441. Upland disposal sites in New Hampshire.
Sec. 442. Southwest Valley, Albuquerque, New Mexico.
Sec. 443. Buffalo Harbor, Buffalo, New York.
Sec. 444. Jamesville Reservoir, Onondaga County, New York.
Sec. 445. Bogue Banks, Carteret County, North Carolina.
Sec. 446. Duck Creek watershed, Ohio.
Sec. 447. Fremont, Ohio.
Sec. 448. Steubenville, Ohio.
Sec. 449. Grand Lake, Oklahoma.
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Sec. 520. Koontz Lake, Indiana.
Sec. 521. West View Shores, Cecil County, Maryland.
Sec. 522. Muddy River, Brookline and Boston, Massachusetts.
Sec. 523. Soo Locks, Sault Ste. Marie, Michigan.

Sec. 524. Minnesota dam safety.
Sec. 525. Bruce F. Vento Unit of the Boundary Waters Canoe Area Wilderness, Minnesota.
Sec. 526. Duluth, Minnesota, alternative technology project.
Sec. 527. Minneapolis, Minnesota.
Sec. 528. Coastal Mississippi wetlands restoration projects.
Sec. 529. Las Vegas, Nevada.
Sec. 530. Urbanized peak flood management research, New Jersey.
Sec. 531. Nepperhan River, Yonkers, New York.
Sec. 532. Upper Mohawk River basin, New York.
Sec. 533. Flood damage reduction.
Sec. 534. Cuyahoga River, Ohio.
Sec. 535. Crowder Point, Crowder, Oklahoma.
Sec. 536. Lower Columbia River and Tillamook Bay ecosystem restoration, Oregon and Washington.
Sec. 537. Access improvements, Raystown Lake, Pennsylvania.
Sec. 538. Upper Susquehanna River basin, Pennsylvania and New York.
Sec. 539. Charleston Harbor, South Carolina.
Sec. 540. Cheyenne River Sioux Tribe, Lower Brule Sioux Tribe, and South Dakota terrestrial wildlife habitat restoration.
Sec. 541. Horn Lake Creek and tributaries, Tennessee and Mississippi.
Sec. 542. Lake Champlain watershed, Vermont and New York.
Sec. 543. Vermont dams remediation.
Sec. 544. Puget Sound and adjacent waters restoration, Washington.
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Sec. 601. Comprehensive Everglades restoration plan.
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TITLE VII—MISSOURI RIVER RESTORATION, NORTH DAKOTA

Sec. 701. Short title.
Sec. 702. Findings and purposes.
Sec. 703. Definitions.
Sec. 704. Missouri River Trust.
Sec. 705. Missouri River Task Force.
Sec. 706. Administration.
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TITLE VIII—WILDLIFE REFUGE ENHANCEMENT

Sec. 801. Short title.
Sec. 802. Purpose.
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Sec. 804. Conveyance of cabin sites.
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Sec. 809. Revocation of withdrawals.
Sec. 810. Authorization of appropriations.

TITLE IX—MISSOURI RIVER RESTORATION, SOUTH DAKOTA

Sec. 901. Short title.
Sec. 902. Findings and purposes.
Sec. 903. Definitions.
Sec. 904. Missouri River Trust.
Sec. 905. Missouri River Task Force.
Sec. 906. Administration.
Sec. 907. Authorization of appropriations.

SEC. 2. DEFINITION OF SECRETARY.

In this Act, the term "Secretary" means the Secretary of the Army.

(ii) by striking "the respective Tribe's" and inserting "the respective affected Indian Tribe's"; and

(E) in subsection (g) by striking "an Indian Tribe" and inserting "any Indian Tribe".

(6) ADMINISTRATION.—Section 607(a) of the Water Resources Development Act of 1999 (113 Stat. 395) is amended by striking "an Indian Tribe" each place it appears and inserting "any Indian Tribe".

SEC. 541. HORN LAKE CREEK AND TRIBUTARIES, TENNESSEE AND MISSISSIPPI.

The Secretary shall prepare a limited reevaluation report of the project for flood control, Horn Lake Creek and Tributaries, Tennessee and Mississippi, authorized by section 401(a) of the Water Resources Development Act of 1986 (100 Stat. 4124), to determine the feasibility of modifying the project to provide urban flood protection along Horn Lake Creek and, if the Secretary determines that the modification is technically sound, environmentally acceptable, and economically justified, carry out the project as modified in accordance with the report.

SEC. 542. LAKE CHAMPLAIN WATERSHED, VERMONT AND NEW YORK.

(a) DEFINITIONS.—In this section, the following definitions apply:

(1) CRITICAL RESTORATION PROJECT.—The term "critical restoration project" means a project that will produce, consistent with Federal programs, projects, and activities, immediate and substantial ecosystem restoration, preservation, and protection benefits.

(2) LAKE CHAMPLAIN WATERSHED.—The term "Lake Champlain watershed" means—

(A) the land areas within Addison, Bennington, Caledonia, Chittenden, Franklin, Grand Isle, Lamoille, Orange, Orleans, Rutland, and Washington Counties in the State of Vermont; and

(B)(i) the land areas that drain into Lake Champlain and that are located within Essex, Clinton, Franklin, Warren, and Washington Counties in the State of New York; and

(ii) the near-shore areas of Lake Champlain within the counties referred to in clause (i).

(b) CRITICAL RESTORATION PROJECTS.—

(1) IN GENERAL.—The Secretary may participate in critical restoration projects in the Lake Champlain watershed.

(2) TYPES OF PROJECTS.—A critical restoration project shall be eligible for assistance under this section if the critical restoration project consists of—

(A) implementation of an intergovernmental agreement for coordinating regulatory and management responsibilities with respect to the Lake Champlain watershed;

(B) acceleration of whole farm planning to implement best management practices to maintain or enhance water quality and to promote agricultural land use in the Lake Champlain watershed;

(C) acceleration of whole community planning to promote intergovernmental cooperation in the regulation and management of activities consistent with the goal of

maintaining or enhancing water quality in the Lake Champlain watershed;

(D) natural resource stewardship activities on public or private land to promote land uses that—

(i) preserve and enhance the economic and social character of the communities in the Lake Champlain watershed; and

(ii) protect and enhance water quality; or

(E) any other activity determined by the Secretary to be appropriate.

(c) PUBLIC OWNERSHIP REQUIREMENT.—The Secretary may provide assistance for a critical restoration project under this section only if—

(1) the critical restoration project is publicly owned; or

(2) the non-Federal interest with respect to the critical restoration project demonstrates that the critical restoration project will provide a substantial public benefit in the form of water quality improvement.

(d) PROJECT SELECTION.—

(1) IN GENERAL.—In consultation with the Lake Champlain Basin Program and the heads of other appropriate Federal, State, tribal, and local agencies, the Secretary may—

(A) identify critical restoration projects in the Lake Champlain watershed; and

(B) carry out the critical restoration projects after entering into an agreement with an appropriate non-Federal interest in accordance with section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962d–5b) and this section.

(2) CERTIFICATION.—

(A) IN GENERAL.—A critical restoration project shall be eligible for financial assistance under this section only if the appropriate State official for the critical restoration project certifies to the Secretary that the critical restoration project will contribute to the protection and enhancement of the quality or quantity of the water resources of the Lake Champlain watershed.

(B) SPECIAL CONSIDERATION.—In certifying critical restoration projects to the Secretary, the appropriate State officials shall give special consideration to projects that implement plans, agreements, and measures that preserve and enhance the economic and social character of the communities in the Lake Champlain watershed.

(e) COST SHARING.—

(1) IN GENERAL.—Before providing assistance under this section with respect to a critical restoration project, the Secretary shall enter into a project cooperation agreement that shall require the non-Federal interest—

(A) to pay 35 percent of the total costs of the project;

(B) to provide any land, easements, rights-of-way, dredged material disposal areas, and relocations necessary to carry out the project;

(C) to pay 100 percent of the operation, maintenance, repair, replacement, and rehabilitation costs associated with the project; and

(D) to hold the United States harmless from any claim or damage that may arise from carrying out the project,

except any claim or damage that may arise from the negligence of the Federal Government or a contractor of the Federal Government.

(2) NON-FEDERAL SHARE.—

(A) CREDIT FOR DESIGN WORK.—The non-Federal interest shall receive credit for the reasonable costs of design work carried out by the non-Federal interest before the date of execution of a project cooperation agreement for the critical restoration project, if the Secretary finds that the design work is integral to the project.

(B) CREDIT FOR LAND, EASEMENTS, AND RIGHTS-OF-WAY.—The Secretary shall credit the non-Federal interest for the value of any land, easement, right-of-way, dredged material disposal area, or relocation provided for carrying out the project.

(C) FORM.—The non-Federal interest may provide up to 50 percent of the non-Federal share in the form of services, materials, supplies, or other in-kind contributions.

(f) APPLICABILITY OF OTHER FEDERAL AND STATE LAWS.—Nothing in this section waives, limits, or otherwise affects the applicability of Federal or State law with respect to a project carried out with assistance provided under this section.

(g) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out this section $20,000,000, to remain available until expended.

SEC. 543. VERMONT DAMS REMEDIATION.

(a) IN GENERAL.—The Secretary—

(1) shall conduct a study to evaluate the structural integrity and need for modification or removal of each dam located in the State of Vermont and described in subsection (b);

(2) shall provide to the non-Federal interest design analysis, plans and specifications, and cost estimates for repair, restoration, modification, and removal of each dam described in subsection (b); and

(3) may carry out measures to prevent or mitigate against such risk if the Secretary determines that a dam described in subsection (b) presents an imminent and substantial risk to public safety.

(b) DAMS TO BE EVALUATED.—The dams referred to in subsection (a) are the following:

(1) East Barre Dam, Barre Town.
(2) Wrightsville Dam, Middlesex-Montpelier.
(3) Lake Sadawga Dam, Whitingham.
(4) Dufresne Pond Dam, Manchester.
(5) Knapp Brook Site 1 Dam, Cavendish.
(6) Lake Bomoseen Dam, Castleton.
(7) Little Hosmer Dam, Craftsbury.
(8) Colby Pond Dam, Plymouth.
(9) Silver Lake Dam, Barnard.
(10) Gale Meadows Dam, Londonderry.

(c) COST SHARING.—The non-Federal share of the cost of activities under subsection (a) shall be 35 percent.

(d) COORDINATION.—In carrying out this section, the Secretary shall coordinate with the appropriate State dam safety officials and the Director of the Federal Emergency Management Agency.

(e) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out this section $5,000,000.

SEC. 544. PUGET SOUND AND ADJACENT WATERS RESTORATION, WASHINGTON.

(a) DEFINITION OF CRITICAL RESTORATION PROJECT.—In this section, the term "critical restoration project" means a project that will produce, consistent with Federal programs, projects, and activities, immediate and substantial ecosystem restoration, preservation, and protection benefits.

(b) CRITICAL RESTORATION PROJECTS.—The Secretary may participate in critical restoration projects in the area of Puget Sound, Washington, and adjacent waters, including—

(1) the watersheds that drain directly into Puget Sound;
(2) Admiralty Inlet;
(3) Hood Canal;
(4) Rosario Strait; and
(5) the Strait of Juan de Fuca to Cape Flattery.

(c) PROJECT SELECTION.—

(1) IN GENERAL.—The Secretary may identify critical restoration projects in the area described in subsection (b) based on—

(A) studies to determine the feasibility of carrying out the critical restoration projects; and

(B) analyses conducted before the date of enactment of this Act by non-Federal interests.

(2) CRITERIA AND PROCEDURES FOR REVIEW AND APPROVAL.—

(A) IN GENERAL.—In consultation with the Secretary of Commerce, the Secretary of the Interior, the Governor of the State of Washington, tribal governments, and the heads of other appropriate Federal, State, and local agencies, the Secretary may develop criteria and procedures for prioritizing projects identified under paragraph (1).

(B) CONSISTENCY WITH FISH RESTORATION GOALS.—The criteria and procedures developed under subparagraph (A) shall be consistent with fish restoration goals of the National Marine Fisheries Service and the State of Washington.

(C) USE OF EXISTING STUDIES AND PLANS.—In carrying out subparagraph (A), the Secretary shall use, to the maximum extent practicable, studies and plans in existence on the date of enactment of this Act to identify project needs and priorities.

(3) LOCAL PARTICIPATION.—In prioritizing projects for implementation under this section, the Secretary shall consult with, and consider the priorities of, public and private entities that are active in watershed planning and ecosystem restoration in Puget Sound watersheds, including—

(A) the Salmon Recovery Funding Board;
(B) the Northwest Straits Commission;
(C) the Hood Canal Coordinating Council;
(D) county watershed planning councils; and
(E) salmon enhancement groups.

(d) IMPLEMENTATION.—The Secretary may carry out projects identified under subsection (c) after entering into an agreement with an appropriate non-Federal interest in accordance with section

New York State Canal Corporation

www.nyscanals.gov

John L. Buono
Chairman

Michael R. Fleischer
Executive Director

Carmella R. Mantello
Director

March 3, 2009

Eugene Brickman
US Army Corp of Engineers
26 Federal Plaza
New York, NY 10278

Subject: Champlain Canal Dispersal Barrier Feasibility Project

Dear Mr. Brickman:

The New York State Canal Corporation (Corporation) formally requests that the US Army Corp of Engineers initiate the Champlain Canal dispersal barrier feasibility study to determine how to best prevent the spread of aquatic invasive species. This study is referenced in the Water Resources Development Act of 2007, Section 5146, which is excerpted as follows:

> *(a) Dispersal Barrier Project – The Secretary shall determine, at Federal expense, the feasibility of a dispersal barrier project at the Lake Champlain Canal, Vermont and New York, to prevent the spread of aquatic nuisance species.*

The Corporation has formed a good working relationship with the Lake Champlain Basin Program and the New York State Department of Environmental Conservation to address aquatic invasive species spread prevention in the Champlain Canal. Our partnership held a Champlain Canal Aquatic Invasive Species Stakeholder Meeting in November, 2008, at which more than 70 stakeholders from municipalities, state agencies, non profit organizations, legislators' offices, watershed organizations, and businesses shared their thoughts and support for reducing the spread of aquatic invasive species via the Champlain Canal. The Corporation believes that the feasibility study is an important next step in managing aquatic invasive species threats to the Lake Champlain ecosystem.

The Corporation looks forward to working with the US Army Corp of Engineers on this endeavor. Please do not hesitate to contact me if you should have any questions.

Sincerely,

Carmella R. Mantello
Director

200 Southern Blvd., P.O. Box 189, Albany, NY 12201-0189 518-436-3055/1-800-253-6244 Fax 518-471-5936

Appendix B – Plans of Record

Appendix B1 – Champlain Canal Plans of Record (Circa 1920)

Appendix B2 – Historic Powerhouse

Appendix B3 – Glens Falls Feeder Canal Plans

Appendix B4 – Argyle Street Diversion

Appendix B5 – Utilities

SECTIONAL ELEVATION ON CENTER LINE.

PLAN.

PARTIAL ELEVATION OF LOWER WALL SHOWING NEEDLE BEAM RECESS.

PARTIAL ELEVATION OF UPPER WALL SHOWING NEEDLE BEAM RECESS.

GENERAL NOTES.

All exposed edges to be rounded to a radius of one inch unless otherwise noted.
No vertical joints allowed between Sta. 1140+82 and Sta. 1141+16 nor between Sta. 1144+24 and Sta. 1144+54.
For sections of lock, see sheet No. 37.
For details of anchorage for needle dam and lock gates, see sheets Nos. 74 and 75.
For detail of valve shaft, see sheet No. 73.
For detail of walls adjoining lock, see sheet No. 40.
For details of lock, see sheets Nos. 51, 52, and 53.
For foundation plan of lock, see sheet No. 38.
Ladders to be placed in both walls.
Fenders are not shown on plan.
All metal reinforcement to be of deformed bars of minimum section given.
No concrete classed as "reinforced concrete" except as noted on detail plans.
All top inner edges of lock walls to be finished as follows:-
Edges of gate recesses, parapets on stairways and walls with fenders to be rounded to a radius of three inches.
Walls without fenders and subject to the wear of lines, to be rounded to a radius of six inches.
In lock chamber from gate recess to gate recess, walls to have standard nosing.

Second class concrete.

○ Cast Iron Snubbing posts.

◎ Capstans-(not included in this Contract.)

MADE BY Underhill.
TRACED BY F. Ainsworth
CHECKED BY H. O. Scheuerman

Contract No. 27.

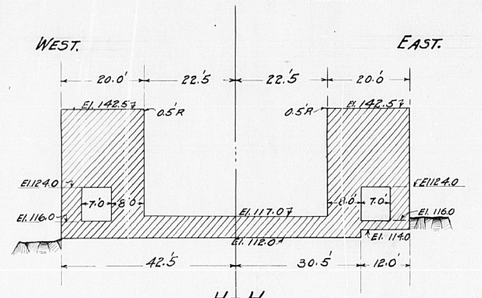
Champlain Canal — Section 2.

From the highway at Dunhams Basin, to the Hudson River at Fort Edward.

PLAN & ELEVATION OF LOCK NO. 8.

Scale: 16 feet to the inch.

Examined and approved
Special Deputy State Engineer



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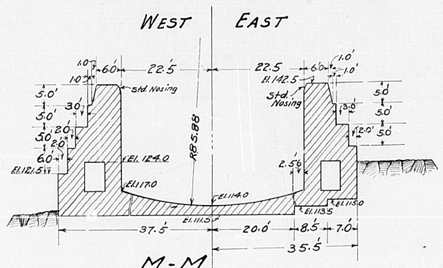

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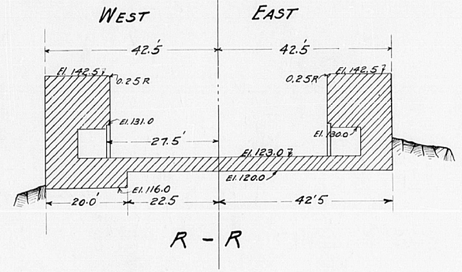

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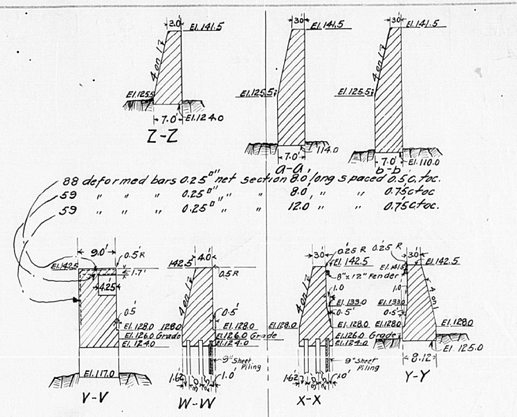

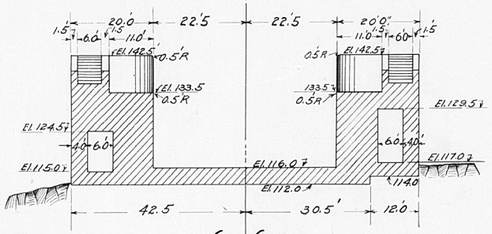

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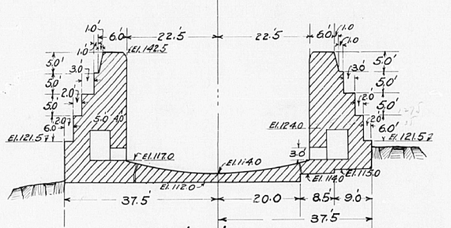

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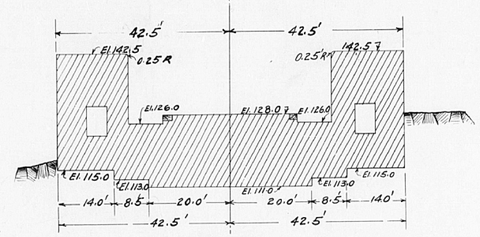
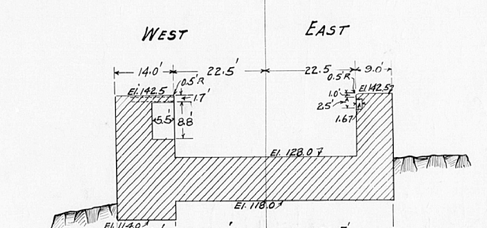


P - P



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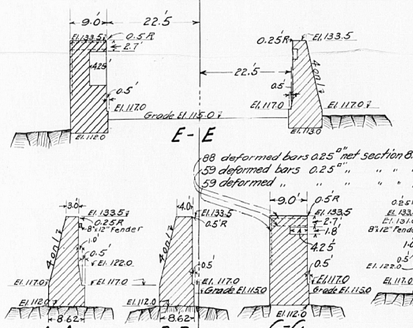

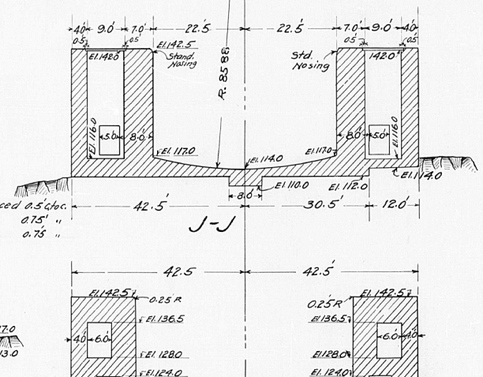

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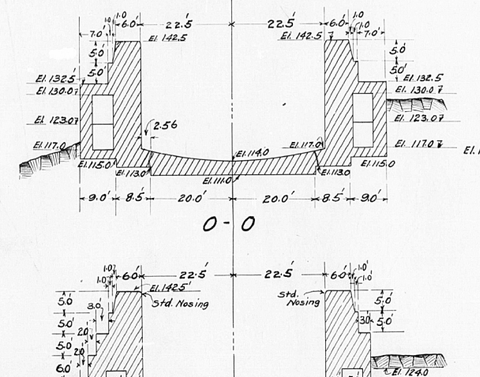

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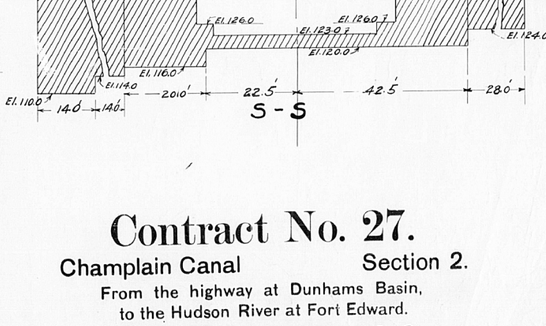

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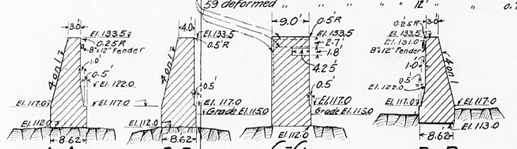

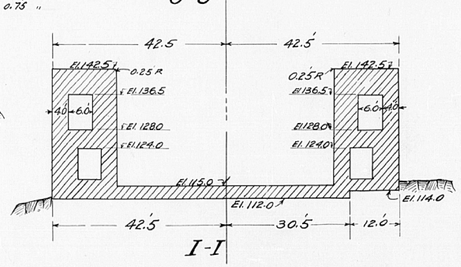

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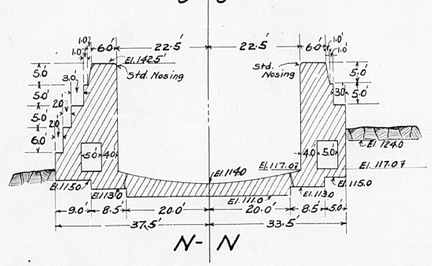


N - N

Contract No. 27.

Champlain Canal — **Section 2.**

From the highway at Dunhams Basin, to the Hudson River at Fort Edward.

SECTIONS OF LOCK NO. 8.

Scale: 16 feet to the inch.

Made By Underhill
Traced By [illegible]
Checked By H.C. Scheuerborn

Examined and approved
Henry A. Allen
Special Deputy State Engineer

24:1

Sectional Elevation on Center Line of Lock.

Plan.

Elevation of Wall at Upper End
Showing Needle Beam Recess

Plan & Elevation of Wall at Lower End
Showing Needle Beam Recess

NOTES

Second Class Concrete

Snubbing Posts

Capstans (Not included in Contract.)

All exposed edges to be rounded to a radius of one inch except as noted.
No vertical joints to be allowed between Sta 827+51 and Sta 827+81 or between Sta 830+90 and Sta 831+20.
For details of Lock see sheets Nos. 118 and 119.
For details of anchorage for needle dam and Lock gates see sheets No. 136 & 137.
For Foundation Plan see sheet No. 114.
For Sections see sheet No. 113.
For detail of valve shafts see sheet No. 138.
For details of walls adjoining Lock see sheet No. 115.
Fenders are not shown on plan.
Ladders in both walls.
All reinforcement to be of deformed bars of minimum cross section given.
No concrete in this Lock to be classed as "Reinforced Concrete."

MADE BY H.C. Schermerhorn
TRACED BY S. Andrews
CHECKED BY Louis Gurley

Contract No. 25.

Champlain Canal Section 3.

From about one half mile north of Comstock P.O., to the highway at Dunhams Basin.

PLAN AND ELEVATION OF LOCK NO. 9.

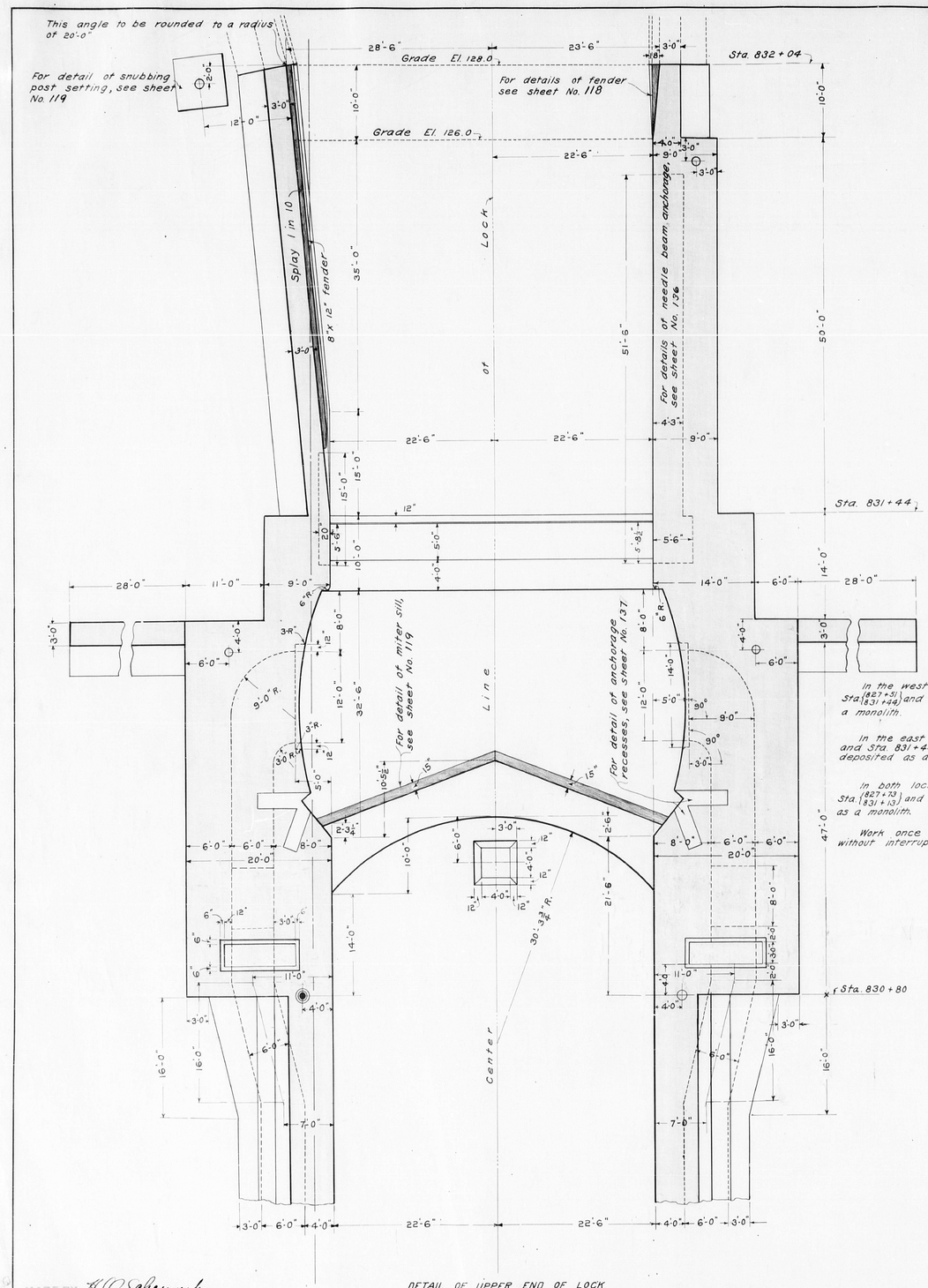
Scale: 16 feet to the inch.

Examined and approved
Lewis B. Allen
Special Deputy State Engineer

111

293

24:1



DETAIL OF UPPER END OF LOCK
Scale 1" = 8'

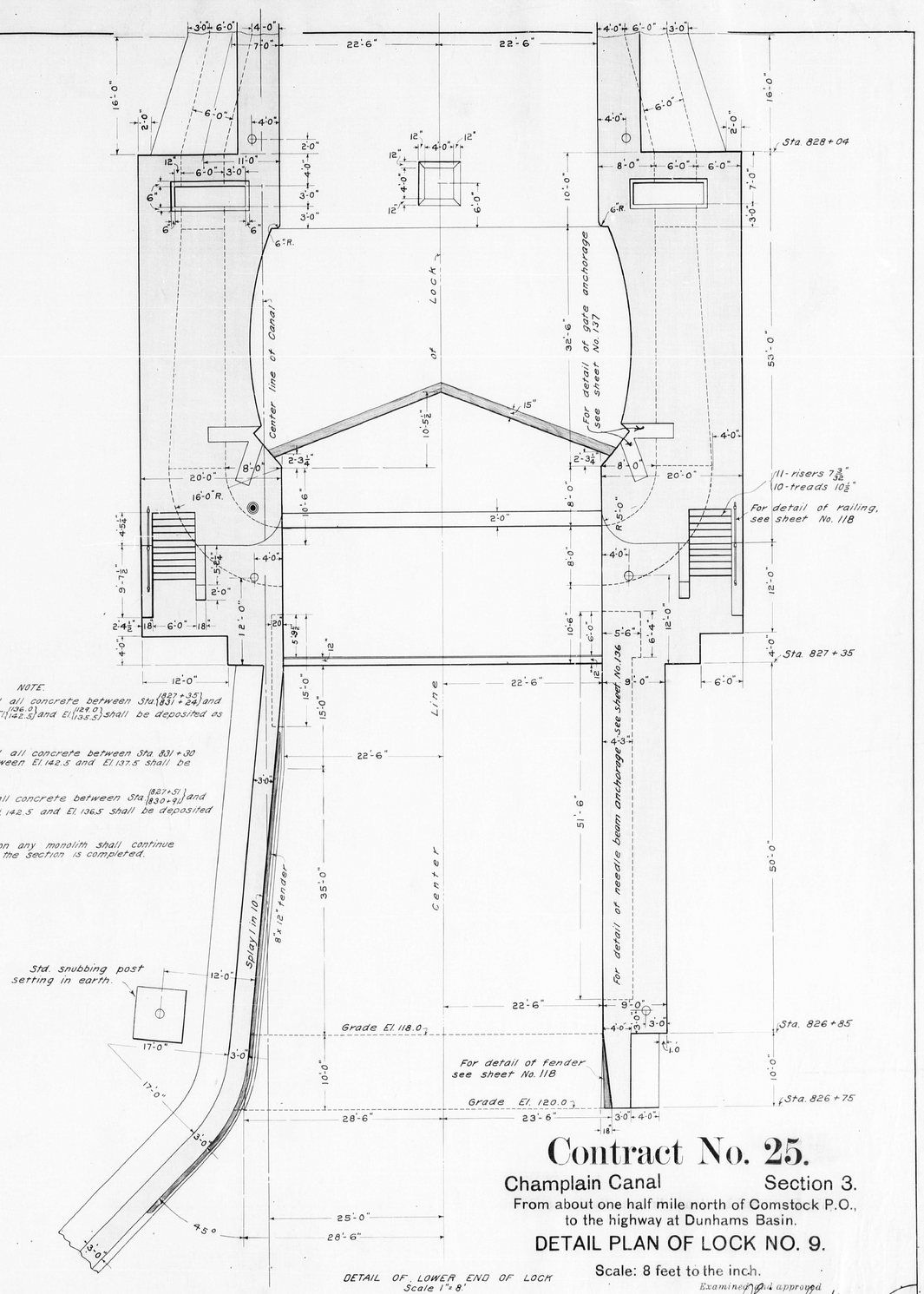
NOTE.

In the west lock wall all concrete between Sta. (827+51 / 831+24) and Sta. (827+51 / 831+24) and between El. (136.0 / 142.5) and El. (129.0 / 135.5) shall be deposited as a monolith.

In the east lock wall all concrete between Sta. 831+30 and Sta. 831+44 and between El. 142.5 and El. 137.5 shall be deposited as a monolith.

In both lock walls all concrete between Sta. (827+51 / 830+91) and Sta. (827+73 / 831+13) and between El. 142.5 and El. 136.5 shall be deposited as a monolith.

Work once begun upon any monolith shall continue without interruption until the section is completed.



DETAIL OF LOWER END OF LOCK
Scale 1" = 8'

MADE BY H.C. Schermerhorn
TRACED BY T.L. Ainsworth & J.J. Rock
CHECKED BY Louis Gabler

Contract No. 25.

Champlain Canal Section 3.

From about one half mile north of Comstock P.O., to the highway at Dunhams Basin.

DETAIL PLAN OF LOCK NO. 9.

Scale: 8 feet to the inch.

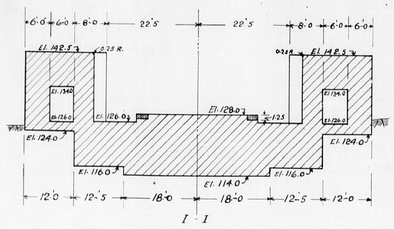
Examined and approved
Henry B. Allen
Special Deputy State Engineer.

112

294

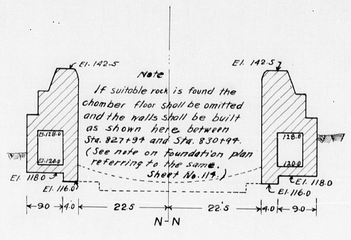
24:1

West East



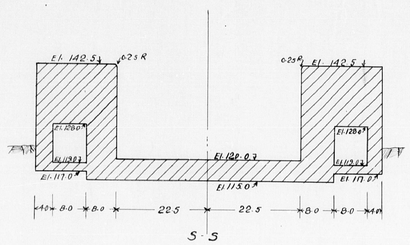
I - I

West East



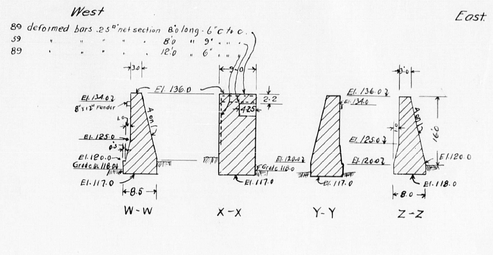
N - N

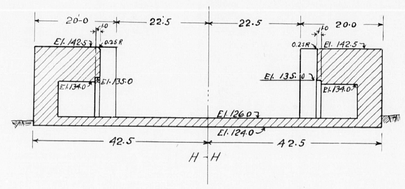
West East



S - S

West East





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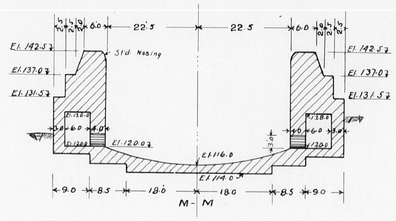

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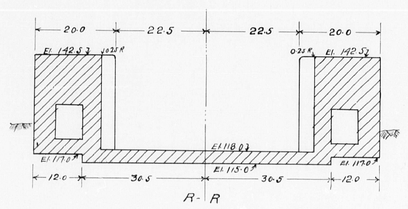

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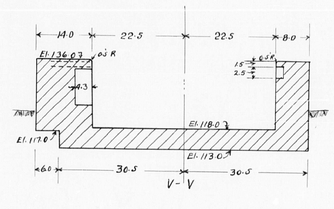

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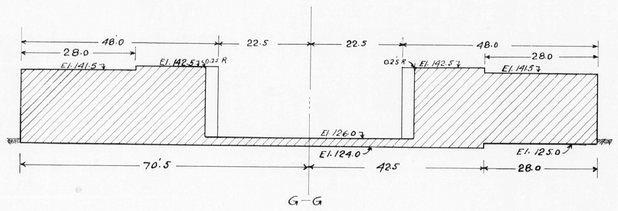

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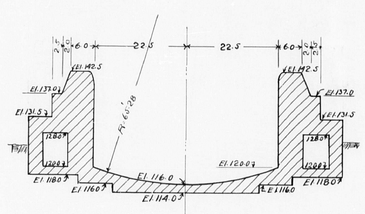
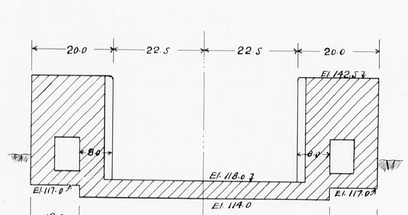
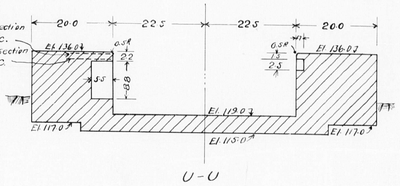


L - L

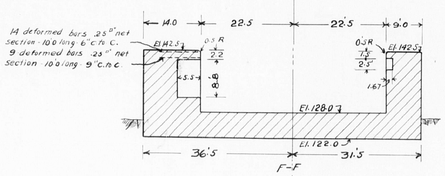


Q - Q

14 deformed bars .25" net section
10'0 long spaced 6'C. to C.
9 deformed bars .25" net section
10.0 long spaced 9'C. to C.



U - U



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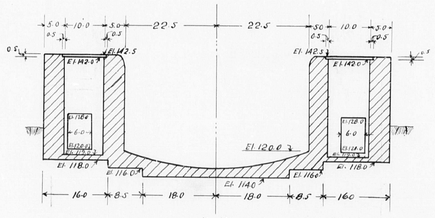
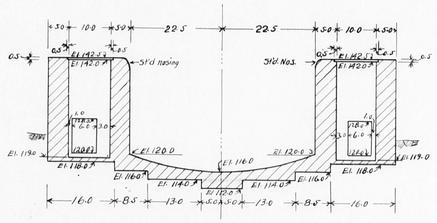


K - K



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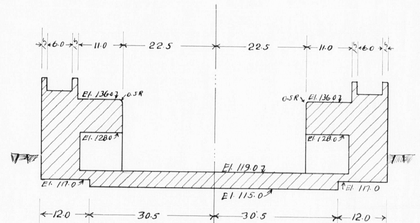
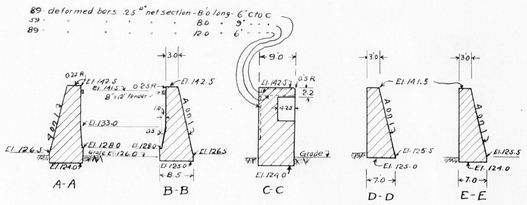
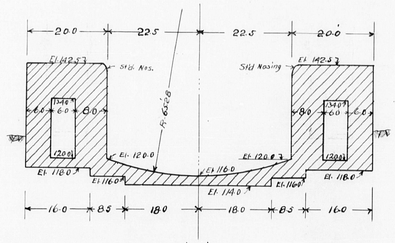


T - T

89 deformed bars .25" net section - 8'0 long - 6" C to C
39 " " " " " 8'0 " 9" " "
89 " " " " " 12'0 " 6" " "



A-A B-B C-C D-D E-E



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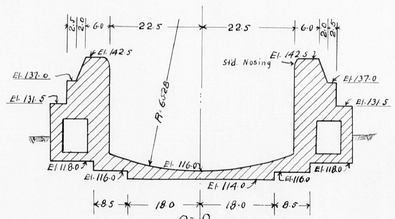


O - O

MADE BY H.C. Schermerhorn
TRACED BY F. Roberts
CHECKED BY Louis Gaboury

Contract No. 25.

Champlain Canal — Section 3.

From about one half mile north of Comstock P.O., to the highway at Dunhams Basin.

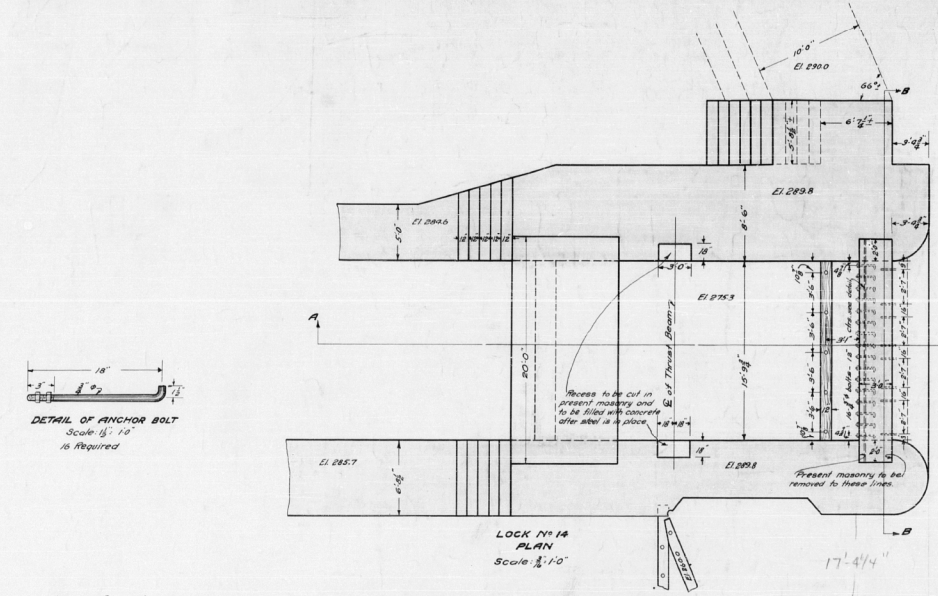
SECTIONS OF LOCK NO. 9.

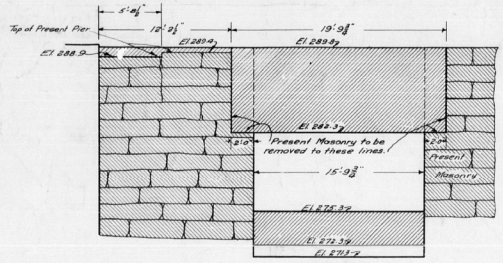
Scale: 16 feet to the inch.

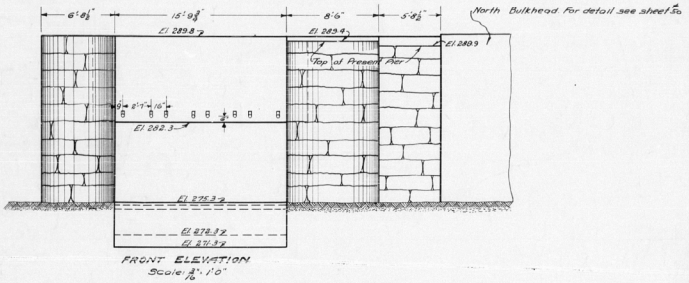
Examined and approved
J. Dwight Allen
Special Deputy State Engineer

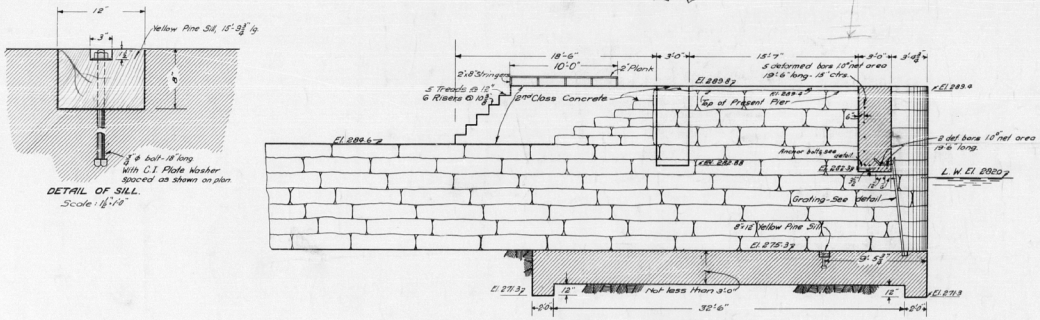
113

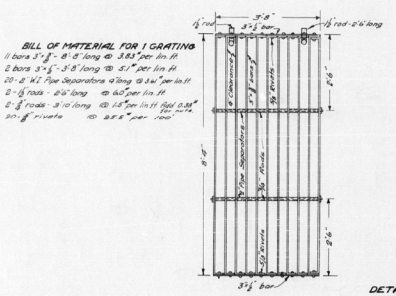
295

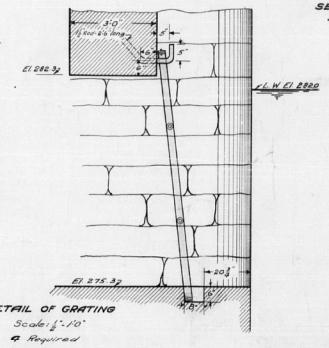












NOTES:-

All masonry shown on this sheet to be second class concrete except as noted.

All exposed edges of concrete to be rounded to a radius of two inches unless otherwise shown.

Metal reinforcement to be deformed bars of minimum cross section given.

The size and spacing of bars may be changed slightly provided the total net section of steel remains unchanged.

For location plan see sheet N°13

All concrete in beam to be second class concrete - classed as Reinforced Concrete.

For details of gate see sheets N° 58-59-60

The bases of structures shown on any of the plans of this contract shall be considered as approximate only, and may be ordered by the State Engineer in writing to be of any elevation and of any dimensions necessary to give a proper foundation.

Contract No. 56.

Champlain Canal Section 2

Glens Falls Feeder.

DETAILS OF BY-PASS, LOCK 14

Scales as indicated

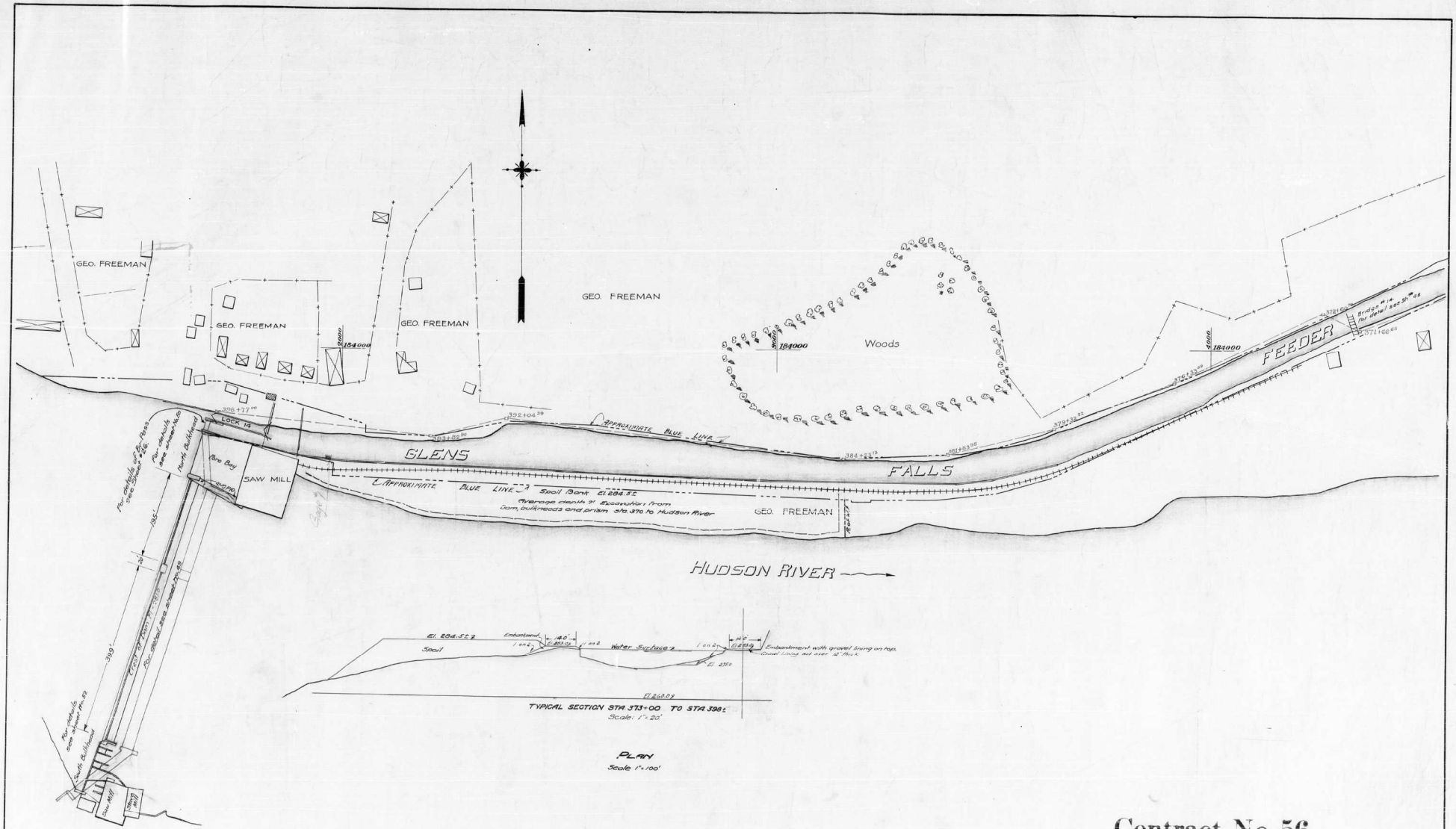
Examined and approved July 1 1912
Supervising Engineer

Examined and approved July 1 1912
Special Deputy State Engineer.

Made By: J. M. Crain
Checked By: A. Williams 5-15-12.
Traced By: H.E. Murray
2nd Check By: A.E. Wilson June 1912

26

194



Contract No. 56.

Champlain Canal — Section 2

Glens Falls Feeder

PLAN & TYPICAL SECTIONS STA. 372+00 TO HUDSON RIVER

Scales as indicated

Examined and approved

July 1, 1912

Superintending Engineer

Examined and approved

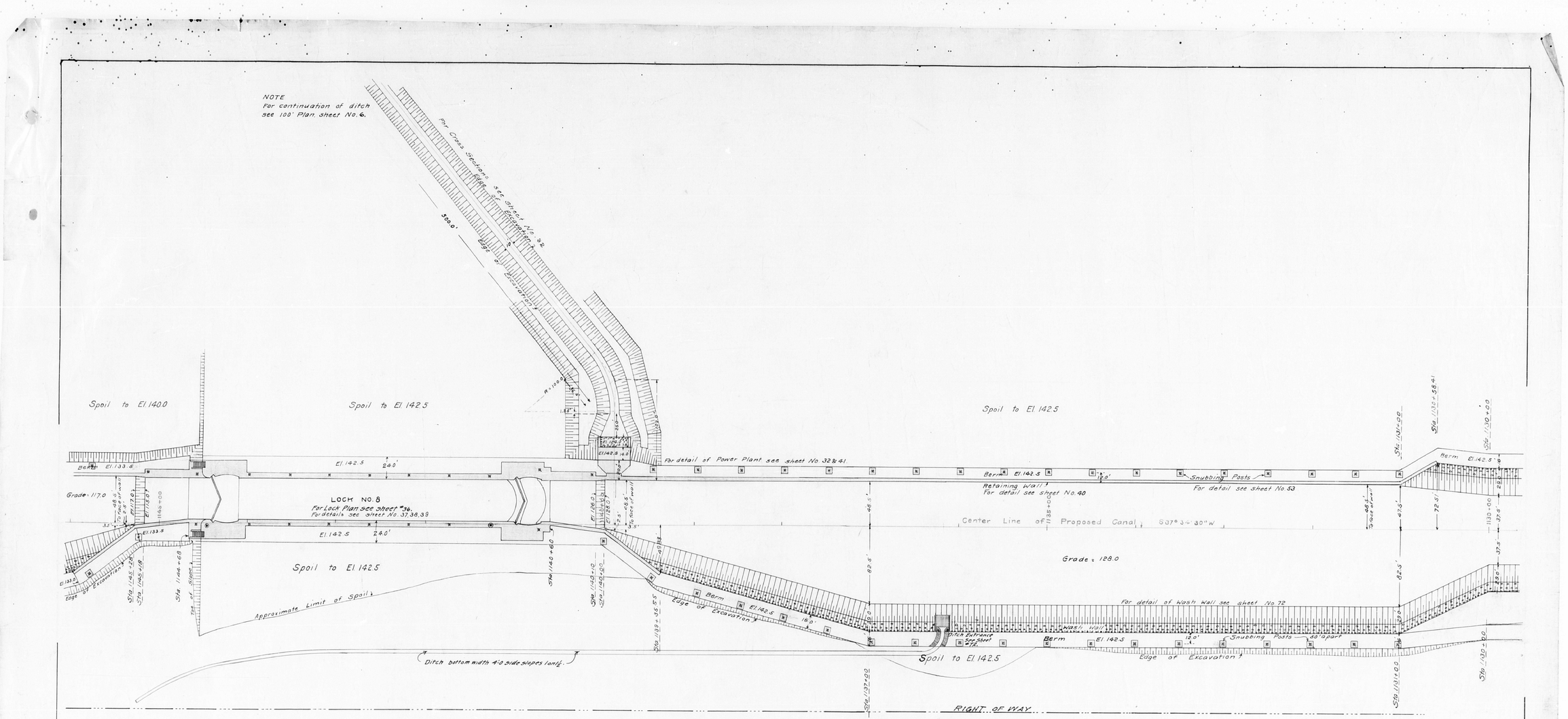
July 1, 1912

Special Deputy State Engineer.

Made by. Traced from
Checked by. mounted maps
Traced by. Cosgrave.
2nd. Check by.

13

24:1



MADE BY Chas. H. Hoyt
TRACED BY G. Andrews
CHECKED BY Charles Kichon Aug. 1906

Final C. B. 8/13/06

Contract No. 27.

Champlain Canal Section 2.

From the highway at Dunhams Basin,
to the Hudson River at Fort Edward.

DETAILED LOCATION PLAN OF LOCK NO. 8.
STA. 1130+00 TO STA. 1146+00

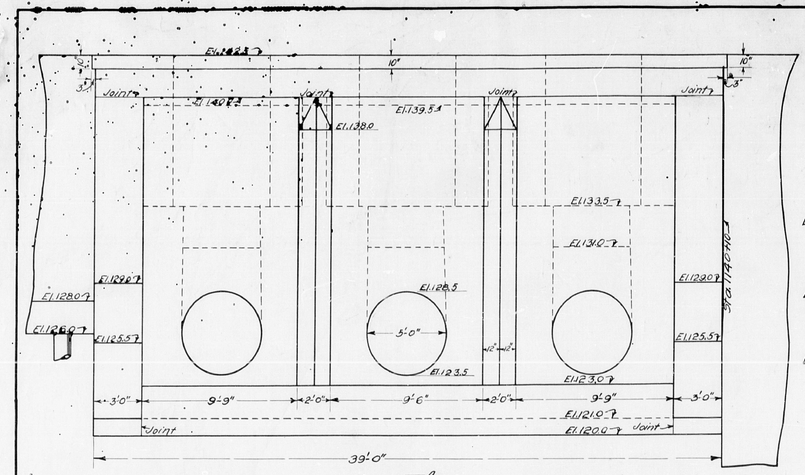
Scale: 50 feet to the inch.

Examined and approved
Special Deputy State Engineer

34

459

24:1


Joints
Joint
Joint
Joint

24:1

HUDSON RIVER

CHAMPLAIN CANAL

Spoil to El. 133.5 ±

Appropriation Line

Top of Bank

Shore Line

CONTRACT NO. 26

CONTRACT NO. 27

LIMIT OF CONTRACT NO. 27

P.T. 1249+46

P.T. 1246+24.4

3°44' Curve

P.C. 1245+ 80

3% Grade

El. 133.5

Center Line of Canal

Grade El. 117.0

Toe of Slope

12' Dyke El. 141.0

RAILWAY

T. M. DENNIS

CORTLAND ST.

C.A. SARGENT

S. SWEET

HENRY WALROOD

T.M. MONTGOMERY

ARGYLE

JOHN TATE

T. LYNCH-OLL

M. FITZGERALD

CHAS. COLEMAN

J.R. LAMB

Proposed Connection to Present Highway

Aqueduct

Bond Creek

HIRAM PARTRIDGE

WILLIAM BREESON

New Location of Highway

Spoil to El. 133.5

Berm El. 133.5

Grade El. 117.0

Top of Slope

Berm El. 133.0

P.T. 1227+63.3

16° 38' Curve

Spoil to El. 133.0

ALEX. BARCLAY EST.

Present Location of Highway

HUDSON

W.S. El. 138.4

Appropriation Line

Hudson Valley R.R.

Champlain Canal W.S. El. 138.1

L.W. El. 129.0

Grade El. 117.0

Grade El. 117.0

1247 1246 1245 1244 1243 1242 1241 1240 1239 1238 1237 1236 1235 1234 1233 1232 1231 1230 1229

1228 1227 1226 1225 1224 1223 1222 1221

PROFILE ON ℄ OF CANAL

Hor. 1" = 100'

Vert. 1" = 10'

MADE BY

TRACED BY

1ST CHECK BY

2ND CHECK BY 6/7/09

Contract No. 27.

ALTERATION NO. 7

SHEETS 98 TO 108 INC.

Champlain Canal Section 2

LOCATION MAP

STA. 1216 TO 1245

Scale : 100 ft. to the inch

Examined and approved

G. F. Stickney

Supervising Engineer

April 27 1909

Examined and approved

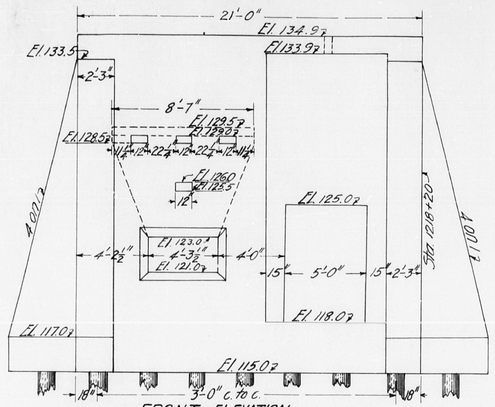
W. S. Sandelle

Special Deputy State Engineer

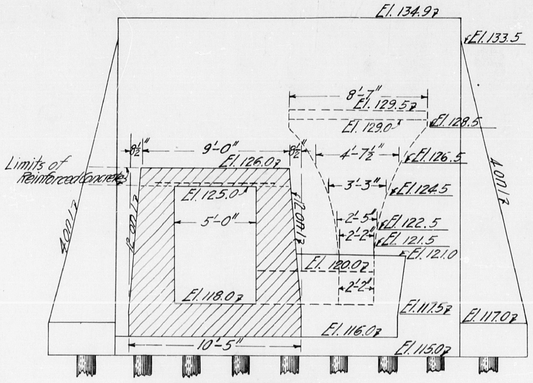
April 27 1909

98

522



FRONT ELEVATION



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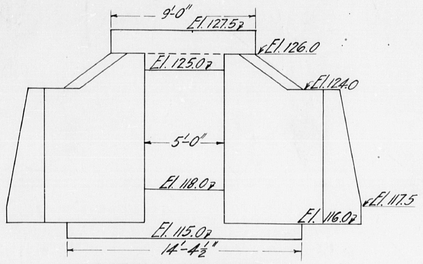
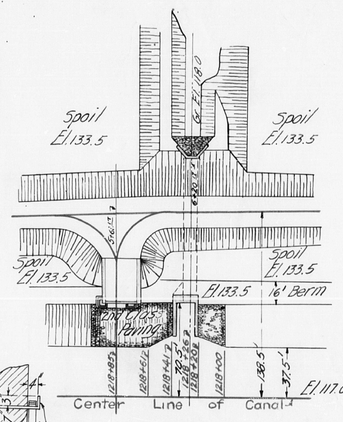
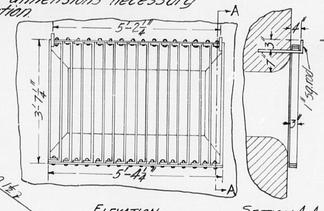


ELEVATION OF OUTLET

The bases of structures shown on any of the plans of this contract shall be considered as approximate only and may be ordered by the State Engineer in writing to be at any elevation and of any dimensions necessary to give a proper foundation.

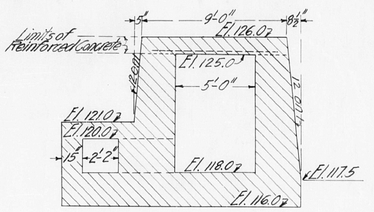


LAY OUT
Scale: 1" = 50'

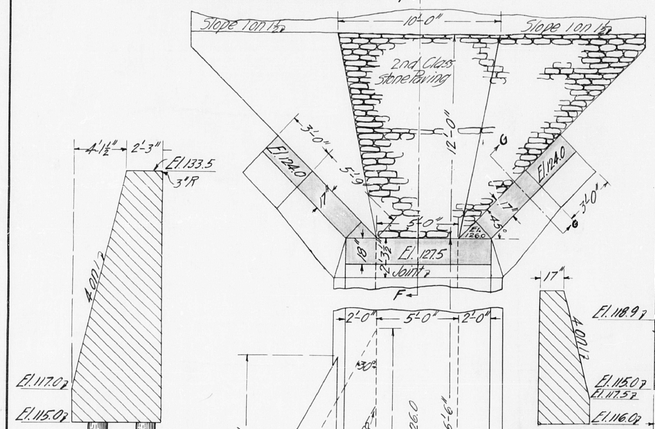


ELEVATION SECTION A-A

DETAIL OF GRATING



SECTION E-E



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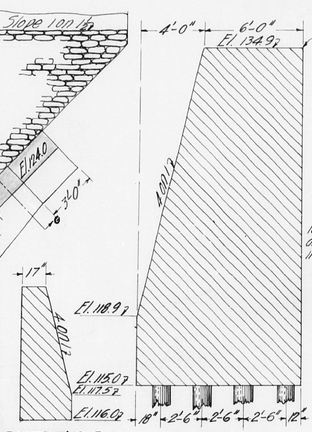
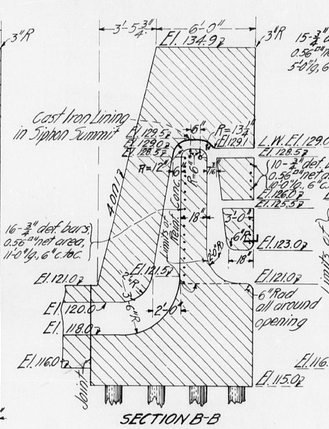
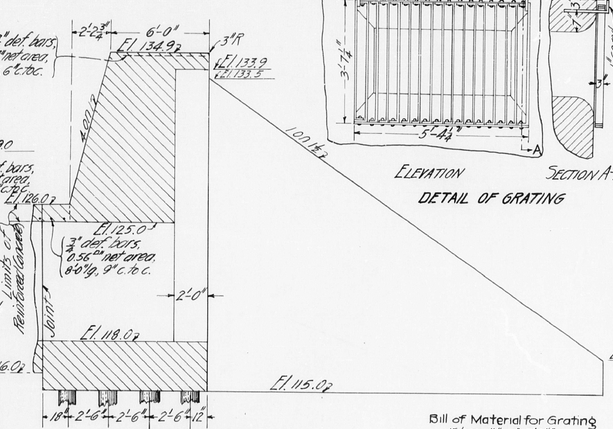


SECTION G-G

SECTION A-A

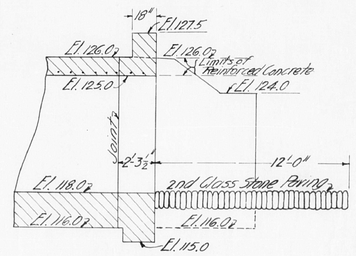


SECTION B-B

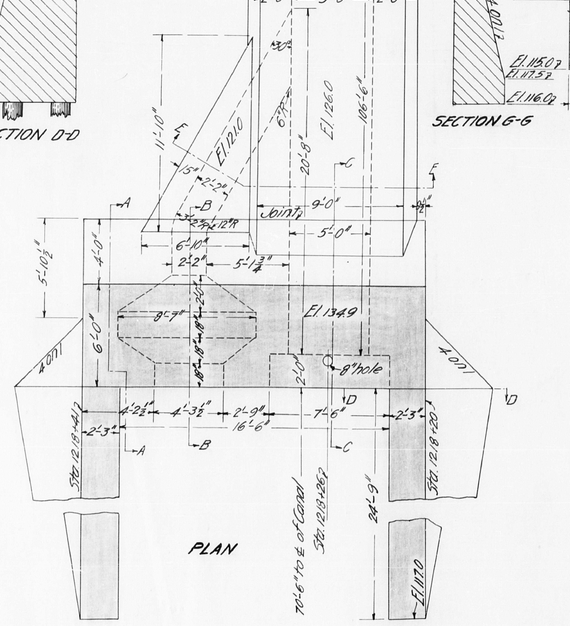


SECTION C-C

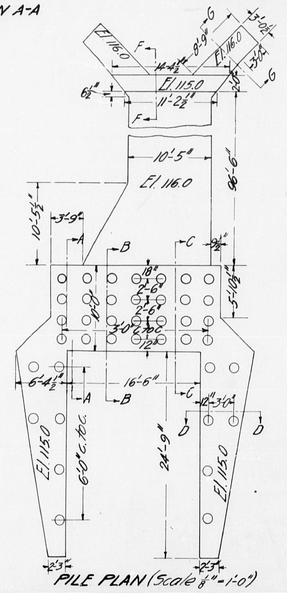
Bill of Material for Grating
15 bars ¼" x 3" x 3'-5⅝"
1 bar ¼" x 3" x 3'-10¾"
1 " ¼" x 3" x 3'-9"
2 bars ⅜" x 3" x 5'-4⅝"
32 - ½" rivets
2 - 1" sq. bars 21⅛" long



SECTION F-F



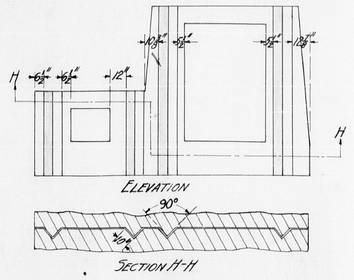
PLAN



PILE PLAN (Scale ⅛" = 1'-0")

All masonry on this sheet to be second class concrete unless otherwise noted.
All masonry in partition wall of siphon between El. 121.0 and El. 129.0 in the slab of sluiceway to be reinforced concrete.
All exposed edges of concrete to be rounded to a radius of one inch unless otherwise shown.
Vertical joints to be spaced not over forty feet.
Length of round piles to be determined by test driving according to specifications.
Piles to be of Class B.
All metal reinforcement shall be of deformed bars of minimum cross-section given. The size and spacing may be changed slightly, provided the total net section of steel remains unchanged.
For detail of Sluice Gates and Supports, see Sheet # 76
" " " Cast Iron Lining of Siphon Summit see Sheet # 94

DETAIL OF JOINT



ELEVATION

SECTION H-H

MADE BY H.G. Weller
TRACED BY A.W. Thayer
CHECKED BY Buckhams
2nd CHECK BY Hawley

Contract No. 27.

ALTERATION NO. 7 SHEETS 98 TO 108. INC.

Champlain Canal Section 2

DETAIL PLAN OF SIPHON SPILLWAY STA. 1218+26

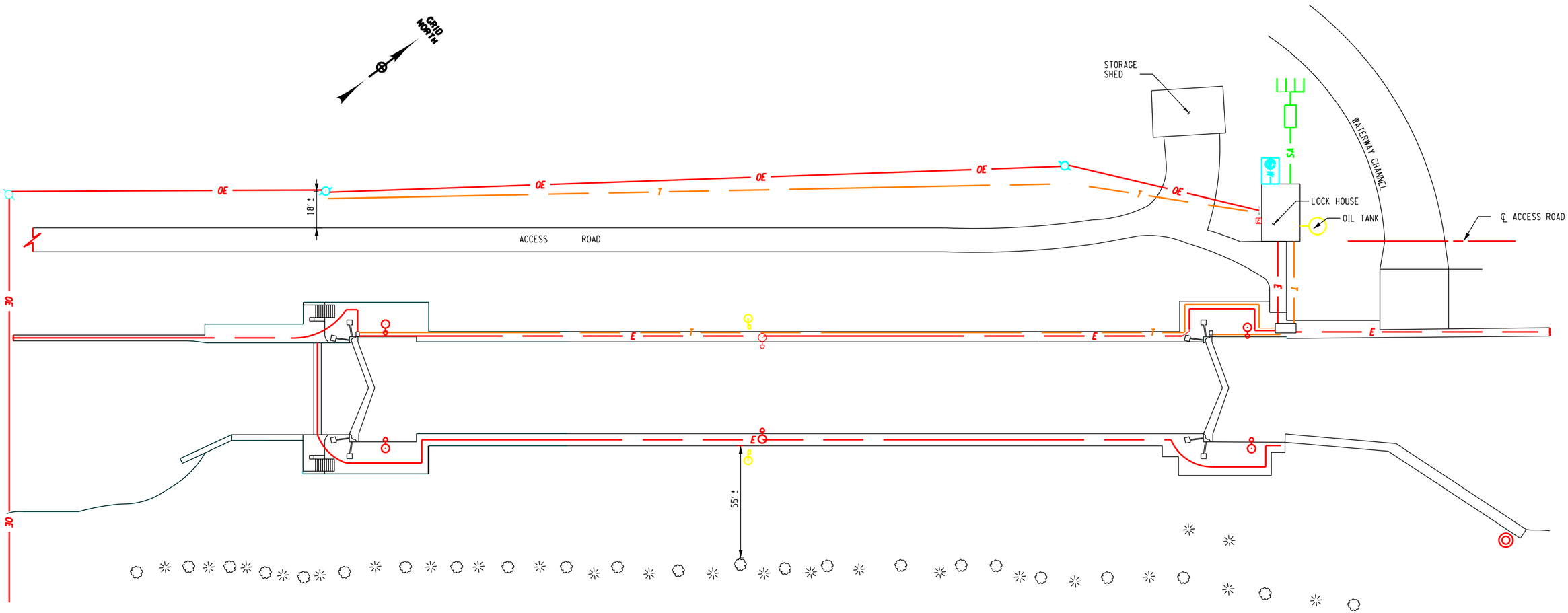
Scale: 4 feet to the inch, except as indicated

Examined and approved
E. F. McKinney
Supervising Engineer
June 12 1924

Examined and approved
Wm. B. Landreth
Special Deputy State Engineer.
June 12 1924

101

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON



LOCK C-8	
UTILITY PROVIDERS	
ELECTRIC	NATIONAL GRID US
ACCOUNT NO	64690-38208
METER NUMBER	05 519 568
PHONE	VERIZON
ACCOUNT NO	518-747-5520
WATER	WELL
SEWER	SEPTIC TANK
HEATING	ELECTRIC (S.SHED) AND OIL (LOCK HOUSE)

25 0 25 50 75 100'
1" = 50'

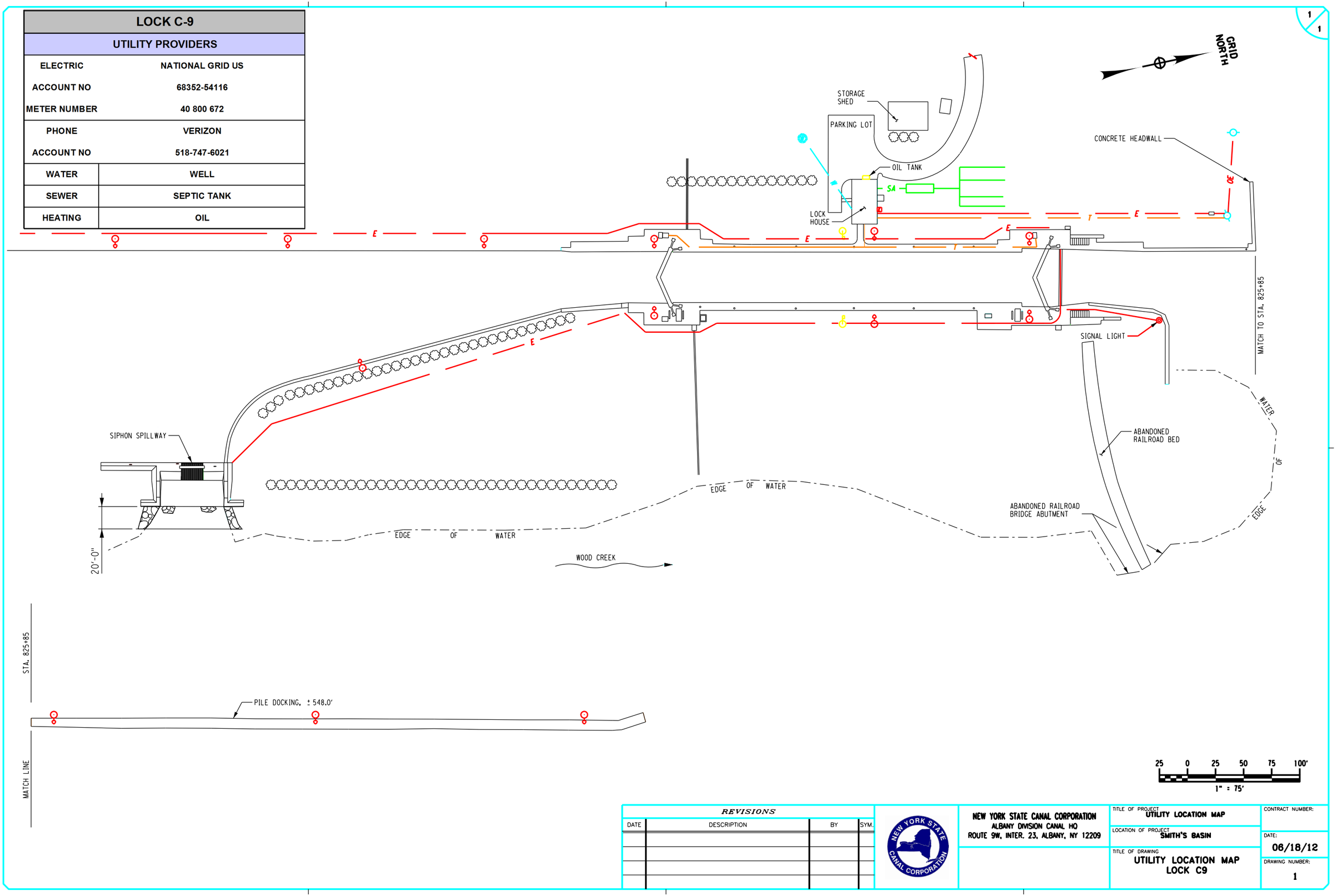
REVISIONS

DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP
LOCATION OF PROJECT: FORT EDWARD
TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C8
CONTRACT NUMBER:
DATE: 06/17/12
DRAWING NUMBER: 1

LOCK C-9	
UTILITY PROVIDERS	
ELECTRIC	NATIONAL GRID US
ACCOUNT NO	68352-54116
METER NUMBER	40 800 672
PHONE	VERIZON
ACCOUNT NO	518-747-6021
WATER	WELL
SEWER	SEPTIC TANK
HEATING	OIL



DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
APPROVED BY: A.DENNISTON

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP
LOCATION OF PROJECT: SMITH'S BASIN
TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9

CONTRACT NUMBER:
DATE: 06/18/12
DRAWING NUMBER: 1

Appendix C – Invasive Species Inventory Report and Matrix

Champlain Canal Invasive Species Barrier Study
Existing Conditions Report - Invasive Species Inventory

Prepared for:

U.S. Army Corps of Engineers
New York District,
26 Federal Plaza, Room 1843
New York, NY 10378

Prepared by:

Princeton Hydro, LLC
1108 Old York Road, Suite 1
P.O. Box 720
Ringoes, New Jersey 08551
(P) 908.237.5660
(F) 908.237.5666
www.princetonhydro.com
Offices in New Jersey, Pennsylvania and Connecticut

February 2019

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Primary Authors:
Emily McGuckin, Nick Niezgoda, Paul A. Cooper, Jesse Smith, and Jack Szczepanski, Ph.D.

1. Introduction

This report discusses the aquatic invasive species (AIS) that could potentially invade Lake Champlain from hydrologically connected waterbodies and other sources, in Section 2, and the aquatic invasive species that can currently be found in Lake Champlain, in Section 3. Each section is divided by the dispersal method used by each species listed. The dispersal methods include natural passive, anthropogenic passive, active, or a combination of the methods. Within the dispersal method sections, the identified species are split up by major taxa. High priority invasive species are denoted by the statement "*This is considered a high priority species."* and listed along with species of concern in Table 1.

The report also addresses species native to the Lake Champlain watershed to give a more complete picture of the ecosystem to be preserved. Consideration of the naturally extant species is important in evaluating any alternatives to be evaluated for AIS exclusion, especially with regard to threatened and endangered species of the region. Native species are discussed in Section 4.

1.1 Documentation

A number of documents listing native, non-native, and invasive species specific to Lake Champlain and other documents focusing on the Hudson River and the Great Lakes were reviewed and summarized herein. The documents reviewed include:

Boat Inspection and Decontamination for Aquatic Invasive Species Prevention prepared by Meghan Johnstone and Hilary Smith from the Adirondack Park Invasive Plant Program, Dr. Eric Holmlund from Paul Smith's College, Meg Modley from the Lake Champlain Basin Program, and Emily DeBolt and Kristen Rohne from the Lake George Association. It includes impacts of AIS and ways they might spread, management measures to prevent the spread of AIS, and possible next steps for the Adirondack Region.

Feasibility of Champlain Canal Aquatic Nuisance Species Barrier Options prepared by Mark Malchoff of Lake Champlain Sea Grant, J. Ellen Marsden from the University of Vermont, and Michael Hauser from Vermont DEC. This document outlines some of the known Lake Champlain aquatic nuisance species (ANS) and management measures used to control ANS populations.

Summary of the GLMRIS Report prepared by the United States Army Corps of Engineers. This document details ANS in the Great Lakes and the Mississippi River Interbasin.

Lake Champlain Basin Aquatic Nuisance Species Management Plan coordinated by Lake Champlain Basin Program, Vermont Department of Environmental Conservation, and New York State Department of Environmental Conservation. This document discusses ANS and potential,

non-native species in the Lake Champlain Basin and the need for early detection and monitoring of ANS species.

The Champlain Canal as a non-indigenous species corridor by J. Ellen Marsden and Bret J. Ladago. This scientific paper outlines a study done in the Champlain Canal and Lake Champlain where dewatered locks were sampled and collected species were documented and categorized as native or non-native in either the Hudson River or Lake Champlain.

Strategies for achieving ecological separation on the Champlain Canal by J. Ellen Marsden. This presentation outlines exotic fish, invertebrates, and plant species found in the Lake Champlain basin and how they entered the basin.

Champlain Canal Aquatic Invasive Species Stakeholder/Informational Meeting prepared by Mark Malchoff, Aquatic Resource Specialist, Lake Champlain Sea Grant, SUNY Plattsburgh, Hilary Oles, director of Adirondack Park Invasive Plant Program, and Meg Modley, Aquatic Nuisance Species Coordinator, Lake Champlain Basin Program. This presentation documents present and potential AIS in the Champlain Canal and the ecological impacts of these species.

The websites reviewed for this document include The IUCN Red List of Threatened Species, Fishbase.org, USGS NAS, and NOAA GLANIS. See Section 5 for a full list of references.

1.2 Dispersal Categorization

The AIS in this document are categorized by dispersal methods. Passive dispersal is denoted as movement of an organism from one location to another by means of an outside force, including by anthropogenic means. This includes any planktonic larvae or organisms that do not swim against the water current or sessile organisms that attach to objects like boats that travel through waterways. Active dispersal is defined as the deliberate movement of an organism from one location to another by that organism's own means.

Natural passive dispersal methods include drifting by water currents or wind, attachment to waterfowl, fish, or vegetation that carries the organism to a new location. Anthropogenic passive dispersal includes attachment to watercraft, fishing gear, and clothing. It also includes accidental introduction in bait buckets or ballast water or intentional introduction by stocking or release of the species into a waterbody. Active dispersal methods include swimming or moving from one location to another by the organism's own means.

1.3 General Habitat and Priority Species

The Lake Champlain Canal is classified as a New York Class C stream (best usage is fishing) and is fed by several other streams including Halfway Creek, Big Creek, Wood Creek, and the Mettawee River. The canal is bordered in multiple areas by state regulated wetlands, particularly in the areas adjacent to Ft. Ann, the area north of State Route 196, and the northern end of the Canal, which also lies adjacent to floodplain forests in the lower end of the Poultney River. Other portions of the Canal are bordered by forested/shrub wetlands and smaller amounts of freshwater emergent wetlands. The area adjacent to the State Route 196 crossing is also adjacent to a raptor winter concentration area. The southern end of the Canal features largely agricultural surrounding land-use in addition to the aforementioned wetlands. The northern portion of the Canal is surrounded mostly by deciduous and coniferous forests. Areas of relatively increased urbanization include Ft. Ann, Whitehall, and Comstock.

Marsden and Ladago (2017) provide lists of fish, mollusk, crayfish, and plant species present in the Dunham basin as of 2010-2011. These include native species such as American eel (*Anguilla rostrada*), brassy minnow (*Hybognathus hankinsoni),* and several native species of pondweed (*Potamogeton sp.*). It should be noted that other portions of the canal contain the state-listed threatened species Eastern Sand Darter (*Ammocrypta pellucida*), as well as the Buffalo pebblesnail (*Gillia altilis*), a species of special concern. The canal also already harbors populations of several invasive species such as zebra mussels (*Dreissena polymorpha*) and Eurasian water milfoil (*Myriophyllum spicatum*).

Thirteen (13) problematic species that are either present in Lake Champlain or have the potential to become established have been given larger attention. Populations of the nonindigenous spiny waterflea (*Bythotrephes longimanus*) and fishhook waterflea (*Cercopagis pengoi*) have been discovered in Lake Champlain within the last decade, hypothesized to have been introduced via transport on watercraft and/or fishing gear. Also present is the nonindigenous fish species alewife (*Alosa pseudoharengus*), an anadromous herring species that negatively impacts zooplankton populations, as well as the parasitic sea lamprey (*Petromyzon marinus*), known to reduce populations of gamefish such as lake trout (*Salvelinus namaycush*) (Fuller et al., 2019). While not known to be present in Lake Champlain, Eurasian ruffe (*Gymnocephalus cernuus*) and round goby (*Neogobius melanostomus*) have become established in the Great Lakes, putting regionally adjacent lakes such as Lake Champlain in danger of being invaded. Zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*, not yet in Lake Champlain) are prolific filter-feeders that deplete the water column of phytoplankton and foul water intake pipes.

Nonindigenous aquatic plants present in Lake Champlain include Eurasian watermilfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*), two highly prolific species that can form dense populations, impeding boat navigation and outcompeting native species. Hydrilla (*Hydrilla verticillata*), while not present in Lake Champlain, is a highly invasive plant species that often can grow to even denser populations than Eurasian watermilfoil. This plant can be very difficult to control once established. Lastly, the wetland plants purple loosestrife (*Lythrum salicaria*) and Japanese knotweed (*Fallopia japonica*) are established on the shorelines of Lake Champlain, as well as in several other locations throughout the state of New York.

2. Potential Invasive Species in Lake Champlain

2.1 Dispersal Method I: Passive Dispersal

2.1.1 Hydrozoa

Cordylophora caspia is a freshwater hydrozoan in the Cordylophoridae family. It is native to Asia and was introduced to the Great Lakes and the east and west coasts of the United States. It was first found in Lake Erie and it is a potential threat to Lake Champlain. It is found in fresh or brackish systems and prefers hard or rocky surfaces and colonies use rocks, pilings, and some mussel shells as substrate. The expansion of zebra and quagga mussels might be beneficial to *C. caspia* by providing substrate (Nalepa 2007). Its dispersal methods include natural passive dispersal by drifting through waterways in the larval stage and anthropogenic passive dispersal through ship ballast water (first introduction to North America).

2.1.2 Annelida

Ripistes parasita is an oligochaete worm. It is native to Eurasia and was introduced to Ontario, Michigan, Mississippi, New York, and the Great Lakes. It is a potential threat to Lake Champlain by competing with native species for resources. It is a freshwater species that prefers 6 - 10 meters of water and rocky substrate (Simpson and Lawrence 1984). Its dispersal methods include by natural, passive dispersal by drifting through waterways and anthropogenic, passive dispersal on watercraft or equipment.

2.1.3 Bivalvia

Atlantic rangia (*Rangia cuneata*), also known as the gulf wedge clam, is a bivalve in the family Mactridae. It is found north of Cape Hatteras to Florida and is native to the Gulf of Mexico. It was introduced to the northwest Atlantic and is a potential threat to Lake Champlain. It is typically found in estuaries and brackish water with low salinity, high turbidity, and soft substrate with vegetation (Benson 2010). Its dispersal method is mainly passive dispersal on watercraft or equipment which include ballast water and sediment contaminated with young clams on anchors and associated equipment.

Paper pondshell (*Anodonta imbecillis*) is a bivalve in the family Unionidae. It is a potential threat to Lake Champlain by displacing native species. It is a freshwater species that prefers quiet, small bodies of water or large rivers with quiet backwaters and eddies. *A. imbecillis* is hermaphroditic and the larvae are discharged into the water and attach to a host on the fins or gills by glochidium which contain hooks and suckers. Host species include various centrarchids (sunfishes and black basses). The planktonic larvae disperse naturally by drifting through waterways. They prefer a substrate of sand and fine sediment (Henley, Patterson, Neves, Lemly 2000).

2.1.4 Crustaceans

2.1.4.1 Copepoda

Eurytemora affinis is a calanoid copepod in the family Temoridae. It is native to North America and Asia and is found in many states in the United States and is a potential threat to Lake Champlain because *E. affinis* can undergo relatively rapid evolution, exhibiting heritable shifts in tolerance and performance with respect to survival in freshwater habitats (Lee et al. 1999). It is found in estuaries, saltmarshes, brackish, and fresh systems and prefers lakes, ponds, and reservoirs (Lee 1990). Its dispersal methods include natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment.

Skistodiaptomus pallidus is a calanoid copepod in the family Temoridae. It is native to North America and is found in the Great Lakes, the southern states on the east coast, California and Nevada. It was first recorded in Lake Ontario in 1967 and is a potential threat to Lake Champlain. It has also been known to attain very high densities in suitable habitats, reaching 10,000 per m3 in a Lake Erie marsh to unknown consequences (Krieger and Klarer 1991) It is a freshwater species that is found in lakes and eutrophic habitats and it can tolerate high turbidity. It is an omnivorous predator and might be the intermediate host for the parasitic worm *Tanaorhamphus longirostris* (Williamson and Butler 1986). Its dispersal methods include natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment (Mills 1993, Torke 2001, Lesko 2003, Williamson, 1988).

2.1.4.2 Decapoda

Chinese mitten crab (*Eriocheir sinensis*) is a crustacean in the Varunidae family. It is native to Asia and was introduced to the west coast of the United States, the Great Lakes, and the Chesapeake Bay. It is currently found in the Hudson River and the St Lawrence River and is a potential threat to Lake Champlain. It is a freshwater, catadromous species and returns to the ocean to breed. *E. sinensis* can easily walk on land or across dams and obstructions will not impede them. It preys on small invertebrates, is a nuisance to anglers, and is the intermediate host to Oriental lung fluke, a mammalian parasite. Its dispersal methods include walking on dry land and migrating through water (up to 11 miles per day). It has also been introduced through ballast water discharge and commercial recreation boating activities (Benson and Fuller 2018).

White river crawfish (*Procambarus acutus*) is a crustacean in the Cambaridae family. It is native to North America and can be found from Maine to Georgia, the Florida panhandle to Texas, Minnesota and Ohio. It has been found in the Hudson River drainage and Maine and is a potential threat to Lake Champlain by outcompeting indigenous species. It is a freshwater species that prefers shallow, vegetated waters and can be found in moderately flowing streams and permanent lentic bodies. It is dark red with long claws and has a black v-shaped stripe on the abdomen. Its dispersal methods include natural passive dispersal by larvae drifting through waterways and anthropogenic passive dispersal on watercraft or equipment, as well as mature individuals traveling along substrate.

2.1.5 Plants

Brazilian elodea (*Egeria densa*) is a plant species in the family Hydrocharitaceae. It is native to South America and was introduced to the United States. It was found in the Pacific Northwest, California, Utah, Illinois, Nevada, Kansas, Texas and the east coast. It is a potential threat to Lake Champlain. It is a freshwater, submerged species that prefers lakes or ponds in still and flowing water and grows in thick mats of intertwining stems (WSDA 2015). *E. densa* reproduces vegetatively in dense thick mats that can become fragmented by boat trailers and boat propellers and then "hitchhike" to new bodies of water where it can then reproduce from the transported fragments (Parsons and Cuthbertson 2001).

Hydrilla (*Hydrilla verticillata*) is a plant species in the Hydrocharitaceae family. It is native to Eurasia and was introduced to the United States and is considered noxious. It was first found in the Erie Canal and is a potential threat to Lake Champlain. It is a freshwater species found in slow flowing, shallow water and is tolerant to heavy metals. It spreads rapidly and is difficult to control. It is capable of clogging waterways, can alter the physical and chemical characteristics of lakes, and shade out other plant species (Bates and Smith 1994). It can outcompete native plants due to its ability to use low light. This allows it to capture most of the carbon dioxide that has entered the water over night. Under water the availability of carbon dioxide often limits plant growth. Hydrilla produces structures called "turions" and "tubers" that can break off the stem and drift for long distances before sinking and starting a new plant. Tubers can survive from 4-7 years in the sediment before sprouting, and one tuber can produce several hundred other tubers during a growing season (Henry 2017). *This is considered a high priority species..*

Indian swamp grass (*Hygrophila polysperma*) is a plant species in the family Acanthaceae. It is native to Asia and is found in states on the east coast of the United States and from Florida to Texas. It is was first found in Delaware in 1985 and was accidentally released from the aquarium industry (Cuda 2000). It is a freshwater species that grows in ditches, marshes and lakes. *H. polysperma* is a rhizomatous perennial that grows up to 1.8 m tall and has bluish-white flowers. It disperses naturally via vegetative fragmentation and has high regrowth potential from the stem fragments that can attach to wildlife moving between water bodies or on recreational boating equipment. It can easily crowd and shade out native plants very much like Hydrilla due to a similar dense, mat-like growth pattern (Hall 2003).

Parrot's feather (*Myriophyllum aquaticum*) is a plant species in the Haloragaceae family. It is native to South and Central America, but is found in the coastal United States and the Great Lakes and it is a potential threat to Lake Champlain. *M. aquaticum* is a freshwater species that prefers subtropical regions and alkaline waters, shallow wetlands, slow streams, reservoirs, canals, lakes, and ponds. It can outcompete native plants. It was first found in the 1800s and was used as an ornamental plant in ponds. It reproduces by fragmentation, has rhizomatous roots and can be dispersed by natural passive dispersal by drifting through waterways attachment to wildlife or on watercraft or equipment (CAIP 2010).

Reed sweetgrass (*Glyceria maxima)* is a plant species in the Poaceae family. It is native to Eurasia, but was introduced to the Great Lakes, Wisconsin, Michigan and Illinois. It was first found in Lake Ontario in the 1940s and is a potential threat to Lake Champlain. It is a freshwater species that can be found in wetlands,

marshes, and shorelines. It prefers direct sunlight and shallow water. When it is near open water, *G. maxima* can form dense mats and can outcompete and shade out many wetland plants (Campbell 2010). Its dispersal methods include the drifting of seeds or rhizomes that rapidly establish into monocultures. A single plant may produce up to 100 shoots and 30 m of rhizome in its first 2 years of growth. *G. maxima* is a perennial plant, requiring 2 to 3 years of treatment before complete control is gained. Management includes hand pulling all parts of the plant or spraying a 3% solution of glyphosate in the early summer to control the population (King County 2012).

Salvinia (*Salvinia spp.*) is a floating fern in the Salviniaceae family. It is native to North America and is widely distributed in the southern United States and now some parts New York. It is a freshwater species found in lakes, ponds, slow streams, rivers, ditches, swamps, and marshes. It forms dense mats on the water surface, shading out other species (Divakaran 1980). It disperses via natural passive dispersal by fragmentation of the buds on the stems. Previous management includes introduction of *Cyrtobagous salviniae,* a subaquatic beetle whose larvae tunnel within the rhizomes causing them to disintegrate. Larvae also tunnel in the buds and adults eat buds, thus suppressing growth and vegetative propagation of this Salvinia (Thomas and Room 1986).

Common or Giant Reed (*Phragmites australis*) perennial, terrestrial; freshwater species will occur in most wetland habitats. It grows 1-6 meters tall, and forms dense stands which include both live and standing dead stems from previous year's growth. Forms a dense network of roots and rhizomes that can extend downward over a meter. It was likely introduced via solid ballast and/or packing material from shipping. It has been intentionally introduced to some locations as a filter plant in wastewater treatment lagoons and used for erosion control (Swearingen and Saltonstall 2010). Phragmites crowds out most other plants where it grows after proliferating and forming large monoculture stands.

Curly Leaf Pondweed (Potamogeton crispus L.) is a submerged aquatic plant that in colder waters produces turions that break dormancy in the fall when water temperatures drop and the plant survives the winter as a whole, intact leafy plant (even under thick ice and snow) then rapidly grow in spring (Tobiessen and Snow 1984). Native to Eurasia and had established in Lake Champlain in the late 1980s. The species has spread across much of the United States, presumably by migrating waterfowl, intentional planting for waterfowl and wildlife habitat, and possibly even as a contaminant in water used to transport fishes and fish eggs to hatcheries. It outcompetes native species for light and space early in growing season often reducing plant diversity (ENSR Int 2005 & WI DNR 2012).

2.1.6 Algae

Stephanodiscus binderanus is a diatom (Bacillariophyceae) in the Stephanodiscaceae family. It was initially identified as a non-native invasive introduced to the Great Lakes from Eurasia; however, recent lake core data show that this species was present in nearby (less than 50 kilometers away) Lake Simcoe since at least the seventeenth century (Hawryshyn et al. 2012). The recent increase in abundance of this species in the Great Lakes has been attributed to changing environmental conditions—namely, eutrophication—which makes it appear to have been recently introduced. As a freshwater species that proliferates in

slightly brackish waters, it is tolerant of osmotic variability. Additionally, it requires silica for growth and construction of the cell wall. Its dispersal methods include natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment however, for many rare diatom species, additional intensive sampling will likely show that they have a wide geographical distribution (Finlay et al. 2002). It actively competes with native diatoms and has reduced those native populations in some of the Great Lakes. It also clogs water ways and causes taste and odor problems in the drinking water. Previous management has included reducing nutrient run-off and pollution in systems to decrease the abundance of the *S. binderanus* populations.

Grass kelp (*Enteromorpha flexuosa)* is a green algae species in the family Ulvaceae. It is a widespread species that occurs all over the world in both coastal and inland waters. It was first found in Muskegon Lake in Michigan in 2003 and is now found in the Mississippi River. It is a potential threat to Lake Champlain. Despite being a marine species, it can tolerate fresh systems. *E. flexuosa* prefers the littoral zone of waterbodies (Lougheed and Stevenson 2004). Areas containing high nutrient concentrations can result in blooms which affect recreation and has been associated with the extirpation of red algae in Europe. Its dispersal methods include the zoospores surviving in ship ballast water and passive dispersal on watercraft or boating equipment. Management of *E. flexuosa* includes reduction of nutrient runoff and pollution to decrease the abundance of the alga (Lougheed and Stevenson 2004, Schories et al. 1997).

Bangia atropurpurea is a red algae species in the Bangiaceae family. It is native to the Atlantic Coast, but was introduced to the Great Lakes and the surrounding states and Ontario. It was first found in Lake Superior in 1944 and is now found in the Mississippi River. It is a potential threat to Lake Champlain if nutrient run-off accumulates resulting in a harmful algae bloom. It can tolerate both fresh and marine systems, create hypoxic conditions, and is found in the littoral zone of the Great Lakes. This alga likely disperses on watercraft or ballast water. Recent genetic analysis indicates that Great Lakes B. atropurpurea came from a European freshwater source (Shea et al. 2014). Management of *B. atropurpurea* includes reduction of nutrient runoff and pollution to decrease the abundance of the alga.

2.1.7 Bacteria

Filamentous sulfur bacteria (*Thioploca ingrica*) is a bacterium in the family Thiotrichaceae. It is native to South America but is a potential threat to Lake Champlain because of their impact on nitrogen and phosphorus dynamics after forming widespread, dense bacterial mats. It poses a threat to aquatic communities due to the fluctuation of phosphorus and nitrogen. The dense mats formed could shade out plant species. It most likely disperses in a natural passive way via water currents (JGLR 2002)

Cylindrospermopsis raciborskii is a cyanobacteria in the family Nostocaceae. It is found in tropical regions, but is also found in the Great Lakes and is a potential threat to Lake Champlain. It has been linked to fish kills, zooplankton reduction, and increased toxicity in shellfish (De Souza et al. 1998, Saker et al. 1999b, Thomas et al. 1998). Its dispersal methods include anthropogenic passive dispersal by attaching to boats or fishing equipment, Migratory birds can transport akinetes in its feet and guts, while imported tropical fishes may carry the vegetative from of *C. raciborskii* or by natural passive dispersal by drifting in the water

currents or the wind (Hong et al 2006.).

2.1.8 Other Pathogens

Heterosporis sutherlandae is a microsporidian parasite that is known to infect the skeletal muscles of susceptible fish hosts that are exposed to the parasitic spores by consumption of an infected host or spores in the water column (IDNR 2005, Sutherland 2002, Sutherland et al. 2004). They are believed to be native to Eurasia. It was first found in 1990 in the Great Lakes and was later found in 26 other lakes in Minnesota, Wisconsin, Michigan and Ontario. It can be dispersed via natural passive dispersal through infected fish or contaminated water and has been seen in yellow perch, walleye, pike, perch, burbot, pumpkinseed, sculpin, and rock bass (IDNR 2015).

Spring viremia of carp, also known as Swim Bladder Inflammation, is a disease of various fishes caused by *Rhabdovirus carpio* virus. It is native to Europe and the Middle East and was found in North Carolina in 2002, in Wisconsin in 2004, and Lake Ontario in 2006 (CFSPH 2007, Cipriano et al. 2011, Garver et al. 2007, MDNR 2012). It is a potential threat to Lake Champlain. It affects carp, pike, guppies, zebrafish, and pumpkinseed and is considered a major threat of infection to native fish populations. It disperses naturally and passively through contaminated water.

Viral hemorrhagic septicemia (*Novirhabdovirus spp.*) is a viral pathogen in the Rhabdoviridae family. It was first found in the Great Lakes in 2009 (Elsayad et al. 2006) and is found in the Mississippi River. It is a potential threat to Lake Champlain's native fish populations. It disperses via natural passive dispersal by drifting down waterways.

Whirling disease (*Myxobolus cerebralis*) is a protozoan in the family Myxobolidae. It is native to Europe but was first found in Pennsylvania and has spread since then. It was first found in 1968 in the Lake Erie drainage and it is a potential threat to Lake Champlain. It is caused by an invasive parasite, which affects salmonid fish. It penetrates the spinal cartilage of fish, causing fish to swim erratically due to infection of nervous system (Mills et al. 1993; Crawford 2001; Gilbert and Granath 2003; Krueger et al. 2006). It can survive in water as cold as -20°C. It disperses in a natural passive method through the infection of various hosts.

2.2 Dispersal Method II: Active Dispersal

2.2.1 Bivalvia

Wabash pigtoe (*Fusconaia flava*) is an invertebrate species in the Unionidae family. It is native to some parts of North America. It has been found in the Erie Canal and probably migrated in naturally (Benson 2018) from its native range from South Dakota to Louisiana to the west. It is a potential threat to Lake Champlain by outcompeting other species for resources. It is a freshwater species that prefers river systems. It disperses via natural, active dispersal by larval forms swimming to new water bodies.

2.2.2 Fish

Bighead carp (*Hypophthalmichthys nobilis*) is a fish species in the Cyprinidae family. It is native to Asia and was introduced to North America. It is identified by its protruding lower jaw. It is a freshwater species that inhabits water with high water level fluctuations. *H. nobilis* prefers large rivers, but can survive in ponds and lakes. It is currently found in the Illinois River and the Great Lakes and is a potential threat to Lake Champlain. Previous management included electrical barriers starting in 2002 to prevent the spread into the Great Lakes. It disperses via active dispersal by traveling to new water bodies. *H. nobilis* spawns during floods (Anonymous 1994).

Grass carp (*Ctenopharyngodon idella*) is a fish species in the Cyprinidae family. It is native to Asia and is found in most states in the United States, but not present in Vermont yet. It was first found in 1985 in Auger Lake, New York and is a potential threat to Lake Champlain. It is believed that *C. idella* was accidentally released from an aquaculture facility. It is a freshwater species that prefers quiet, vegetated areas, but reproduces in fast, well-oxygenated waters (Mitzner 1978; Nixon and Miller 1978; Bain et al. 1990). It is also tolerant of low salinity levels. *C. idella* lacks a sucker-like mouth and barbels and is silver-white in color. It was first brought to the United States in 1963 to aquaculture facilities (Courtenay et al. 1984). It competes for food with native species and might indirectly affect other organisms by altering the habitat because of the amount of vegetation they consume. It disperses actively by freely swimming from one location to another. Sterile triploid fish are widely stocked throughout the United States to control nuisance aquatic macrophytes (DeVaney et al. 2009).

Eurasian ruffe (*Gymnocephalus cernuus*) is a fish species in the Percidae family. It is native to Eurasia, but is found in the Great Lakes. It is a freshwater species and the adults are found in the benthic zone. It prefers turbid waters with soft bottoms and little to no vegetation (Kolar et al. (2002). It was first found in 1986 in Lake Superior and the Mississippi River and is a potential threat to Lake Champlain. *G. cernuus* is a threat to sport fish populations, competes with native species, and is a threat to recreational and commercial fisheries because of its very fast growth rate, high reproductive capacity and adaptation to a wide variety of environments. It disperses actively by swimming to new water bodies. *This is considered a high priority species.*

Northern snakehead (*Channa argus*) is a fish species in the family Channidae. It is native to Asia, but was found in the Delaware River and is a potential threat to Lake Champlain because of its ability to inhabit a wide range of aquatic environments (Herborg et al. 2007) and its rapid establishment. It prefers shallow, vegetated freshwater systems and is able to jump out of the water when startled. It does not have natural enemies, has sharp teeth, and is light brown in color. It is an obligate air-breather, capable of survival in poorly oxygenated waters (Courtenay and Williams 2004), and can outcompete native fish species. Humans introduced *C. argus* by means of unauthorized intentional release from aquariums or live food markets. It disperses actively by freely swimming from one location to another and has been introduced to waterbodies as well.

Oriental weatherfish (*Misgurnus anguillicaudatus*) is a freshwater fish in the Cobitidae family. This fish is

native to Eastern Asia from Siberia south to northern Vietnam, including Japan (Berg 1949; Masuda et al. 1984; Talwar and Jhingran 1992). The Oriental weatherfish is found in muddy or silty substrates in low-gradient, shallow water, often in aquatic macrophyte beds (Tabor et al. 2001; Schmidt and Schmidt 2014). This species is highly tolerant to extreme conditions or marginal habitat quality, and can withstand desiccation and starvation for more than 81 days. (Koetsier and Urquhart 2012). It is also estimated that the critical thermal minimum of this species is -1°C and -2°C and reported survival of experimental fish partially of or fully encased and in direct contact with ice (Koetsier and Urquhart 2014a). It has been reportedly been introduced through aquarium releases in several locations and has become established in NY as a result of introduction through the Hudson River (USEPA 2008).

Silver carp (*Hypophthalmichthys molitrix*) is a fish species in the Cyprinidae family. It is native to Asia, but was introduced to the United States and by the mid-1970s the silver carp was being raised at six state, federal, and private facilities. By 1980 the species was discovered in natural waters, probably as a result of escapes from fish hatcheries and other types of aquaculture facilities (Freeze and Henderson 1982). It has been found in the Great Lakes and the Illinois River and is a potential threat to Lake Champlain. It is a freshwater species that is sensitive to low temperatures and oxygen depletion. It disperses actively by swimming to new water bodies. The IUCN Red List Status of *H. molitrix* is near threatened (IUCN).

Tubenose goby (*Proterorhinus marmoratus*) is a fish species in the family Gobidae. It is native to Eurasia, but was introduced to the United States. It is currently found in Lake Erie and Lake St Clair (Jude 1993) and is a potential threat to Lake Champlain because of their tenacious ability to outcompete native species for limited resources. It is found in marine, brackish, and estuarine systems and prefers shallow water and rocky substrate and overwinters in deeper waters. It is often confused with the round goby, but *P. marmoratus* has a single, round pelvic fin, is brown in color, and has light black stripes on the dorsal fin. It disperses actively by swimming to new water bodies.

2.3 Dispersal Method III: Active and Passive Dispersal

2.3.1 Bivalvia

Green floater (*Lasmigona subviridis*) is an invertebrate species in the family Unionidae. It is native to some parts of North America and can be found from Cape Fear (North Carolina) to the Hudson River and the St Lawrence River, South Carolina, North Carolina, West Virginia, and Virginia. It has now been found to the north in Lake Ontario and is a potential threat to Lake Champlain, where it has yet to occupy. It is a freshwater species and is found in small, quiet streams with gravel or sandy bottom (Bogan 2002, Harman 1970, Howard and Cuffey 2006, Strayer 1993). It disperses actively by larval forms freely moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats and equipment.

2.3.2 Gastropoda

Liver elimia (*Elimia livescens*) is a snail species in the family Pleuroceridae. It is native to North America

and is native to Vermont, the St Lawrence River, and the Great Lakes. It can be found in Quebec, Ohio River, Illinois River, and the Erie Canal (Burch 1989). It is established in the Erie Canal and is a potential threat to Lake Champlain where it has yet to occupy. It is a freshwater species that prefers substrates of silt, sand, gravel, cobble, and boulders. It is most likely dispersed actively via moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats, equipment, and humans (Benson 2018) and could outcompete native species.

New Zealand mudsnail (*Potamopyrgus antipodarum*) is a snail species in the Hydrobiidae family. It is native to New Zealand and was introduced to North America. It has been found in Idaho, the Colorado River and the Great Lakes, including Lake Erie and Lake Ontario. It is a potential threat to Lake Champlain by outcompeting native species. It is found in fresh and marine systems and prefers shallow, slow water. It disperses actively by freely moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats, equipment, and humans (River Alliance of Wisconsin 2017).

Piedmont elimia snail (*Elimia virginica*) is a snail species in the Pleuroceridae family. It is found in many of the states on the east coast and is now a potential threat to Lake Champlain. It is a freshwater species that prefers large rivers, smaller streams, northern lakes, and waterways with hard substrate (Smith 1980). It is most likely dispersed actively via moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic, passive dispersal on boats, equipment, and humans.

Ridged lioplax (*Lioplax subcarinate*) is a snail species in the Viviparidae family. It is native to North America and can be found on the east coast of the United States from New York to South Carolina. It is a potential threat to Lake Champlain. It is a freshwater species that prefers river drainages and lakes. It is most likely dispersed actively via moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats, equipment, and humans (IUCN).

2.3.3 Crustaceans

2.3.3.1 Mysida

Bloody-red shrimp (*Hemimysis anomala*) is a mysid shrimp species in the Mysidae family. It is native to the Black, Azov, and Caspian Seas, but is found in the Great Lakes and the surrounding states. It was first found in Lakes Michigan and Ontario in 2006 and is a potential threat to Lake Champlain. The European introductions resulted in mild to severe modification of existing habitats and food webs, causing extinction of local species in some instances. It is a freshwater species that prefers slow moving water with hard substrates and is usually found near shore, but can be found in up to 50 meters of water (Salemaa and Hietalahti 1993). It is similar in appearance to a native mysid *Mysis diluviana*. Impacts on the lower food web in Europe have shown that the combined effect of high densities and high feeding rates led to a reduction of both algal and zooplankton biomass. It disperses via active by freely swimming from one location to another and via anthropogenic, passive dispersal by attaching to boats, equipment and

humans.

2.3.3.2 Cladocera

Fishhook waterflea (*Cercopagis pengoi*) is an invertebrate species in the family Cercopagididae. It is native to the Mediterranean Sea, but was introduced to Michigan, Illinois, New York, Ohio, Pennsylvania, and Wisconsin. It is established in Lake Ontario and it is a potential threat to Lake Champlain. It is found in fresh and brackish systems and lakes. It disperses actively by freely moving from one location to another and via anthropogenic passive dispersal by attaching to boats, equipment, and humans. *C.pengoi* competes directly with other planktivores and is not as palatable to predators due to long spine making it easier it to establish populations (Bushnoe et al. 2003). *This is considered a high priority species..*

2.3.3.3 Amphipoda

Gammarus daiberi is an amphipod species in the Gammaridae family. It is native to Eurasia but has a wide distribution and is a potential threat to Lake Champlain by competing for resources with indigenous species. It is a freshwater species that is euryhaline, thus able to withstand a wide range of salinity. It is most likely dispersed actively via moving from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats, equipment, and humans.

Echinogammarus ischnus is an amphipod species in the Gammaridae family. It is native to Europe and was introduced to the Great Lakes, Detroit River, Mississippi River, and Ohio River. It was found in Lake Erie in 1993 and is a potential threat to Lake Champlain. It is a freshwater species that occurs in shallow parts of running and still waters. It is an omnivore and crawls on the bottom. It disperses actively by freely swimming from one location to another and by natural passive dispersal via drifting through waterways and by anthropogenic passive dispersal on boats, equipment, and humans (Witt et al. 1997).

2.3.3.4 Arguloida

Japanese fishlouse (*Argulus japonicus*) is a species of fish lice in the Argulidae family. It is native to Asia and was introduced to the much of the United States and the Great Lakes and is a potential threat to Lake Champlain. It was probably introduced via *Cyprinus auratus* (goldfish), a host species, through the aquarium industry (Mills et al. 1993). *A. japonicus* is found in the planktonic, oligohaline, and limnetic zones of fresh systems with unstructured bottom. It is a parasitic copepod that can swim from one fish to another. It is known to parasitize catfish in Lake Michigan and can potentially effect rainbow trout populations through ectoparasitism (Lamarre and Cochran 1992). It is most likely dispersed actively through parasitic attachment and by anthropogenic passive dispersal on boats and equipment.

3. Present Invasive Species in Lake Champlain

3.1 Dispersal Method I: Passive Dispersal

3.1.1 Bivalvia

Asian clam (*Corbicula fluminea*) is a clam species in the Corbiculidae family. It is native to Asia and is a non-native, invasive species in Lake Champlain. It is a fresh and marine species that occurs in rivers, lakes, and pools of fresh and brackish water. It is often found near estuary mouths. It prefers sandy, mud substrate. It was first introduced to Lake Champlain in 2010. In 2010, benthic barrier mats were used in Lake George to cut off oxygen supply to smother the clams and over 99% were killed. Its dispersal methods include natural passive dispersal by larval forms drifting through waterways and anthropogenic passive dispersal of larger individuals on watercraft or equipment (Isom 1986). *C. fluminea* is thought to be associated with algal blooms and might change the benthic substrates (Sickel 1986).

European fingernail clam (*Sphaerium corneum*) is a clam species in the Sphaeridae family. It is native to Europe and was introduced to North America and is found in the St Lawrence River system, Kentucky, New York, Vermont, and Quebec and Ontario in Canada. *S. corneum* is a freshwater species that inhabits pools, lakes, rivers, and streams. It is found in the demersal zone, up to 40 meters deep, and is tolerant to moderate pollution, but not to desiccation. It is dispersed naturally and can attach to amphibians to be dispersed (Kwet 1995, Petkeviciutie et al. 2004). It was first found in the Champlain Basin in the mid-1990s.

Greater European pea clam (*Pisidium amnicum*) is a clam species in the family Sphaeriidae. It is native to Eurasia (Mackie 2000, Por et al. 1986, Vincent et al. 1981), but was introduced to North America. It is found in New Jersey, New York, Minnesota, Pennsylvania, Michigan, and Vermont. It is a freshwater species and in England it requires high levels of calcium and clean water to proliferate. *P. amnicum's* dispersal has been attributed to solid ballast (Mills et al. 1993; Grigorovich et al. 2003). It was first found in the Champlain Canal and Basin in 1972.

Quagga mussel (*Dreissena bugensis*) is a bivalve species in the family Dreissenidae. It is native to Eurasia and was first reported in Lake Ontario in 1989, thought to have been brought in by ship ballast water. From there it spread to the other Great Lakes and south to the Mississippi River, Nevada, Colorado, Arizona and California. It is a non-native, invasive species in Lake Champlain. It is a freshwater species that occurs in mesohaline lakes at depths of 20 - 80 meters but can be found as deep as 130 meter in the Great Lakes. *D. bugensis* is dispersed via passive drifting, and larvae can be carried by the water current until it finds hard substrate to attach to. It poses the same problems as zebra mussels. *D. bugensis* was recently found in the Champlain Basin and was thought to have entered via the Champlain Canal. *This is considered a high priority species.*

Zebra mussel (*Dreissena polymorpha*) is a D-shaped mollusk with brown and white zebra-like pattern. It has not been found on the walls of lock chambers in Lake Champlain, but has been found in the sediment. Adults have trouble staying attached where velocity is more than 2m/s. *D. polymorpha* is currently threatening seven native mussel species in Lake Champlain. Snorkel surveys have documented that many historical shipwrecks are becoming less scientifically and historically significant due to increased coverage

of zebra mussels on their surfaces. It disperses by natural passive dispersal by drifting through waterways and attached to errant vegetation and anthropogenic passive dispersal on watercraft or equipment. It is a bivalve species in the Dreissenidae family. It is native to Eurasia and was first found in the Great Lakes in 1988 and has spread since then. It prefers freshwater, but can occur in oligohaline water in rivers, estuaries, and coastal shallow waters of the Caspian Sea and other large brackish waters. *D. polymorpha* was first found in Lake Champlain in 1993. It was thought to have entered via the Champlain Canal on barges, boats, vegetation, bait buckets, or SCUBA gear (Gatlin et al. 2013). *This is considered a high priority species.*

3.1.2 Gastropoda

Banded mystery snail (*Viviparus georgianus*) is snail species in the family Viviparidae. This species is native to North America and is found from the northeastern United States to Florida and the Gulf of Mexico. It is also found in the Mississippi River and the St Lawrence River and in Illinois and Indiana (Clench 1962), but is a non-native, invasive species in Lake Champlain. *V. georgianus* is a freshwater species and is dispersed via anthropogenic passive dispersal by attaching to boats and equipment (Havel et al., 2014). It was first found in the Champlain Basin and was thought to have entered via the Champlain Canal.

Chinese mystery snail (*Cipangopaludina chinensis*) is a snail species in the Viviparidae family. It is native to Asia and was introduced to North America and is a non-native, invasive species in Lake Champlain. It is a freshwater species found in lakes, reservoirs, ditches, ponds, and paddy fields. It is dispersed anthropogenically via attachment to fishing equipment and water holding areas of watercraft.

European ear snail (*Radix auricularia*), also known as the big-ear radix, is a snail species in the family Lymnaeidae. It is native to Eurasia and the Middle East and was introduced to the United States and most of the world. It is a freshwater species found in small pools, lakes reservoirs, brooks, irrigation canals, and brackish lakes. *R. auricularia* can self-fertilize and larvae are dispersed passively by drifting through waterways and by "hitchhiking" on watercraft or boating equipment. It feeds on diatoms. It was first found in the Champlain Basin. It is a common host vector for many parasites, particularly trematodes (Boray 1978).

Faucet snail (*Bithynia tentaculata*), also known as the mud bithynia, is an invertebrate species from the Bithyniidae family. It is native to Europe and was introduced to North America. It was originally found in the Great Lakes in Lake Michigan in 1871 and can be found from Quebec to Wisconsin to Pennsylvania and some parts of New York. It is a freshwater species found in a wide range of aquatic habitats including streams, rivers, canals, marsh drains and lakes (Jokinen 1992; Pennak 1989; Vincent et al. 1981). *B. tentaculata* prefers richly vegetated habitats with muddy or silty substrates. It was found in the Champlain Basin in 1883 and was thought to enter via the Champlain Canal.

3.1.3 Crustacea

3.1.3.1 Copepod

Thermocyclops crassus is a cyclopoid copepod species in the Cyclopidae family. It is native to Eurasia but is present in Lake Erie and was first detected in Champlain Basin in 1991. It is a freshwater species and was passively dispersed by ship ballast water as its initial introduction.

3.1.3.2 Cladocera

Spiny waterflea (*Bythotrephes longimanus*) is a cladoceran species in the family Cercopagididae. It is native to Europe and was introduced to North America and is a non-native, invasive species in Lake Champlain. It was first found in Lake Huron in 1984, and was then found in all the Great Lakes by 1987. It is a freshwater species found in large, deep temperate lakes (Grigorovich et al. 1998). It was first found in Lake Champlain in 2014. It is a nuisance to fishermen, can ruin fishing gear (Berg and Garton 1988, Evans 1988, Vanderploeg et al. 1993), and may lead to reduced populations of the preferred prey of native fish. *B. longimanus* is dispersed by natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment. Eggs are resistant to desiccation, while free-swimming organisms cannot survive out of water for long. *This is considered a high priority species..*

3.1.4 Plants

American water plantain (*Alisma subcordatum)* is a plant species in the family Crambidae. It is native to North America and can be found from Massachusetts to Minnesota, south to Florida and Texas. It can be found in fresh and wetland systems and prefers shallow, slow-moving waters including ponds, lakes and streams. *A. subcordatum* has fruits that contain buoyant seeds and is dispersed via natural passive means and through fragmentation.

Brittle naiad (*Najas minor*) is a plant species in the family Hydrocharitaceae. It is native to Eurasia and was introduced to much of North America, including Vermont and is a non-native, invasive species in Lake Champlain. It is a freshwater species and occurs in a variety of lakes, pools, rivers, and streams, and will occasionally occur in ditches and rice fields. *N. minor* can auto-fragment and is dispersed via anthropogenic passive dispersal on boats and equipment and naturally on animals as fragments (Tarver et al. 1986). It was first found in the Champlain Basin and entered via the Champlain Canal.

Eurasian watermilfoil (*Myriophyllum spicatum*) is a plant species in the Haloragaceae family. It is native to Eurasia and was introduced to much of North America, including the northeast, and is a non-native, invasive species in Lake Champlain. It is a freshwater species and occurs in lakes, rivers, streams, canals, and ditches. It prefers base-rich water systems with high dissolved inorganic carbon, nitrate, nitrite, and pH, and in hydrosoils with high phosphate and organic matter content. It was first found in 1962 in St Albans Bay in Lake Champlain. Infestation is currently considered light or moderate. *M. spicatum* is dispersed naturally via fragmentation. Previous management has included the use of bottom barriers, suction harvesting, mechanical harvesting, hand-pulling, lake drawdowns, hydroraking, biological and

chemical controls, release of aquatic weevils and non-native aquatic moth *Acentria ephmerella*. *This is considered a high priority species.*

European frogbit (*Hydrocharis morsus-ranae*) is a plant species in the Hydrocharitaceae family. It is native to Europe and was introduced to the eastern United States and Canada and is a non-native, invasive species in Lake Champlain. It prefers freshwater and typically occurs in shallow, mesotrophic or meso-eutrophic water in the sheltered bays of lakes or in ponds, canals, and ditches. The propagules of *H. morsus-ranae* float and are dispersed naturally via waterways. It was first found in the Champlain Basin in 1999 and entered via the Champlain Canal.

Flowering rush (*Butomus umbellatus*) is a wetland species in the Butomaceae family. It is native to Europe and some of the northern hemisphere. It has naturalized throughout southern Canada and the northern United States, Ireland, and some of the British Isles. It is a non-native, invasive species in Lake Champlain. It is a species that can grow on wet mud and is emergent in shallow water to permanently submerged in deep or fast-flowing water. It is most often found on nutrient-rich, calcareous clay substrates and will occur in a variety of water bodies such as rivers, lakes, streams, ditches, and canals. *B. umbellatus* is dispersed naturally via clonal reproduction, drifting down waterways and by animals. It was first found in the Champlain Basin in 1929 and entered via the Champlain Canal.

Great water cress (*Rorippa amphibia*) is a plant species in the Brassicaceae family. It is native to Europe and exotic to Lake Champlain. It is a freshwater species and typically occurs on the margins of mesotrophic to eutrophic water bodies, such as ponds, lakes and large lowland rivers. *R. amphibia* seeds are dispersed naturally via drifting down waterways and by animals and anthropogenically on watercraft, equipment or by people. It was first found in the Champlain Basin in 1944.

Japanese knotweed (*Fallopia japonica*) is a plant species in the family Polygonaceae. It is native to Asia and was introduced to the United States in the late 1800s and is a non-native, invasive species in Lake Champlain. It occurs in disturbed areas, floodplain, fields, and shores of rivers or lakes. *F. japonica* is dispersed naturally via vegetative spreading of underground rhizomes and wind dispersal. It is known to alter the characteristics of riparian zones, compete with native plants, decrease diversity, and alter wildlife habitat. It made its way to Lake Champlain sometime after it was introduced in America in the late 1800s. *This is considered a high priority species..*

Purple loosestrife (*Lythrum salicaria*) is a plant species in the family Lythraceae. It is native to Eurasia and was introduced to Australia and much of North America and is a non-native, invasive species in Lake Champlain. It is a freshwater species that occurs in most wetland systems from river margins and banks, to low-lying seasonally inundated areas in rough pasture, the margins of wet woodlands, and even seasonal pools. It was first found in 1929 in Lake Champlain in the basin and canals. *L. salicaria* is dispersed naturally through fragmentation, while the seeds are naturally dispersed by animals and wind, and anthropogenically dispersed by humans and equipment. The plant can resprout from broken roots. Prior management practices included introduction of a beetle (*Galerucella)* that eats the plant that was tested in various wetlands in Vermont and New York. *This is considered a high priority species.*

Slender leaved naiad (*Najas flexilis*) is a plant species in the Hydrocharitaceae family. It is native to North America and is widespread across North America, Asia and Europe, but is a non-native, invasive species in Lake Champlain. It is a freshwater species that grows in still or slow-moving, circumneutral to basic water of rivers and lakes. *N. flexilis* is dispersed via natural passive dispersal by seeds drifting down waterways.

Yellow floating heart (*Nymphoides peltatum*) is a plant in the family Menyantheceae. It is native to Eurasia and was introduced to much of North America and is a non-native, invasive species in Lake Champlain. It is a freshwater species that typically occurs in naturally eutrophic, calcareous, slow-moving rivers and large ditches. *N. peltatum* can reproduce from plant fragments and seeds and can be dispersed naturally by animals. It was first found in the Champlain Basin and entered via the Champlain Canal in 1929.

Yellow iris (*Iris pseudacorus*) is a plant species in the Iridaceae family. It is native to Europe and was introduced to North America, but is a non-native, invasive species in Lake Champlain. It is a freshwater species that occurs in shallow water or saturated soils in marshes, along the shores of lakes or ponds with stagnant or slow flowing waters, and occasionally in ditches. The seeds of *I. pseudacorus* are naturally dispersed via the water current and germinate on shorelines. It was first found in the Champlain Basin in 1909.

Variable - leaf watermilfoil (*Myriophyllum heterophyllum*) is a plant species in the Haloragaceae family. It is native to North America and is widespread in eastern and central parts of the United States, Quebec, Texas and Florida, but is a non-native, invasive species in Lake Champlain. It is a freshwater species and was first found in Lake Champlain in 2011 at the southern end of the lake. *M. heterophyllum* can reproduce via fragmentation and its dispersal methods include natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment. At Hall's Lake, Vermont, management of *M. heterophyllum* included hand harvesting.

Water chestnut (*Trapa natans*) is a plant species in the Trapaceae family. It has been naturalized in North America but is exotic and invasive in Lake Champlain. It is a freshwater floating-leaved plant that grows in stagnant waters, lakes, channels with weak currents, ponds and swamps. It primarily occurs in unpolluted lowlands without low calcium. It was first found in Lake Champlain in the 1940s and has been managed in the north and south ends of the Champlain Basin by mechanical harvesting and hand-pulling. *T. natans* is an annual plant with simple submerged stems found in up to 5 meters of water. It prefers nutrient rich lakes and can severely limit light and reduce oxygen levels in systems where it is found. It can also limit recreation like boating, fishing, and swimming. The fruits can cause painful wounds if stepped on because the seeds have sharp barbs that can attach to boats and animals. It is also an important food source for birds and provides spawning habitat for fish. It disperses via natural passive dispersal by hitchhiking on waterfowl due to its sharp barbs or by anthropogenic passive dispersal because it can become latched by its barbs, or during intentional plantings. *This is considered a high priority species.*

3.1.5 Algae

Rock snot (*Didymosphenia geminata*) is a diatom in the Gomphonemataceae family. It is native to North

America but is over taking much of Lake Champlain. It is a freshwater species found in the benthic zone of clear, shallow, cool water with low conductivity and rocky substrate. It was first found in 2008 in the Champlain Basin. *D. geminata* is dispersed via anthropogenic passive dispersal via attaching to watercraft and fishing equipment. It can alter the diversity of local macroinvertebrates at bloom sites. It can remain viable for weeks under seemingly dry conditions. Management of this species includes drying gear for a minimum of 48 hours or cleaning with a solution of bleach.

3.1.6 Bacteria

E. coli (*Escherichia coli*) is a gut bacterium in the family Enterobacteriaceae. While some strains are pathogenic, it is typically considered an indicator of other pathogens, including viruses, associated with animal waste products. Sources are varied, but it is typically associated with fecal contamination of urban runoff, failing septic systems, and domestic animals and wildlife. It can cause gastrointestinal illness in humans. *E.coli* presence in Lake Champlain has caused beach closures in the past.

3.2 Dispersal Method II: Active and Passive Dispersal

3.2.1 Hydrozoa

Freshwater jellyfish (*Craspedacusta sowerbyi*) is a hydrozoan in the Olindiidae family. It is native to Asia was introduced to North America and Europe. It was first found in the Huron River and spread to other states including the northeastern United States, Quebec, and Ontario regions including Lake Champlain. It is found in temperate climates globally, but has been recorded in tropical locations. *C. sowerbyi* was first found in the Champlain Basin in 1883. It disperses via active dispersal by freely moving through the water column by expanding and contracting itself but also drifting with the current and being transported in ballast water.

3.2.2 Gastropoda

European stream valvata (*Valvata piscinalis*) is a snail in the Valvatidae family. It is native to Eurasia and has invaded North America. It was first found in Lake Ontario and spread to Lake Erie, St Lawrence River, Hudson River, and Cayuga Lake and is a non-native, invasive species in Lake Champlain. It is a freshwater species inhabiting both standing and slightly flowing water and is found in lakes, rivers, creeks, canals, and reservoirs. The preferred substrate of *V. piscinalis* is sand or silt and it feeds on detritus and diatoms. It was first found in the Champlain Basin in 1972. It mostly disperses passively through shipping vessels.

Sharp hornsnail (*Pleurocera acuta*) is a snail in the family Planorbidae. It is native to North America and is found in the St Lawrence River and the Great Lakes, the Ohio River, the Erie Canal to the Hudson River and in Tennessee, Illinois, Colorado and New York, but is a non-native, invasive species in Lake Champlain. It is a freshwater species found in rivers and lakes on varied substrates of silt, sand, gravel, cobble, and boulders. It was first found in the Champlain Basin and was thought to have entered via the Champlain Canal. It most likely disperses actively by moving through connected waterbodies and via anthropogenic

passive dispersal by watercraft.

Woodland Pondsnail (*Stagnicola catascopium*) Freshwater species that occurs in lakes, creeks, and other shallow bodies of water. It is a very adaptable species that can withstand changing temperature and oxygen concentrations, have faster crawling rates and resist desiccation better. Movement of American freshwater snails is dependent on outside passive dispersal methods like boating, periodic flooding, and transport by vertebrates. It was recorded in Lake Champlain in 1994.

Buffalo Pebblesnail (*Gillia altili)* is usually found in freshwater stream environments but is not uncommon for it to inhabit both stagnant waters in lakes and streams and rapidly moving waters. It was first collected in Lake Champlain in 1978.

3.2.3 Platyhelminthes

Schmidtea polychroa is a flatworm of the Dugesiidae family. It is found in North America and Europe. It is a freshwater species which prefers shallow water and solid surfaces. It most likely disperses via by actively traveling across substrate but also drifting with water currents.

3.2.4 Crustacea

3.2.4.1 Decapoda

Allegheny crayfish (*Orconectes obscurus*), also known as the obscure crayfish, is a crustacean in the Cambaridae family. It is native to North America and is found on the east coast and in Pennsylvania, Ohio, Texas and Ontario, but is a non-native, invasive species in Lake Champlain. It was introduced to Canada. *O. obscurus* is a freshwater species found in pools and streams with rocky substrate. It is usually found underneath rocks, gravel and boulder sand, but is not normally found in fast flowing portions of streams. It was first found in the Champlain Basin in 1988. It mostly disperses via actively moving from one location to another but can be dispersed via bait bucket releases.

Rusty crayfish (*Orconectes rusticus*) is a crustacean in the Cambaridea family. It is native to North America and native to the Ohio River system where it spread to Kentucky, Indiana and Mississippi. It was introduced to many more states including Vermont where it is a non-native, invasive species in Lake Champlain. It is a freshwater species that inhabits permanent streams and lakes with a range of substrates such as clay, silt, sand and gravel. It prefers areas which consist of rocks, logs, or other debris which it uses to construct burrows. It was first found in 2005 in the Champlain Canal and Basin. *O. rusticus* can displace or hybridize with native crayfish, prey on native plants, small fish, and eggs, decrease diversity of the ecosystems, destroy habitats, and might also spread Eurasian water milfoil. It is dispersed anthropogenically by accidental introduction in bait buckets and intentional introduction and actively disperses by moving from one location to another.

Big Water Crayfish (*Cambarus robustus* Girard) is a crustacean in the Cambaridae family whose native range extends from the eastern Midwest of the U.S. to the Northeast, from Michigan to New York (west of the Hudson River). Non-burrowing and lives on rocky substrates and its breeding occurs in the late

summer. Bait Release is attributed to its means of introduction to Lake Champlain where it was first recorded in 1957.

3.2.4.2 Amphipoda

Gammarus fasciatus is an amphipod in the family Gammarida. It is native to North America and is natively found in Lakes Erie and Ontario, but is a non-native, invasive species in Lake Champlain. It is a freshwater species and was first found in the Champlain Basin. It disperses via active dispersal by freely swimming from one location to another through canals and locks and via anthropogenic passive dispersal by accidental via bait bucket releases or in the water of intentionally stocked fish.

3.2.5 Insecta

Water veneer moth (*Acentria ephemerella*) is an insect species in the family Crambidae. It is native to Europe and was first recorded in New York in 1938. It is now found in Lakes Ontario and Erie. It is found in the lentic zones where algae are scarce and oxygen is plentiful. Adult males, and some adult females, can fly and disperse through the air. Otherwise, the aquatic larval form swims and crawls. Eggs and larva are associated with plants. It is sometimes intentionally introduced as a biological control of Eurasian water milfoil.

3.2.6 Fish

Alewife (*Alosa pseudoharengus*) is a species river herring in the family Clupeidae. It is a native species to North America, but a non-native, invasive species in Lake Champlain. *A. pseudoharengus* occurs in both fresh and marine systems, as it is anadromous. Spawning takes place in quiet parts of a river for the marine populations and in shallow inshore water for landlocked freshwater populations. This species was first found in Lake Champlain in 2003 in the Champlain Basin. In 2006, the Lake Champlain alewife population was documented to alter zooplankton communities. The population is in direct competition with other native species such as lake trout and Atlantic salmon and feeds on native fish eggs and larvae. In addition, the presence of *A. pseudoharengus* also leads to decreased water clarity. Adult alewife are strong swimmers. Larvae and eggs spread by drifting through waterways. Anthropogenic dispersal includes bait bucket releases and intentional stocking by humans. *This is considered a high priority species.*

Common carp (*Cyprinus carpio*), is a fish species in the Cyprinidae family. It is native to Europe and Asia and has been introduced throughout the world, but is a non-native, invasive species in Lake Champlain. It is found in fresh systems in warm, deep, slow flowing or still waters. *C. carpio* is a potential pest to humans, but is highly commercial outside of the United States. It was first found in the Lake Champlain in 1982. It disperses via freely swimming from one location to another through canals and locks and via anthropogenic, passive dispersal by accidental or bait bucket releases and intentional stocking by humans.

Black crappie (*Pomoxis nigromaculatus*) is a sunfish in the family Centrarchidae. It is native to North America, with the exception of states north of Virginia, most of the east coast of the United States and west to Texas. It is native to Lake Champlain, but is spreading to other nearby water bodies. It is found in

temperate waters in the benthopelagic zone of freshwater habitats. *P. nigromaculatus* was recorded as established in Lake Champlain in 1962. It disperses via active dispersal by freely swimming from one location to another through canals and locks and via anthropogenic passive dispersal by accidental or bait bucket releases and intentional stocking.

Blueback herring (*Alosa aestivalis*) is another river herring in the family Clupeidae, a sister species to alewife. It is native to North America, found from Nova Scotia to Florida, but is a non-native, invasive species that has expanded its range to Lake Champlain from areas where it was originally stocked in the early 1970s. It has been introduced to reservoirs in several states and the Tennessee River System in Tennessee. *A. aestivalis* is found in both marine and freshwater habitats. Spawning occurs in brackish or fresh waters, in shallow areas covered with vegetation. *A. aestivalis* has been found in the Champlain Basin and Canal. It was first found in the Champlain Canal. It disperses by swimming from one location to another through canals and locks. Anthropogenic passive dispersal includes accidental or bait bucket releases and intentional stocking by humans. Eggs adhere to objects, drift downstream, and then unstick and settle to the substrate.

Brook silverside (*Labidesthes sicculus*) is a fish species in the family Atherinopsidae. It is native to North America, found from the Great Lakes basin to the Mississippi basin and from the Galveston Bay drainage to Florida. It is native to the southern region of the St. Lawrence basin, but is a non-native, invasive species in Lake Champlain. *L. sicculus* is found in freshwater systems in varying habitats. Dispersal methods are passive; eggs attach to objects and are distributed throughout a system. *L. sicculus* has been found in the Champlain Basin and Canal and is believed to have entered through the canal. It disperses through swimming from one location to another through canals and locks as well as egg attachment to boats and other equipment.

Brown trout (*Salmo trutta*) is a trout in the family Salmonidae. This species is native to Europe and was introduced to North America and throughout the world, but is a non-native, invasive species in Lake Champlain. It is found in the pelagic-neritic zone of fresh, marine and brackish systems. In some systems it is anadromous, with spawning between October and March. *S. trutta* was intentionally stocked in Lake Champlain in the early 90's. It is known to reduce native fish populations and was originally stocked by the US Fish Commission in Michigan. It is a strong swimmer and is intentionally stocked as a gamefish in many settings.

European rudd (*Scardinius erythrophthalmus*) is a fish species in the family Cyprinidae. It is native to Europe and exotic to Lake Champlain. It is a potadromous fish found in the benthopelagic zone of temperate fresh and brackish systems. It was legal to sell *S. erythrophthalmus* in Vermont but is now illegal to sell. *S. erythrophthalmus* was first found in 1991 in Champlain Canal and Basin. It disperses by freely swimming from one location to another through canals and locks and via anthropogenic, passive dispersal by accidental or bait bucket releases and intentional stocking.

Gizzard shad (*Dorosoma cepedianum*) is a fish species in the family Cyprinidae. It is native to North America and is found in three of the Great Lakes (Erie, Huron, and Ontario), New York to Mississippi and

the Gulf of Mexico, but is a non-native, invasive species in Lake Champlain. *D. cepedianum* is an anadromous fish found in the pelagic-neritic zone of fresh and brackish systems. *D. cepedianum* is harmless to humans but has minor commercial and recreational fishery use. It is thought that *D. cepedianum* entered via the Champlain canal. It was originally intentionally stocked as a forage species but now disperses actively to new bodies of water.

Largemouth bass (*Micropterus salmoides*) is a fish species in the Centrarchidae family. It is native to North America and is found in St Lawrence - Great Lakes basin, Hudson Bay, and the Mississippi River from Quebec to Mississippi and south to Texas and southern Florida. It is a non-native, invasive species that was first recorded in Lake Champlain in 1930. It is found in the benthopelagic zone of fresh systems in subtropical regions. No records of *M. salmoides* were found in Vermont prior to 1887. It has been found in the Champlain Canal and Basin and was thought to have entered via the Champlain Canal. It was originally intentionally stocked for sport fishing but is now naturalized and disperses actively to new bodies of water.

Rainbow trout (*Oncorhynchus mykiss*), sometimes known as steelhead in migratory populations, is a fish species in the Salmonidae family. It is a native species found on the west coast and from Arkansas to Mexico, but is a non-native, invasive species in Lake Champlain. It is an anadromous species found in the benthopelagic zone of marine and brackish systems in subtropical regions. It was recorded as being established in Lake Champlain in 1986. It was then intentionally stocked for sport fishing and is still stocked annually in some locations. Rainbow trout are strong swimmers that move between waterbodies and by intentional stocking.

Round goby (*Neogobius melanostomus*) is a fish species in the family Gobidae. It is native to the Middle East and was introduced to North America in 1991 via ballast water on ships. It is a non-native, invasive species in Lake Champlain. It is an amphidromous species found in the demersal zone of marine, fresh and brackish systems in temperate regions. *N. melanostomus* is known to outcompete native species for habitat and food and preys on native species eggs and young-of-the-year. It can thrive in poor water quality conditions. Additionally, it is known to eat zebra mussels, but not in large enough quantities to alleviate the effects of the mussels in Lake Champlain. It was first found in the Champlain Basin and entered via the Champlain Canal sometime after 1990. It disperses via active dispersal by freely swimming from one location to another through canals and locks and via anthropogenic, passive dispersal by accidental or bait bucket releases. *This is considered a high priority species..*

Sea Lamprey (*Petromyzon marinus*) is a jawless fish species in the family Petromyzontidae. It is a species native to North America and is found from Labrador, Canada to the Gulf of Mexico and from Norway to northern Africa. It is an anadromous species found in the demersal zone of marine, fresh and brackish systems in temperate regions. *P. marinus* was first found in the 1920s in the Champlain Canal. In 1990, an experimental application of lampricide was used to reduce sea lamprey populations. In 2001, applied integrated pest management (biological and chemical control) was tried. In 2014, new lamprey barrier dams were installed in a Lake Champlain tributary. A recent study might suggest that *P. marinus* is native to Lake Champlain. Regardless, a Great Lakes study estimates a 40-60% mortality rate for fish with sea

lamprey wounds, which have been found on walleye, lake whitefish, pike, burbot, sturgeon, and more. It disperses via active dispersal by freely swimming from as well as through parasitism of gamefish moving through the waterways. *This is considered a high priority species.*

Silver lamprey (*Ichthyomyzon unicuspis*) is a fish species in the family Petromyzontidae. It is native to North America and is found in the St Lawrence River, Quebec and Ontario to the Altamaha River, Hudson River to Manitoba and the Mississippi and Missouri Rivers. It is a potamodromous fish species found in the demersal zone of fresh systems. *I. unicupis* has a single dorsal fin distinguishing it from *P. marinus* and is harmless to humans. It disperses via active dispersal by freely swimming from one location to another through canals and locks.

Tench (*Tinca tinca*) is a fish in the Cyprinidae family. This species is native to Europe and was introduced to North America. It is considered a pest in Maryland and Indiana and is a non-native, invasive species in Lake Champlain. It is a potamodromous fish found in the demersal zone in fresh and brackish systems in temperate regions. It was first found in 2002 in the Champlain Basin. *T. tinca* has a potential negative impact on the minnow population in Lake Champlain. It can stir up the bottom sediment, which can suffocate eggs of other native fish species. It was first imported as a food and sport fish, but it now disperses actively.

White crappie (*Pomoxis annularis*) is a fish species in the Centrarchidae family. It is native to North America and is found in the Great Lakes, Hudson Bay, Mississippi River from New York to Ontario and south to the Gulf of Mexico. It was widely introduced in the United States and is found in demersal zones of fresh systems in temperate regions. It was first found in the Champlain Canal and Basin in 1940. It was first stocked intentionally, but now it disperses via active dispersal freely swimming through waterways and is intentionally stocked in many areas.

White perch (*Morone americana*) is a fish species in the Moronidae family. It is native to North America and is found in the St Lawrence River, Lake Ontario, Quebec to South Carolina, but is a non-native, invasive species in Lake Champlain. It is an anadromous species found in demersal zones of marine, fresh and brackish waters in temperate regions. Inland populations are more common in northern areas. *M. americana* is known to heavily prey on the eggs of walleye and might directly compete with yellow perch and native shiners. It was first found in 1990 in the Champlain Canal and Basin and was thought to have entered via the Champlain Canal. It disperses via active dispersal by freely swimming.

The Black bullhead (*Ameiurus melas)* native range includes Great Lakes, Hudson Bay, and Mississippi river basins from New York to southern Saskatchewan and Montana. It is not native to the Atlantic Slope and was first recorded in Lake Champlain in 1883. It had been established in most locations where introduced. It was intentionally stocked for sport and as a food fish. They are voracious predators that outcompete natives and have been shown to reduce the abundance and diversity of native prey species in several Pacific Northwest rivers.

4. Current Native Aquatics Species in Lake Champlain

4.1 Invertebrates

Ash Gyro (*Gyraulus parvus*) is a freshwater snail in the Planorbidae family. Its native range is North America and South America. It occurs from AK to northern Canada down to Mexico and across USA. This species is found in a wide range of freshwater habitats, including pools, ponds and lakes (Meier-Brook 2002). It is well-adapted to lacustrine habitats in the northern USA and Canada (Dillon *et al*. 2007).

Eastern Elliptio (*Elliptio complanata*) is a freshwater bivalve in the Unionidae family. Its native range is the Atlantic coast of the United States, Altamaha River system of Georgia north to the St. Lawrence River system of Canada. In the Interior basin it is found west to Lake Superior and within the Hudson Bay drainage. The eastern elliptio is mainly found in stable shoals of lakes or river-lakes in the northern part of the Lower Peninsula and the Upper Peninsula. This species is an ecological indicator and its presence indicates good water quality.

Eastern lampmussel (*Lampsilis radiate*) is a freshwater mussel of special concern in the Unionidae family. Its native range is North America and occurs from Nova Scotia, west to St. Lawrence River, as far as Ontario, Quebec and down to SC. Its preferred habitat includes small streams, large rivers, ponds, and lakes. Seems to prefer sand or gravel substrates but can be found on many different types of substrates.

Eastern Sand Darter (*Ammocrypta pellucida*) is a freshwater fish in the Actinopterygii family. This fish inhabits sandy runs of small to medium rivers, usually 60cm or deeper water. Populations for this species have been reported to be decreasing in abundance due to siltation and deterioration of water quality

(Page and Burr, 1991)> The fish is currently reported in Poultney, Winooski, and LaPlatte Rivers in VT and the Mettawee River in NY, all tributaries to Lake Champlain. This species is listed as threatened in NY and VT.

Giant Floater (*Pyganodon grandis*) is a river mussel in the Unionidae family. Its native range is North America and is widespread across 32 states and also many territories in Canada. This species is a freshwater, generalist species is found in small shallow streams that are high in conductivity, with a fine sediment cover and detritus' as well as headwater creeks in marshes, pools, the margin of streams and backwater areas (Gagnon *et al.* 2006). Adults are essentially sessile. About the only voluntary movement they make is to burrow deeper into the substrate. Some passive movement downstream may occur during high flows. Dispersal occurs while the glochidia are encysted on their host. This species is listed as threatened in Vermont.

Marsh Ramshorn (*Planorbella trivolvis*) is a freshwater snail in the Planorbidae family. Its native range is North America, Ecuador, and Peru; MS River to Arctic Canada and AK, and down to TN and MS, and as south as FL Keys, up to NC. Marsh Ramshorn is found in a broad range of habitats demonstrating a tolerance to habitat modification (NatureServe 2009). It can be found in freshwater river drainages and tributaries, lakes and permanent artificial bodies of water.

Mossy Valvata (*Valvata sincera*) is a freshwater snail in the Valvatidae family. Its native range is North America, occurring from ME west to Alberta, south to SD, IN, IL, WI, MN, and Quebec. This species is found in freshwater river drainages and tributaries.

Northern Clearwater Crayfish (*Orconectes propinquus*) is a freshwater crustacean in the Cambaridae family. Its native range is North America occurring in Ontario and Quebec, and has been introduced to northeast USA. This species is a habitat generalist and has been found in habitats such as small streams, large rivers, ponds, and lakes (Taylor *et al.* 2005). The substrates it dwells on ranges from sandy to rocky (Taylor *et al*. 2005). Under detritus, such as rock or wood, this species creates small depressions in the substrate. This species is benthic and may burrow in or use soil for habitat. It is listed as least concern (IUCN).

Pink Heelsplitter (*Potamilus alatus*) is a freshwater mussel in the Unionidae family. Its native range is USA and Canada, from MS River to PA and MN, west to KS and NE, south to AK. Found in St Lawrence and from Lake Huron to Champlain. Pink Heelsplitters are found on a variety of substrates in slow to swiftly flowing water. It can also adapt to shallow lake and river-lake habitat (Oesch 1984). Substrates include clay, clay mixed with silt, sand, pea gravel and sand, and cobble/sand/silt (Fichtel and Smith 1995). This species disperses actively via its glochidial host, the freshwater drum. This species is listed as endangered in Vermont.

Striated Fingernail Clam (*Sphaerium striatinum*) is a freshwater mollusk in the Sphaeriidae family. Its native range is North America, occurring most of USA and Canada including Mexico and Panama. It thrives in both lotic and lentic environments and on mud, sand, gravel and rock substrates and is most abundant at water depths of less than 2m (Mackie 2007). Lake and river specimens tend to be high and river specimens tend to be long in shape (Herrington 1962, Bailey et al. 1983) It is listed as least concern (IUCN).

Swamp Fingernail Clam (*Musculium partumeium*) is a freshwater mollusk in the Sphaeriidae family. Its native range is North America, occurring east of Rocky Mountains, Alberta to Newfoundland, TX to FL, range west of Rocky Mountains including CA and NV. It is most common in ponds and swamps with muddy

substrates and much organic detritus, but it also occurs in small lakes and river eddies with rooted vegetation and soft bottoms (Mackie 2007). It is listed as least concern (IUCN). Typically lives for 1-2 years.

Three-Ridge Valvata (*Valvata tricarinata*) is a freshwater snail in the Valvatidae family. Its native range is North America, occurring from Quebec and New Brunswick to Alberta and south to WY, AK, and VA, rare in western US. This species is found in freshwater rivers and tributaries, as well as lakes and ponds. *V.tricarinata* has eye spots at the base of its tentacles, which perceive light. Chemo-senses are likely also used to find food (Burch and Jung, 1992; Burch, 1989). Egg cases have been found attached to Potamogeton, Chara, and Sagittaria species or to floating objects. This species is listed as least concern (IUCN).

Two-Ridge Ramshorn (*Helisoma anceps*) is a freshwater snail in the Planoribidae family. It is native to North America occurring in the Hudson Bay to GA, AL, TX, and Mexico, west to Northwest Territories, Alberta, and Oregon, and Lake Superior. Two-Ridge Ramshorn is found in permanent lakes and ponds and rivers and streams on varied substrates, including sand, silt, gravel and cobble. While other pulmonate snails may move seasonally or daily, *Helisoma anceps* tends to stay in one place. In a northern Michigan study, released snails moved a distance of 1.6m within 48 hours. *H. anceps* may use chemosensory stimulation to move to areas with higher food sources such as periphyton (Boss et al. 1984). It is listed as least concern (IUCN).

4.2 Fish

Allegheny pearl dace (*Margariscus margarita*) is a fish species in the Cyprinidae family. It is native to the United States and can be found in the Hudson River, New York, Vermont to Virginia and the Ohio River. It is a freshwater species that prefers cool, clear, or peaty or boggy water. It spawns in clear water with a moderate current, over sand or gravel. Localized threats may exist to this fish, but on a range-wide scale no major threats are known, and is listed as Least Concern by IUCN.

American brook lamprey (*Lethenteron appendix*) is a fish species in the Petromyzontidae family. It is native to North America and can be found in the Great Lakes, the Mississippi River, and many other states in the United States. It is a freshwater species that prefers stable, cold, very clean water with sand-silt or gravel substrate. This species is a filter feeder consuming small plant and animal life such as protozoans, diatoms, algae, desmids, and pollen. This species is listed as threatened in VT.

American eel (*Anguilla rostrata*) is a fish species in the Anguillidae family. It is listed as endangered by the IUCN. It is native to the United States and subtropical and tropical regions. Historically, the *A. rostrata* was widely distributed in the continental watersheds associated with this extensive range, including the Mississippi river basin and Great Lakes-St. Lawrence river basin below Niagara Falls. It is a catadromous, freshwater species that prefers the demersal zone of subtropical regions. Measures are now being taken to decrease the impact of fisheries on *A. rostrata* populations in the United States, such as more closely regulating harvesting of glass eels and elvers (Landau, 1992). Ongoing studies still track juveniles and adults during their time in freshwater and movements to the Sargasso Sea for spawning (Sumich 1999). Some *A. rostrata* have been found infected with Asian eel nematode *Anguicolla crassus*.

Atlantic salmon (*Salmo salar*) is a fish species in the Salmonidae family. It is native to North America and Europe and is introduced to much of the Atlantic and south Pacific Oceans. It is fresh and marine anadromous species. Currently, North America's population of *S. salar* is at its lowest point in history.

Declining numbers and loss of whole stocks in some rivers are causing increasing concern. Habitat destruction, denial of access to spawning grounds by dams and other obstructions, overfishing (including high-seas fishing and poaching), pollution and especially acid rain are taking their toll. Cooperation and compromise by the major groups harvesting Atlantic salmon are essential if native stocks are to be saved. Scientific research has led to the creation of artificial spawning channels which provide a significant supplement to the production of salmon from natural streams. The Atlantic Salmon Federation is the largest, most effective organization devoted to the conservation of the Atlantic salmon and its habitat. This group has been successful in reducing commercial salmon fishing and some salmon streams have reported encouraging increases in the number of returning sea run fish as a result (Scott and Crossman, 1973; Atlantic Salmon Federation, 1996). Atlantic Salmon are listed as lower risk by the IUCN, and they are considered an endangered species by the U.S. Fish and Wildlife Service. Young salmon in streams feed on mainly the larvae of aquatic insects, including blackflies, stoneflies, caddisflies, and midges. In late summer, salmon begin to incorporate terrestrial insects into their diet (Schaffer and Elson 1975). As individuals grow, their diet shifts to include a greater proportion of fishes, including smelt, capelin, herring and alewife, small mackerel, and small cod (Bigelow 1963, Fay et al. 2006, Scott and Crossman 1973). Atlantic salmon is listed as Least Concern (IUCN).

Banded killifish (*Fundulus diaphanus*) is a fish species in the Fundulidae family. This minnow is native to North America and can be found in the Great Lakes and the St Lawrence and Mississippi Rivers, as well as states in the United States and Canada. It is a fresh and marine species that prefers quiet lakes, ponds, sand or gravel, and commonly occurs in estuaries. Eggs are released in clusters and attach to plants, which disperse passively down river. This species is listed as Least Concern (IUCN) and does not migrate. It primarily feeds on insects, nymphs, mollusks and other small crustaceans.

Black bullhead (*Ameiurus melas*) is a fish species in the family Ictaluridae. It is a catfish native to North America and Mexico and is native to the Great Lakes, Hudson Bay and Mississippi River, but is exotic to Lake Champlain. It is a freshwater species that prefers warm and turbid waters with muddy bottoms and slow currents. Black Bullheads are common and sometimes very abundant throughout their range. They have become a popular gamefish in many areas, so due to stocking in many ponds and lakes black bullheads are a stable and growing species ("A Boundary Waters Compendium", 2004). It is not currently found in L. Champlain, but has been reported in nearby NY drainages. This species is listed as Least Concern (IUCN) and does not migrate. Their diet consists of insects of all stages, clams, snails, water fleas and other small crustaceans (MDNR).

Blackchin shiner (*Notropis heterdon*) is a fish species in the Cyprinidae family. It is native to North America and has been found in the Great Lakes, Mississippi and St Lawrence Rivers as well as the Hudson and Ohio Rivers and various states on the east coast and Canada. It is a freshwater species that prefers clear, cool weedy glacial lakes with sandy bottoms. This species is listed as Least Concern (IUCN) and does not migrate.

Blacknose shiner (*Notropis heterolepis*) is a fish species in the Cyprinidae family. It is native to North America and can be found in the Great Lakes, Hudson Bay and Mississippi River and from Nova Scotia to Saskatchewan, south to Ohio, Illinois, Mississippi and Kansas. It is a freshwater species that prefers the benthopelagic zone of temperate regions. It was first found in the Lake Champlain canal. *N. heterolepis* would benefit from habitat restoration and improved protection and management of occupied waters. This species is listed as Least Concern (IUCN) and does not migrate.

Bluegill (*Lepomis macrochirus*) is a fish species in the Centrarchidae family. This sunfish is native to North America and Mexico and can be found in the Great Lakes, St Lawrence and Mississippi Rivers and from New York to Minnesota and south to the Gulf of Mexico, west to Texas and New Mexico and northern Mexico. It is a freshwater species that prefers the benthopelagic zone of subtropical regions including areas of the Lake Champlain canal. *L. macrochirus* is abundant in its native range. No records of *L. macrochirus* were found prior to 1929. It is known to outcompete native Sacramento perch, *Archoplites interruptus.* This species is listed as Least Concern (IUCN) and does not migrate.

Bluntnose minnow (*Pimephales notatus*) is a fish species in the family Cyprinidae that is native to North America and can be found in the Great Lakes, Hudson Bay, Mississippi River and from southern Quebec to Manitoba and south to Louisiana, and St Lawrence River to Roanoke River, Virginia, and Alabama. It was first found in the Lake Champlain canal. This species is listed as Least Concern (IUCN) and does not migrate.

Bowfin (*Amia calva*) is a fish species in the Amiidae family. It is native to North America and can be found in most of the eastern United States and Canada, the Great Lakes and St Lawrence River, Minnesota, the Gulf of Mexico to the Colorado River and north to Pennsylvania. It is a freshwater species that prefers swampy, vegetated sloughs, lowland streams and warm clear lakes. Eggs are laid under vegetation or logs. *A. calva* is unique to Lake Champlain and the mouths of large tributaries. This species is listed as Least Concern (IUCN) and does not migrate.

Brassy minnow (*Hybognathus hankinsoni*) is a fish in the Cyprinidae family. It is native to North America and can be found in the St Lawrence River, Quebec across to the Great Lakes, Hudson and Mississippi River to Montana and Colorado, Fraser River (Pacific Slope) and BC, Canada. It was first found in the Lake Champlain canal in the late 1970s. It is a freshwater species that prefers the demersal zone of waterbodies. This species is listed as Least Concern (IUCN) and does not migrate.

Bridle shiner (*Notropis bifrenatus*) is a fish species in the family Cyprinidae. It is native to North America and can be found in Lake Ontario, the St Lawrence River, and many other states in the United States. It is a freshwater species that prefers warm, clear to moderate water bodies with mud, silt or detritus covered bottoms in tidal or brackish southern waters. *N. bifrenatus* spawns in still, shallow water near vegetation. It is vulnerable to poor water quality and high turbidity, so increased abundance of zebra and quagga mussels might help its abundance. Eurasian Watermilfoil might decrease its abundance. This species moves to shallow water near shore where vegetation is present to spawn (Scott and Crossman 1973) and is considered endangered in the Quebec portion of the Lake Champlain Basin.

Brook trout (*Salvelinus fontinalis*) is a fish species in the Salmonidae family. It is native to North America and can be found from Newfoundland to Labrador and in the Hudson River, the Great Lakes, the Mississippi River, Minnesota and northern Georgia. It is a fresh and marine anadromous species that prefers clear, cool, well-oxygenated creeks and rivers. There are many extensive conservation efforts directed towards brook trout, especially naturally reproducing brook trout populations due to susceptibility to urbanization and deforestation effects.

Brown bullhead (*Ameiurus nebulosus*) is a fish species in the Ictaluridae family. It is native to North America. It is common in the northeast and the Atlantic Gulf coast, but is sporadic everywhere else. It was first found in the Lake Champlain canal. It is a freshwater species that prefers the demersal zone of water bodies. *A. nebulosus* competes with other native predators and can reduce the populations of those predators. This species is listed as Least Concern (IUCN) and does not migrate. Usually this bullhead occurs

in vegetated shallows over sand, rock, mud or silt (most often soft substrates), in clear to turbid water (Lee et al. 1980, Page and Burr 2011).

Burbot (*Lota lota*) is a fish species in the Gadidae family. It is native to the North Atlantic and Arctic Sea and can be found in the northern and southern hemispheres. It is a freshwater and brackish potamodromous species that prefers the demersal zone of temperate regions. It is known to compete with and limit other non-native species. This species is listed as Least Concern (IUCN) and life history may be confined to lakes or rivers or may migrate between lake and riverine habitats (Scott and Crossman 1973).

Central mudminnow (*Umbra limi*) is a fish species in the Umbridae family. It is native to North America and can be found in the Great Lakes, St Lawrence River, Hudson Bay and the Mississippi River and from Quebec to Manitoba, Ohio, Tennessee, Arkansas, and New York. There are isolated populations in the Missouri River, South Dakota and Iowa. It is a freshwater species that prefers moderate or densely vegetated streams or swamps. *U. limi* avoids currents or water deeper than 0.5 m, but is tolerant of low oxygen levels and high temperatures. It spawns in the overflow along water bodies. Eggs stick to vegetation and can naturally disperse by drifting down water ways on vegetation. This species is listed as least concern (IUCN) and does not migrate. It is usually found in moderate to densely vegetated streams, sloughs, or swamps. It avoids areas with current and water more than 0.5m deep. It can be found in detritus on bottom. It is tolerant of low oxygen and high temperature and spawns in overflow areas along creeks.

Chain pickerel (*Esox niger*) is a fish species in the Esocidae family. It is native to North America and was introduced to southern Florida, the Gulf of Mexico to Louisiana, Mississippi to Kentucky and Missouri. It was also introduced to Lakes Ontario and Erie. It has been found in the Lake Champlain canal. It is a freshwater, non-migratory species that prefers the demersal zone of water bodies. This species is listed as least concern by (IUCN) and does not migrate. Its habitat includes vegetated lakes, swamps, and backwater and quiet pools of creeks and small to medium rivers (Page and Burr 2011). This fish tolerates warm water, acidity and pH 3.8, and salinity to 22ppt (Lee et al. 1980).

Channel catfish (*Ictalurus punctatus*) is a fish species in the family Ictaluridae. It is native to North America and can be found in the Great Lakes and the St Lawrence River and has been introduced to most of the United States. It has been found in the Lake Champlain canal. It is a freshwater species that prefers the benthopelagic zone of subtropical regions. This species is listed as least concern (IUCN) and does not migrate. Habitat for this species includes the main channels of small to large rivers. Adults usually are in pools or under log jams or cut banks by day, and move to riffles at night.

Channel darter (*Percina copelandi*) is a fish species in the Percidae family. It is native to North America and can be found in the Great Lakes, the St Lawrence River and in many states in the United States and Canada. It is a freshwater species that prefers warm, moderate rivers and creeks with a moderate current and sand or gravel substrate. *P. copelandi* spawns over gravel or rubble in a moderate or swift current. Its habitat includes warm, low and moderate gradient rivers and large creeks in areas of moderate current. Channel darters may overwinter in quiet pools or backwaters. In the northeast this species occurs and spawns along lake shores (Suttkus et al. 1994). This species is listed as endangered in Vermont and Quebec portions of the Lake Champlain Basin.

Cisco (*Coregonus artedi*) is a fish species in the family Salmonidae. It is native to North America with a wide distribution in the United States and can be found in the Great Lakes and St Lawrence River as well

as the Mississippi River, Ohio, Illinois, Minnesota, Quebec, Alberta and the Arctic. It is a freshwater and marine species that prefers lakes, rivers and the coastal waters of the Hudson Bay. Severe over-exploitation of *C. artedi* from 1930 to 1960, as well as competition with invasive rainbow trout, resulted in dramatic population declines. Other potential competitors include alewives and bloaters. The greatest current threat to *C. artedi* populations in the Great Lakes is eutrophication. This causes oxygen depletion in lower lake strata, forcing ciscoes into shallower, warmer parts of the water column. These higher temperatures, particularly during the summer months, cause large number of the fish to die. Because *C. artedi* are so sensitive to temperature fluctuations, their responses to eutrophication are thought to be a good indicator of the adverse effects of global warming. This species is listed as least concern (IUCN) and is migratory.

Common shiner (*Luxilus cornutus*) is a fish species in the Cyprinidae family. It is native to North America and can be found in the Great Lakes drainage, and from the lower Missouri River and upper Mississippi River to the Hudson Bay, southern Canada, northern Ohio and central Montana. It has been found in the Lake Champlain canal. It is listed as least concern (IUCN) and does not migrate. This species inhabits creeks and small to medium rivers with clear cool weedless water, moderate to swift current, gravel to rubble bottom, and alternating pools and riffles (usually avoids riffles).

Creek chub (*Semotilus atromaculatus*) is a fish species in the Cyprinidae family. It is native to North America and can be found in the Great Lakes, Hudson Bay, and Atlantic coast, Mississippi, Wyoming, Texas and the Gulf of Mexico. There is an isolated population in New Mexico. It is a freshwater species that is found in clear creeks, rivers and streams with less than 12 meters of water and gravel bottoms (Scott and Crossman 1973, Johnston and Page 1992). *S. atromaculatus* spawns in the littoral zone of lakes or near riffles in streams and the eggs are covered with stones. This species is listed as least concern (IUCN) and does not migrate.

Cutlips minnow (*Exoglossum maxillingua*) is a fish species in the Cyprinidae family. It is native to North America and can be found in the St Lawrence River and Lake Ontario as well as New York, West Virginia, Virginia, North Carolina and Quebec. It is a freshwater species that prefers clear small creeks or rivers. Spawning of *E. maxillingua* takes place on upstream slopes and the eggs are lodged and buried in nest mounts. This species is listed as least concern (IUCN) and does not migrate. This species inhabits clear creeks and small to medium rivers with gravel, rubble, and boulder bottom relatively free of rooted plants; usually under or near boulders in quiet pools and runs (Lee et al. 1980, Page and Burr 2011).

Eastern blacknose dace (*Rhinichthys atratulus*) is a fish in the Cyprinidae family. It is native to North America and can be found in Lake Ontario and on the Atlantic slope from Nova Scotia to South Carolina. It is a freshwater species that prefers cool creeks or rivers with gravel bottoms (Lee et al. 1980). *R. atratulus* spawns over gravel in fast water. This species is listed as least concern (IUCN) and does not migrate. This species often rests on bottom under or beside stones. This fish often rests under banks in deepest water in winter. It also spawns over gravel in fast water of shallow riffles (Scott and Crossman 1973).

Eastern Silvery Minnow (*Hybognathus regius*) is a minnow in the Cyprinidae family. Its native range includes the Atlantic Slope from St. Lawrence River drainage, Quebec to Altamaha River drainage, Georgia, Lake Ontario drainage, Ontario and New York. It occurs in pools and backwater of low-gradient creeks and small to large rivers. Oviparous, open substratum spawners that feed on plant material, benthic diatoms, algae and detritus. Habitat for this species includes quiet weedy inshore waters of lakes, pools and backwaters of low gradient creeks and small to large rivers (page and Burr 2011). Adults move to well-

vegetated lagoon or slow lower reaches of tributary streams to spawn. It is listed as least concern (IUCN) and does not migrate.

Emerald Shiner (*Notropis atherinoides*) is a fish in the Cyprinidae family. In its native range in the Upper Niagara River, juveniles are more often found in natural habitat (e.g. marshes) than developed habitat (e.g. seawalls) It has a translucent "emerald" upper body, becoming more whitish toward the belly; silvery stripe along the side. It primarily eats macrocrustaceans and aquatic adult immature insects as well as terrestrial insects. Its means of introduction include bait bucket releases and active dispersal through canals to other bodies of water. This species is listed as least concern (IUCN) and does not migrate. This species inhabits large open rivers, lakes, and reservoirs; pools and runs of rivers with low or moderate gradient (Burkhead and Jenkins 1991); also mouths of smaller streams. Often aggregates in large schools in mid-water or near surface (Becker 1983).

Fallfish (*Semotilus corporalis*) is a freshwater fish in the Cyprinidae family. Its native range is the Atlantic slope from New Brunswick to James River drainage. Virginia; Hudson Bay, Lake Ontario, and St. Lawrence drainages, Quebec, Ontario, and New York. Most likely introduced through bait bucket releases where it was able to travel via canals and waterways that were constructed (especially in Adirondack Mountains). This species is listed as least concern (IUCN) and does not migrate. It occupies clear, flowing gravel- to rubble-bottomed small to medium rivers; lake margins. Fallfish spawn over pit made by male in gravel bottom.

Fantail Darter (*Etheostoma flabellare*) is a freshwater fish in the Percidae family. In large streams, this darter occurs in shallow areas away from main current. Eggs are laid in flat clusters on the undersides of stones. Adults feed on midge, blackfly, and caddisfly larvae. This species is listed as least concern (IUCN) and does not migrate. Habitat for this species includes riffles with gravel or rubble substrate in streams of 1st through 8th order (creeks and small to medium rivers).

Fathead Minnow (*Pimephales promelas*) is a freshwater fish in the Cyprinidae family. Its native range includes much of North America from Quebec to Northern territories, and south to Alabama, Texas, and New Mexico. The popularity of this species as a baitfish and forage fish has led to widespread introductions. It has established in most states where introduced. They prefer small rivers and ponds and are commonly found in muddy pools of headwaters and creeks and appear to tolerate habitat conditions that exclude many freshwater fishes such as high turbidity and temperature, variable pH and salinity. This species does not migrate. Habitat for this species includes lakes, ponds, headwaters, creeks, small rivers, ditches, reservoirs, residual pools of intermittent streams (where sometimes very abundant).

Finescale Dace (*Chrosomus neogaeus*) is a freshwater fish in the Cyprinidae family. Found in slow-moving streams that are clear because they are sight feeders. They prefer creeks lined with sand or gravel as opposed to mud. They can also be found in pools of boggy headwaters, creeks, and small rivers and common in beaver ponds (Lee et al. 1980, Page and Burr 2011). Spawning times depend on water temperature but usually occur from April to June. This species is listed as least concern (IUCN) and does not migrate.

Freshwater Drum (*Aplodinotus grunniens*) is a freshwater fish in the Sciaenidae family. It is the only member of its family in North America known to occur completely in freshwater habitats. It typically inhabits the bottom of medium to large rivers and lakes up to about 40 – 60ft depths (Etnier and Starnes 1993, Scott and Crosman 1973). It is tolerant of clear and turbid conditions (Fremling 1980). Its native range includes East of the Rocky Mountains in the St. Lawrence-Great Lakes, Hudson Bay, and Mississippi

River basins from Quebec to northern Manitoba and southern Saskatchewan in Canada and south to the Gulf of Mexico. It was stocked in the late 1800s in Illinois lakes as a sport fish (Bean 1892), and later in Colorado in the 1950s for the same reason (Everhart and Seaman 1971) and present in all the Great Lakes by the 1970s. This species is listed as least concern (IUCN) and does not migrate.

Golden Shiner (*Notemigonus crysoleucas*) it is a freshwater fish in the Cyprinidae family. Its native range is Atlantic and Gulf Slope drainages from Nova Scotia to southern Texas; Great Lakes, Hudson Bay (Red River), and Mississippi River basins west to Alberta, Montana, Wyoming, and western Oklahoma. The Golden shiner is widely used as bait and as an ornamental and therefore has been transplanted into many areas. This species is widely introduced throughout California with unknown effects on native species. It has become established in the states that it has been introduced to. It is listed as least concern (IUCN) and does not migrate. This species usually occupies clean, quiet, vegetated water with access to extensive shallows, and often inhabits sluggish sections of streams and rivers. It spawns over beds of submerged vegetation (Becker 1983).

Johnny Darter (*Etheostoma nigrum*) it is a freshwater fish in the Percidae family. Its native range is North America; St Lawrence-Great Lakes, Hudson Bay, MS R., Quebec, VA, CO, NC, SC, VA, AL. It occupies sandy, muddy, or rocky areas of small and large streams, creeks, pools, reservoirs, and lakes. It primarily consumes chironomid and other insect larvae. Its means of introduction is unknown (USGS). This species is most often found over sand or silt in quiet or sluggish areas of headwaters, creeks, and small to medium rivers (Leidy 1992, page and Burr 1991). This species is listed as least concern (IUCN) and does not migrate.

Lake Chub (*Couesius plumbeus*) is a freshwater fish in the Cyprinidae family. Its native range includes much of Canada and northern United States; south to Delaware River, and parts of New York; southern end of Lake Michigan, Illinois; Platte River system, Colorado; and Columbia River drainage, Washington. Relict populations of this species are found in the Mississippi River basin, and Iowa. It was introduced via bait bucket release. It can disperse actively from introduction points through canals and waterways. This species is listed as least concern (IUCN) and does not migrate. This chub occurs in varied habitat, including standing or flowing water, and large or small bodies of water, it is most common in gravel-bottomed pools and runs of streams and along rocky lake margins (Page and Burr 2011).

Lake Sturgeon (*Acipenser fulvescens*) is a freshwater fish in the Acipenseridae family. Its native range includes St. Lawrence-Great Lakes, Hudson Bay, and Mississippi River basins from Quebec to Alberta and south to Alabama and Louisiana; Coosa River system (Mobile Bay drainage), Alabama and Georgia. This species has been intentionally stocked throughout the NE and northern mid-west United States. Lake Sturgeon are capable of actively dispersing upwards of 20km in a study done by Wisconsin DNR. Lake sturgeons are known to move great distances to spawning and feeding habitats (Auer 1996). Usual lake sturgeon habitat is the highly productive shoal areas of larger lakes and rivers. They require moderate to swift currents and large rough substrates for spawning and embryo development. While migrating presumable en-route to spawning habitats or high use (feeding/home) areas, lake sturgeon will use areas of the river with relatively high current velocities including tail waters, the main channel in the upper and mid reaches of navigation pools, and tributaries. This species is listed as threatened in New York and endangered in Vermont.

Lake Trout (*Salvelinus namaycush*) are a freshwater fish in the Salmonidae family. It is native to North America and widely distributed from northern Canada and Alaska (missing in southern prairie provinces) south to New England and Great Lakes basin (Page and Burr 1991). They have been intentionally stocked as a sport fish. Lake trout often lead to the demise of other trout species where it is introduced (McAffee

1966; Moyle 1976; Behnke, personal communication). The ability of *S. namaycush* to inhabit almost benthic-like environments gives it an upper hand in competition with other fish species.

Logperch (*Percina caprodes*) it is a freshwater fish in the Percidae family. It is native to North America; St Lawrence-Great Lakes, Hudson Bay, MS River from eastern Quebec, south to GOM, MO, and southern FL. Introduced throughout US, southern Canada and much of the world. These fish are very mobile and usually forage long stretches of river or streambed for food. This species is listed as least concern (IUCN) and does not migrate. This species inhabits ranges from small creeks to rivers, and also includes deep waters of lakes and reservoirs. In streams this species prefers clean riffles and runs over substrates of mixed sand and gravel. It is often associated with bottom debris (Page 1983).

Longnose Dace (*Rhinichthys cataractae*) is a freshwater fish in the Cyprinidae family. They have the widest geographic distribution of any member of the Cyprinidae family which spans much of North America, ranging from the Atlantic coast to the Pacific Ocean and from northern Mexico to the Arctic Circle. They are found in fast-flowing, cold water, and stream riffles. In lakes they are typically in the turbulent surge zone less than 10m deep. They have been introduced during bait bucket releases and have been able to actively disperse through waterways and canals from their points of introduction. This species is listed as least concern (IUCN) and does not migrate.

Longnose Gar (*Lepisosteus osseus*) is a freshwater fish in the Lepisosteidae family. It is widely distributed throughout the United States from the eastern seaboard to the upper mid-west, Quebec, and all of the Great Lakes except Superior. It prefers sluggish areas of larger rivers, lakes, reservoirs and estuaries. Longnose gar have long, narrow snouts more than twice as long as the rest of the head and have abundant sharp, villi form teeth. They have interlocking, rhomboid, ganoid scales that act as armor and as a result have no major predators, allowing populations to thrive wherever it occurs. This species is listed as least concern (IUCN) and does not migrate.

Longnose Sucker (*Catostomus catostomus*) it is a freshwater fish in the Catostomidae family. Its native range is the Atlantic, Arctic, and Pacific basins throughout most of Canada and Alaska; Atlantic Slope south to Delaware River drainage, and parts of New York; Great Lakes basin; upper Monongahela River drainage, Maryland and West Virginia; Missouri River drainage south to northeastern and central Colorado. Has been introduced through bait bucket releases and in 1952 was reported to be introduced in the Colorado River Drainage in Colorado. This species is listed as least concern (IUCN) and is migratory. This species is a bottom dweller that prefers cold, clear, deep water of lakes and tributary streams to depths of 600 ft in the Great Lakes; this fish also occurs in brackish water near the mouths of Arctic streams (Page and Burr 2011).

Mimic Shiner (*Notropis volucellus*) it is a freshwater fish in the Cyprinidae family. Its native range is the St. Lawrence-Great Lakes, Hudson Bay, and Mississippi River basins from Quebec and Vermont to west-central Manitoba, and south to Gulf. It is noted to scatter eggs over aquatic vegetation in deeper weedy littoral areas in Lakes. This species is listed as least concern (IUCN) and does not migrate. It occupies clear streams from medium sized creeks to small rivers and also in clear, moderately weedy lakes. This shiner may move to bottom in deeper water at night in lakes (Becker 1983).

Mooneye (*Hiodon tergisus*) it is a freshwater fish in the Hiodontidae family. Its native range is the St. Lawrence-Great Lakes (except Superior), Mississippi River, and Hudson Bay basins from Quebec to Alberta and south to Gulf; Gulf Slope drainages from Mobile Bay, Alabama, to Lake Pontchartrain, Louisiana. Habitats include deep pools and backwaters of medium to large rivers and interconnecting lakes and

reservoirs with clear water (Wallus and Buchanan 1989). It mainly eats aquatic and terrestrial insects and crustaceans, mollusks, and small fishes. This species is listed as threatened in New York.

Mottled Sculpin (*Cottus bairdii*) it is a freshwater fish in the Cottidae family. Its native range is North America with disjunct populations across the Western and Eastern United States Arctic, Quebec, and Alberta, It is generally found in gravel or rocky rubble substrates or under vegetative cover in swift waters of headwater, creeks, and small rivers (Scott and Crossman 1973, Peden and Hughes 1984, Lee et al. 1980, Page and Burr 2011). It eats mainly aquatic and terrestrial insects, crustaceans, mollusks, and small fishes. This species is listed as least concern (IUCN) and does not migrate.

Muskellunge (*Esox masquinongy*) It is a freshwater fish is the Esocidae family. Its native range includes St. Lawrence River-Great Lakes and Mississippi River basins, from Quebec to southeastern Manitoba; south in the Appalachians to Georgia and in the west to Iowa. It is typically found in lakes with numerous submerged weed beds but can also be found in clear, sterile lakes with almost no weeds. Muskies are considered a cool water species preferring temperatures from 0.55C to 25.5C but can withstand temperatures up to 90F (Michigan DNR 2012; Becker 1983). It is listed as least concern (IUCN) and does not migrate. This species is noted to be threated historically by habitat alteration, pollution, overexploitation, and increased abundance of northern pike caused declines in some areas (Kerr 2011).

Northern Brook Lamprey (*Ichthyomyzon fossor*) is a freshwater fish in the Petromyzontidae family. Its native range includes North America; St Lawrence R., Quebec, Great Lakes, MS R., OH R., PA, KY, MO R., Ozark Uplands, MO, and Manitoba. Habitat includes clean, clear gravel riffles and runs of small rivers, does not occur in large river or small brooks, but over gravel or sand-silt bottoms in moderately warm water (Becker 1983). They feed mainly on organic detritus, diatoms, desmids, protozoans, algae and pollen; the adults are nonparasitic. This species is listed as endangered in Vermont and threatened in the Quebec portion of the Lake Champlain Basin.

Northern Pearl Dace (*Margariscus nachtriebi*) it is a freshwater fish in the Cyprinidae family. Its native range is the Atlantic, Hudson Bay, Great Lakes, and Mississippi River basins in southern Canada and northern United States from Atlantic Coast to southern Northern Territories. Its habitat includes cool, clear headwater streams in the south, bog drainage streams, ponds and small lakes in the north, and in stained, peaty waters of beaver ponds (Scott and Crossman 1973). It spawns in clear water over sand or gravel in weak or moderate current. It is listed as least concern (IUCN) and does not migrate.

Northern Pike (*Esox lucius*): It is a freshwater fish in the Esocidae family. It is native to North America and Eurasia. They are found from Labrador west to AK, south to PA, MO, and NE. They are found in almost every type of freshwater, from cold deep lakes, to warm shallow ponds, to muddy rivers. It is extremely adaptable to different conditions. They are a tertiary predator in the aquatic ecosystems they inhabit. This species is listed as least concern (IUCN) and does not migrate.

Northern Redbelly Dace (*Chrosomus eos*) it is a freshwater fish in the Cyprinidae family. Its native range is the Atlantic, Great Lakes, Hudson Bay, upper Mississippi, Missouri, and Peace-Mackenzie River drainages, from Nova Scotia west to Northwest Territories and British Columbia, south to northern Pennsylvania, Wisconsin, Nebraska, and Colorado. Habitat includes boggy lakes, ponds; beaver ponds, and pools of headwaters and creeks; this fish is often in tea colored water over fine detritus or silt, usually near vegetation (Lee et al. 1980, Page and Burr 2011). This species is listed as least concern (IUCN) and does not migrate.

Northern Sunfish (*Lepomis peltastes*) it is a freshwater fish in the Centrarchidae family. Its native range is North America; St. Lawrence-Great Lakes, Hudson Bay (Red River), and upper Mississippi River basin from Ontario in Canada to Minnesota, and south to Ohio, Indiana, Illinois and Iowa (where extirpated) in USA. Its habitat includes freshwater; rocky and sandy pools, headwaters, creeks, medium rivers, near vegetation.

Pumpkinseed (*Lepomis gibbosus*) it is a freshwater fish in the Centrarchidae family. Its native range is the Atlantic Slope drainages from New Brunswick to Edisto River, South Carolina; Great Lakes, Hudson Bay, and upper MS basins from Quebec and NY west to southeastern Manitoba and ND, and south to northern KY and MO. It prefers freshwater; brackish; benthopelagic; potamodromous; clear water with aquatic vegetation. It is capable of actively dispersing through water bodies that discharge into water courses and actively swim within water courses. It is listed as least concern (IUCN) and does not migrate. Habitat for this species includes lakes, reservoirs, ponds, sloughs, and sluggish streams prefers quiet clear water with aquatic vegetation and some organic debris.

Quillback (*Carpiodes cyprinus*) it is a freshwater fish in the Catostomidae family. Its native range is Great Lakes, St. Lawrence R., Hudson Bay, MS R., Quebec, Alberta, LA, WY, DE R., NY, FL, and GA. Its preferred habitat includes freshwater; warm, shallow, slow water, mud and sand bottom. They actively migrate up small creeks to spawning areas. In Manitoba, upstream spawning migrations began after water temperatures reached 5°C but only when discharges were high. *C.cyprinus* eats debris in bottom ooze, plant materials, and insect larvae. It is listed as least concern (IUCN) and does not migrate.

Redbreast Sunfish (*Lepomis auritus*) It is a freshwater fish in the Centrarchidae family. Its native range is Atlantic slope from New Brunswick to FL and GA, Gulf of Mexico drainages to the Rio Grande and Mississippi Rivers, as far north as KT and AR. Its preferred habitat includes freshwater; rocky and sandy creeks and small and medium rivers. Eggs laid in nests on the bottom, usually on the downstream side of rocks. This species is listed as least concern (IUCN) and does not migrate.

Redfin Pickerel (*Esox americanus*) It is a freshwater fish in the Escoidae family. Its native range is North America; St Lawrence R., Quebec, FL, TX, MS R., Great Lakes, NE, WI, MI, WA, CA, CO, and Ontario. Its preferred habitat is freshwater; quiet, heavily vegetated, often streams. Eggs sink to bottom and stick to vegetation. Adults can actively disperse and move upstream to spawn in flooded stream margins or marshes where vegetation is abundant (Scott and Crossman 1973). It is listed as least concern (IUCN) and it does not migrate.

Rock Bass (*Ambloplites rupestris*) is a freshwater fish in the Centrarchidae family. Its native range encompasses St. Lawrence-Great Lakes, Hudson Bay, and Mississippi River basins. It has been introduced in many places on Atlantic slope south to Roanoke River, Virginia, and west of native range in Missouri, Arkansas, northeastern Oklahoma, Southeastern Kansas, and some western states. Research suggests that this species was intentionally stocked as a sport-fishing target with its expansion through natural dispersal. It is listed as least concern (IUCN) and does not migrate. Habitat for this species includes pools and brushy margins in creeks and small to medium rivers (Page and Burr 2011). This bass prefers small, cool, weedy lakes or littoral regions of larger lakes, and streams with typically rocky, always silt-free substrates, permanent flow, low turbidity, and extensive cover (Lee et al. 1980).

Rosyface Shiner (*Notropis rubellus*) is a freshwater fish in the Cyprinidae family. Its native range is North America; Great Lakes drainage, upper OH River, northern Atlantic slope, southern Quebec and Ontario to KY and VA. Its preferred habitat is clear, swift, large creeks and small rivers with bottoms of clean gravel

or rubble; usually in or around riffles. Actively disperse through waterways to find waters of their temperature preference (warm water adapted). This species is listed as least concern (IUCN) and does not migrate.

Round Whitefish (*Prosopium cylindraceum*) it is a freshwater fish in the Salmonidae family. Its native range is North America; St Lawrence, Great Lakes, Hudson River, CT, NY and northern BC. Its preferred habitat includes freshwater; cool, clear, lakes and rivers, many depths, gravel or rocky bottoms. *P. cylindraceum* consumes zooplankton and benthic invertebrates. May make upstream spawning migration between inshore spawning areas and offshore non-spawning areas in lakes (Becker 1983). This species is listed as endangered in New York.

Sand Shiner (*Notropis stramineus*) It is a freshwater fish in the Cyprinidae family. Its native range is North America; St Lawrence, Great Lakes, Hudson Bay, MS R., TN, TX, MO, WY, CO, NM, and Mexico. Its preferred habitat includes most freshwater streams, but is rarely found upland. It can be found on sandy substrate, little to no vegetation, moderate to slow current, and sheltered locations. This species may actively make seasonal movements between rivers and tributary creeks (Becker 1983). Eats various aquatic and terrestrial invertebrates (especially chironomids), algae, and (mainly) bottom particulate matter. This species is listed as least concern (IUCN) and does not migrate.

Sauger (*Sander canadensis*) it is a freshwater fish in the Percidae family. Its native range St Lawrence River, Great Lakes, Hudson Bay, Mississippi River, WY, KS, AK, LA, TN, AL, Quebec and Alberta. Its preferred habitat includes freshwater, sand and gravel bottoms, large, slow, turbid waters. Spawns on sandy or rocky bottoms in lakes, or deep rocky runs in rivers. This species is known to hybridize with walleyes. Saugers are a highly migratory species that can actively disperse hundreds of kilometers to spawn (3 to 350km). It is listed as a “critically imperiled species” in New York.

Shorthead Redhorse (*Moxostoma macrolepidotum*) It is a freshwater fish in the Catostomidae family. Its native range Mississippi and Missouri River basins, St Lawrence-Great Lakes, Hudson drainage, Quebec, Alberta, WY, OK, northern MO, IL, northern OH, NY also coast to SC; Ozarks and OH River populations are considered distinct species. Its preferred habitat is freshwater that is brackish; demersal, and temperate as well as rocky pools and riffles of small to large rivers, natural lakes, and impoundments. This species migrates locally to its spawning grounds and is listed as least concern (IUCN).

Silver Redhorse (*Moxostoma anisurum*) it is a freshwater fish in the Catostomidae family. Its native range is North America; upper MS and Great Lakes-St Lawrence, Quebec to Alberta, south to AL and AK, OH River, Ozarkian uplands, southwest Hudson Bay. This species is a benthic forager, consuming insect larvae, crustaceans, mollusks, algae, and detritus. This species actively migrates upstream to its spawning grounds and is listed as least concern (IUCN). Habitat for this species includes silty to firm-bottomed pools and runs of small to large rivers also in natural lakes and impoundments (Scott and Crossman 1973).

Slimy Sculpin (*Cottus cognatus*) It is a freshwater fish in the Cottidae family. It is native to Canada, Russia, and the United States. Its North American range includes the Atlantic, Arctic, and Pacific basins of Alaska and most of Canada. Species occurs primarily in three areas: Lake Superior and its tributaries, Lake Michigan, and small cold streams in the "Drift less Area" of southwestern Wisconsin, northeastern Iowa and Southeastern Minnesota. Their preferred habitats are benthic, deep cool lakes and streams and deep oligotrophic lakes and swift rocky-bottomed streams (Becker 1983). This species actively migrates large distances to spawn, but during non-spawning periods the species forages within a more restricted range. This species is listed as least concern (IUCN).

Smallmouth Bass (*Micropterus dolomieu*) is a freshwater fish in the Centrarchidae family. It is native to North America; St Lawrence -Great Lakes, Hudson Bay, Mississippi River from southern Quebec to ND and south to AL and OK. *M. dolomieu* is typically found in cooler rivers and lakes, with rocky or sandy substrates. In lakes, they seek out structures, such as logs, rocky outcroppings, or pier posts. When weather gets colder, smallmouth bass will often actively disperse in search of deeper pools in which they enter a semi-hibernation state until waters warm in spring. It is listed as least concern (IUCN) and does not migrate.

Spotfin Shiner (*Cyprinella spiloptera*) is a freshwater fish in the Cyprinidae family. Its native range includes the Great Lakes except Lake Superior, Hudson Bay, Mississippi River from Canada and NY to ND and AL and OK, isolated in Ozarks. It inhabits sand and gravel runs and pools of creeks, and small to medium rivers. Adults feed on surface insects and aquatic immatures. Spotfin Shiners actively migrate to spawning grounds from their foraging grounds in late spring and early summer.

Spottail Shiner (*Notropis hudsonius*) is a freshwater fish in the Cyrpinidae family. Its native range is North America; including the Atlantic and Gulf slope drainages from St Lawrence, Quebec, Altamaha and GA, Hudson Bay, Great Lakes, MS River, Ontario, Alberta, northern OH, southern IL, MT. It prefers large sluggish coastal rivers and brackish water to small clear rapidly flowing montane streams. Locally migrates to spawn in spring or early summer in aggregations over areas of gravelly riffles near mouths of brooks, or along sandy shoals of lakeshores. It is listed as least concern (IUCN).

Stonecat (*Noturus flavus*) is a freshwater fish in the Ictaluridae family. Its native range is North America, which includes St Lawrence, Great Lakes, Hudson, MS R., Quebec, Alberta, AL, MS, AK, OK, CO, and NY. Its preferred habitat is freshwater; runs riffles, rapid warm creeks and rivers, natural lakes, with loose rocks. It also occurs in natural lakes near sand and gravel bars with wave action. Stonecats spawn in rocks areas in spring and summer, later in north than in south. Stonecats may also move to deep water in winter. This species is listed as endangered in VT.

Tessellated darter (*Etheostoma olmstedi*) is a freshwater fish in the Percidae family. Its native range is North America, St Lawrence River, Quebec and Ontario to Altamaha River, GA, FL and Lake Ontario drainage to NY. It inhabits sandy and muddy pools of headwaters, creeks and small to medium rivers; and shores of lakes. Tessellated darters spawn in April to May or June in New York. They are also host fish for the federally endangered dwarf mussel. It is a species of least concern (IUCN). Habitat for this species includes sand-and mud bottomed pools, slow runs, and backwaters of headwater, creeks, and small to large rivers; occasionally found in brackish water also recorded from shallow rocky shoals of lakes (Lee *et al*. 1980, Kuehne and Barbour 1983, Page 1983, Page and Burr 2011).

Trout-Perch (*Percopsis omiscomaycus*) is a freshwater fish in the Percopsidae family. Its native range is North America which includes the Atlantic and Arctic through most of Canada from Quebec to Yukon and BC, Potomac in VA, Great Lakes, MS River to WV, eastern KY, southern IL, central MO, ND, and northern MT. Its preferred habitat includes lakes but also found in deep flowing pools of creeks and small to large rivers; usually over sand (Page and Burr 1991). Normally in deep water by day, moves into shallows at night (Becker 1983). Locally migrates to spawning grounds in spring. This species is listed as least concern (IUCN).

Walleye (*Sander vitreus*) is a freshwater fish in the Percidae family. Its native range is North America, St Lawrence-Great Lakes, Mississippi River from Quebec to Northwest Territories, south to AL, MS, and AK. Introduced in US, including Atlantic, GOM, and Pacific. Preferred habitat for walleyes include lakes, pools,

backwaters, and runs of medium to large rivers; generally in moderately deep waters. It is also generally found in quiet water when not spawning, often in beds of aquatic vegetation. Walleyes may migrate as much as 160km between spawning habitat and non-spawning habitat in the spring (in north) and early summer. This species is listed as least concern (IUCN).

White Sucker (*Catostomus commersoni*) is a freshwater fish in the Catostomidae family. Its native range is North America; throughout most of Canada to the Atlantic Coast, south through North Carolina to New Mexico in the USA, becoming less common in the southern High Plains. White suckers occur in a wide variety of lake and stream habitats. Some migrate dozens of kilometers between lakes or streams to spawn. Spawning occurs in swift water or rapids often in small, clear, cool creeks and small to medium rivers in water less than 30cm deep.

Yellow bullhead (*Ameiurus natalis*) is a freshwater fish in the Ictaluridae family. Its native range is Canada and the United States. It is native throughout most of the eastern and central United States and adjacent southern Canada. It has been introduced widely outside of its native range. This bullhead occurs in shallow, soft-bottomed, weedy parts of clear warm lakes, ponds, reservoirs, or slow-moving streams or canals. Yellow bullheads migrate to spawning grounds in spring and early summer and is listed as least concern (IUCN).

Yellow Perch (*Perca flavescens*) is a freshwater fish in the Percidae family. Its native range is North America occurring east of Rockies in Atlantic, Arctic, Great Lakes, Mississippi River, from Nova Scotia and Quebec to Northwest Canadian Territories, south to OH, IL, NE and south to SC, and introduced in most western states. Yellow perch are usually found in clear weedy backwaters or pools of creeks and small to large rivers, shallow waters of lakes, and large ponds. Often, they are associated with heavy growths of aquatic plants in lakes. Yellow perch may migrate from lakes into tributary rivers to spawn or into fresh water from brackish water. It is listed as least concern (IUCN). They occur and spawn in brackish water in some areas. Spawning occurs in spring or late winter over submerged beds of aquatic plants or brush, or over sand, gravel, or rubble, in quiet water (Moyle 1976, Sublette et al. 1990).

4.3 Plants

Arrow Arum (*Peltandra virginica*) is a perennial plant in the Araceae family. Its native range is Eastern North America but also occurring in OR, and CA. *P.virginicia* is a terrestrial; freshwater; species is found in bogs, swamps, freshwater to low-salinity tidal marshes, and ditches as well as along the edges of ponds, lakes, and rivers (Flora of North America Editorial Committee 1993+). This species is listed as least concern (IUCN).

Big Duckweed (*Spirodela polyrhiza*) is a floating aquatic plant in the Lemnaceae family. Its native range is North America; however it is widespread throughout, Europe, Africa, Asia, Australia and parts of South America. This species is found in fresh lentic waters in regions with warm summers. It occurs in lakes, large dams, among reeds, often together with *Lemna* sp. and *Wolffia* sp., or with *Pistia* and/or *Salvinia* spp. The species occurs generally in mesotrophic to eutrophic lake and river waters (New England Wild Flower Society 2011-2015). It is listed as least concern (IUCN).

Broadleaf Arrowhead (*Sagittaria latifolia*) is a perennial plant in the Alismataceae family. It is native North America; being widespread across USA and Canada, including VT. *S. latifolia* is a terrestrial, freshwater species that occurs in fresh tidal marshes or flats, shores of rivers, streams, lakes and ponds. It thrives in

fresh water 6 to 12 inches deep and it is a multipurpose emergent plant that offers food and cover for aquatic animal life. This plant can be successfully established vegetatively with tubers. It is listed as least concern (IUCN).

Clasping Leaf Pondweed (*Potamogeton perfoliatus*) is a perennial plant in the Potamogetonaceae family. It is native to North America and occurs widely throughout the southeastern and north eastern United States, Western and Eastern Canada and Greenland. *P. perfoliatus* is a freshwater, submerged aquatic plant that occurs in still and flowing freshwater in temperate climates. It is common in lakes, ditches and slow rivers and streams, and it is tolerant of quite a wide range of nutrient levels. It will grow in natural and artificial lakes, ponds, backwaters and slower-flowing sections of larger rivers and canal systems. It is listed as least concern (IUCN).

Common Duckweed (*Lemna minor*) is a perennial aquatic plant in the Lemnaceae family. Its native range is native to North America and widespread throughout much of the United States and Canada. This species is particularly common in lakes, ponds, canals, rice fields, and ditch systems but will occur in most still or slow-flowing water bodies under most conditions, except in very oligotrophic or acidic water, it is even capable of growing in a trickle of water over vertical surfaces such as canal lock gates or seepages in cliffs. It is listed as least concern (IUCN).

Eelgrass (*Vallisneria americana*) is a perennial plant in the hydrocharitaceae family. Its native range is North America, and it is widespread throughout the United States, Canada and the Caribbean. It is terrestrial and occurs in freshwater. The species grows in lakes and slow-moving rivers, primarily in circumneutral to basic water (New England Wild Flower Society 2011-2015). It is listed as least concern (IUCN).

Fennel pondweed (*Stuckenia pectinate*) is a widespread freshwater plant in the Potamogetonaceae family. It is native to North America but has been widespread throughout Europe, Africa, Asia, Caribbean and South America. This species is typical of eutrophic or brackish waters where it may form dense stands in lakes, reservoirs, rivers, streams, canals, ditches, ponds, and flooded mineral workings. It is tolerant of disturbance in canals and navigable rivers. It is listed as least concern (IUCN).

Flatstem Pondweed (*Potamogeton zosteriformis*) is a perennial plant in the Potamogetonaceae family. It is native to North America and occurs throughout all of Canada and the northern half of the United States including CA and VA. This species is both lacustrine (occurs in lakes or ponds), riverine (occurs in rivers or streams). *P.zosteriformis* reproduces by turions that can also be dispersed be consumed and or dispersed by waterfowl. It is listed as endangered in Maryland and New Jersey and threatened in New Hampshire (USDA).

Floating leaf pondweed (*Potamogeton natans*) is a freshwater perennial plant in the Potamogetonaceae family. It is native to North America and widely distributed throughout much of the Canada and the United States except for the Southeast USA. It is floating-leaved aquatic in still or slowly flowing waters, and more rarely found as plants with submerged phyllodes in more rapid streams and rivers. It has a very wide ecological tolerance, growing in oligotrophic to eutrophic and base-poor to base-rich water over a wide range of substrates. It is listed as least concern (IUCN).

Large Leaf Pondweed (*Potamogeton amplifolius*)is a freshwater perennial plant in the Potamogetonaceae family. Its native range is North America and is widespread throughout the United States and Canada. *P.amplifolius* is a terrestrial; freshwater; species occurs in shallow, still or slow-moving, slightly acidic to

basic water of lakes, ponds, rivers and streams. This species has been used successfully in restoration projects, growing 10-fold in the first season (NEWFS). It is listed as least concern (IUCN).

Pickerel Weed (*Pontederia cordata*) is a freshwater perennial plant in the Pontederiaceae family. It is native to North America and occurs from Nova Scotia to MN, south to FL and TX. This aquatic plant grows in a variety of wetlands, including pond and lake margins across and extremely large range from eastern Canada, south to Argentina.

Ribbon Leaf Pondweed (*Potamogeton epihydrus*) is a freshwater perennial plant in the Potamogetonaceae family. It is native to North America and widespread throughout northern USA including VT and southern Canada. It is a freshwater species that grows in shallow, still or slow-moving, acidic to basic water of lakes and rivers (New England Wild Flower Society 2011-2015). This species is listed as least concern (IUCN).

Rigid Hornwort (*Ceratophyllum demersum*) is a freshwater aquatic plant in the Ceratophyllaceae family. It is native to North America that is widespread throughout all of the United States and Canada. It grows in static and slow-moving shallow or deep water in lakes, ponds, rivers, and streams, and also in reed swamps. It can tolerate brackish conditions in estuaries and forms thick mats just below the surface. This species is free-floating and has no roots. This species is listed as least concern (IUCN).

Small Pondweed (*Potamogeton pusillus*) is a freshwater perennial plant in the Potamogetonaceae family. It is native to North America and is widespread throughout much of US and Canada, including Vermont. It occurs in standing or slow-flowing water in a wide range of habitats, including sheltered lakes and reservoirs, ponds, rivers, streams, canals, and ditches. This species is listed as least concern (IUCN).

Softstem Bulrush (*Schoenoplectus tabernaemontani*) is a perennial aquatic rush in the Cyperaceae family. It is native to North America and found in most of northern hemisphere, as well as Australia and parts of South America. It grows in moist and wet habitat, and sometimes in shallow water. *S. tabernaemontani* is a species of both fresh and brackish water, lakes, fens, bogs, streams and marshy ground. It occurs both in the montane zones and coastal area. This species is listed as least concern (IUCN).

Water Stargrass (*Heteranthera dubia*) is a perennial, aquatic plant in the Pontederiaceae family. It is native to North America and is widespread through much of the United States and Canada. This species occurs in lakes, ponds, rivers, and streams where it forms submersed populations or floats on the water surface. It is listed as least concern (IUCN).

Western Waterweed (*Elodea nuttallii*) is an aquatic freshwater perennial plant in the Hydrocharitaceae family. It is native to North America and occurs throughout most of the United States and Canada. This species is found in shallow, still, or slow-moving, slightly acidic to basic water of lakes, ponds and rivers. It is considered an invasive weed where it occurs outside of North America (UK). This species is listed as least concern (IUCN).

White Water Lily (*Nymphaea odorata-tuberosa*) is a perennial aquatic plant in the Nymphaeaceae family. Its native range is central United States and considered native to Lake Champlain (NEWFS). It also occurs in central to eastern Canada. It occurs in lakes, ponds, and slowing moving water of streams.

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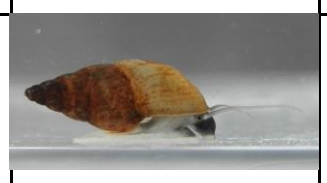
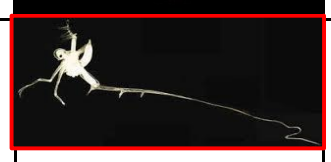
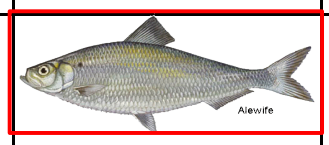
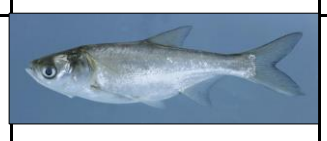
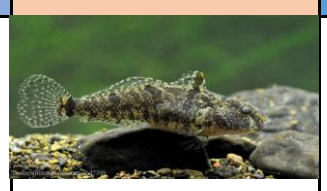
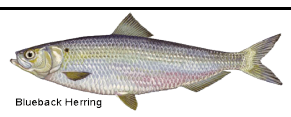
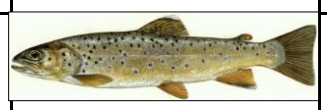
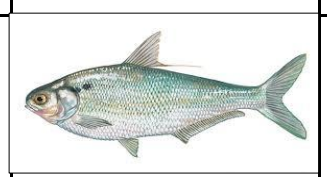
Organism	*Description*	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Liver elimia (*Elimia livescens*)-	The liver elimia is found in freshwater rivers and streams on rock shoals and gravel bars. It currently inhabits Vermont, Quebec, Eerie Canal, the St. Lawrence, Ohio, and Illinois Rivers . Sexes are separate and eggs are usually laid in spring in Elimia snails; often sexually mature in a year; can live 5 years. Average length is 5cm.	Mollusk - Gastropod			X		X	X	X							Concern - Potential
New Zealand mudsnail (*Potamopyrgus antipodarum*)	New Zealand mudsnail originally comes from freshwater streams and lakes of New Zealand and adjacent small islands; it is naturalized in Australia and Europe. It has been found in Idaho, the Colorado River and the Great Lakes, including Lake Erie and Lake Ontario.*P. antipodarum* can survive passage through the guts of fish and may be transported by these animals. It can also float by itself or on mats of *Cladophora* spp., and move 60 m upstream in 3 months through positive rheotactic behavior. Intorduced vai ships or in the water of live gamefish and may outcompete native species. Average length is 1mm.	Mollusk - Gastropod			X		X	X	X	X						Concern - Potential
Piedmont elimia snail *(Elimia virginica*)-	Piedmont elimia snail is native to large Atlantic coast rivers in eastern North America from Massachusetts to Virginia, found east of the continental divide and can now be found in the Mohawk River in NY. The northeastern limit of the native range of the species is the lower Connecticut River.Hybridization and introgression have the potential to jeopardize the genetic integrity of a species, especially when the population is already small. Average length is 5cm.	Mollusk - Gastropod			X		X	X	X							Concern - Potential
Ridged lioplax (*Lioplax subcarinata)*	The ridged lioplax is a small snail, less than 35 mm, with a thick spiral shell and whorls with a median low ridge. It has a reported range from parts of NY to SC. The ridged lioplax is a burrowing species that prefers sandy substrates. it is possible that the species is sensitive to water quality. The fact that the ridged lioplax needs to burrow in sand instead of other, more fine-grained material also suggests that this snail may require highly oxygenated clean water environments. This snail disperses by planktonic trocophore larvae and travelin galong substrate, can be carried on boat hulls and in bilge.	Mollusk - Gastropod			X		X	X	X							Concern - Potential
Buffalo pebblesnail *(Gillia altilis)*-	This is a freshwater species, usually found in stream enviornment, it is adapted for inhabiting high-velocity lotic enviornments, on silty substrates as well as stagnant water in lakes and streams and rapidly flowing water. Average length is about 5mm .	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
Banded mystery snail (*Viviparus georgianus*)	This species is native to North America and is found from the northeastern United States to Florida and the Gulf of Mexico. It is also found in the Mississippi River and the St Lawrence River and in Illinois and Indiana, but is a non-native, invasive species in Lake Champlain. *V. georgianus* is a freshwater species and is dispersed via anthropogenic passive dispersal by attaching to boats and equipment. Average length is about 4cm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
Chinese mystery snail (*Cipangopaludina chinensis*)	It is native to Southeast Asia and eastern Russia. It is a freshwater species found in lakes, reservoirs, ditches, ponds, and paddy fields.This species was sold in Chinese food market in San Francisco in the late 1800s; collected as early as 1914 in Boston. Probably released from an aquarium into the Niagara River between 1931 and 1942. It is a potential vector for the transmission of parasites and diseases. It is dispersed anthropogenically via attachment to fishing equipment and water holding areas of watercraft. Average lenght is ~10cm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
European ear snail or big-ear radix *(Radix auricularia)*	It is native to Eurasia and the Middle East and was introduced to the United States and most of the world. It is a freshwater species found in small pools, lakes reservoirs, brooks, irrigation canals, and brackish lakes. It feeds on diatoms. It was intorduced on plants and released from aquaria. It is a common host vector for many parasites, particularly trematodes. Average length is about 20mm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
European stream valvata (*Valvata piscinalis*)	It is native to Eurasia and has invaded North America. It was first found in Lake Ontario and spread to Lake Erie, St Lawrence River, Hudson River, and Cayuga Lake and is a non-native, invasive species in Lake Champlain. It is a freshwater species inhabiting both standing and slightly flowing water and is found in lakes, rivers, creeks, canals, and reservoirs. The preferred substrate of *V. piscinalis* is sand or silt and it feeds on detritus and diatoms. The European valve snail was most likely first introduced to Lake Ontario in packing material made of straw and marsh grasses used to protect breakable items arriving from Europe. When V. piscinalis was introduced to Oneida Lake, native gastropods (in particular, hydrobiid snails) decreased in abundance due to competetion. It disperses actively and passively and through shipping. Average length is ~5mm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin

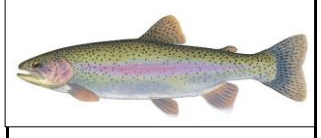
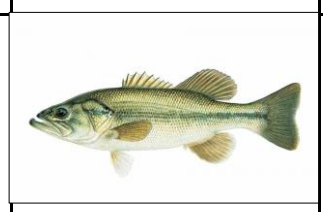
Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Faucet snail or mud bithynia (*Bithynia tentaculata*)	Native to Europe and was introduced to North America. It was originally found in the Great Lakes in Lake Michigan in 1871 and can be found from Quebec to Wisconsin to Pennsylvania and New York. This species functions as both a scraper and a collector-filterer, grazing on algae on the substrate, as well as using its gills to filter suspended algae from the water column. Bithynia tentaculata is dioecious and lays its eggs on rocks, wood and shells in organized aggregates. It was introduced in solid ballast and has recetnly been found attached to invasive plant, Eurasian watermilfoil. Average length is ~10mm.	Mollusk - Gastropod			X		X	X	X	X						Concern - In Basin
Globe slitsnail (*Birgella subglobosa*)	The globe siltsnail is a deep water species found only in large lakes and large rivers on soft silt substrates,. This species is found in North America, in the Great Lakes and Mississippi River drainages. In the Great Lakes, it is found in the immediate area of the St. Lawrence and eastern Great Lakes region. Average length is 10mm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
Sharp hornsnail (*Pleurocera acuta*)-	A snail in the family Planorbidae. It is native to North America and is found in the St Lawrence River and the Great Lakes, the Ohio River, the Erie Canal to the Hudson River and in Tennessee, Illinois, Colorado and New York, but is a non-native, invasive species in Lake Champlain. It is a freshwater species found in rivers and lakes on varied substrates of silt, sand, gravel, cobble, and boulders. Average length is ~2.5cm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
Woodland Pondsnail *(Stagnicola catascopium)*	Woodland Pondsnail is a freshwater species that occurs in lakes, creeks, and other shallow water bodies. Native to various parts of North America; widely distributed in eastern Canada and Nova Scotia, west to ND to IO, OH and MD, Great Lake to Hudson Bay, Great Lakes from Superior to Ontario. Average length is about 15mm.	Mollusk - Gastropod			X		X	X	X							Concern - In Basin
Zebra mussel (*Dreissena polymorpha*)*	Native to the middle east, it inhabits freshwater to oligohaline water in rivers, estuaries, and coastal shallows of the Caspian sea and other large brackish lakes. It disperse by passive drifting; larvae carried downstream with stream flow, then settle to bottom to find suitable substrate to attch themselves to. The species was ninitially introduced in ballast water and are notorious for their biofouling capabilities by colonizing water supply pipes of hydroelectric and nuclear power plants, public water supply plants, and industrial facilities. Zebra mussels can have profound effects on the ecosystems they invade. They primarily consume phytoplankton, but other suspended material is filtered from the water column including bacteria, protozoans, zebra mussel veligers, other microzooplankton and silt. Average length is about 15mm.	Mollusk - Bivalve			X		X	X								High - Present
Quagga mussel *(Dreissena bugensis*)*	This bivalve species is native to Eurasia and was first reported in Lake Ontario in 1989, thought to have been brought in by ship ballast water. From there it spread to the other Great Lakes and south to the Mississippi River, Nevada, Colorado, Arizona and California. The quagga mussel can inhabit both hard and soft substrates, including sand and mud. Quaggas are prodigious water filterers, removing substantial amounts of phytoplankton and suspended particulate from the water. As such, their impacts are similar to those of the zebra mussel. By removing the phytoplankton, quaggas in turn decrease the food source for zooplankton, therefore altering the food web. Impacts associated with the filtration of water include increases in water transparency, decreases in mean chlorophyll a concentrations, and accumulation of pseudofeces. Dreissena species ability to rapidly colonize hard surfaces causes serious economic problems including biofouling power and water plants as well as recreational facilities like docks and boats. Average length is ~20mm.	Mollusk - Bivalve			X		X	X								High - Potential
Asian clam (*Corbicula fluminea*)	A clam species in the Corbiculidae family native to Asia. It is often found near estuary mouths. It prefers sandy, mud substrate. Corbicula fluminea was thought to enter the United States as a food item used by Chinese immigrantsand may have come in with the importation of the Giant Pacific oyster also from the Asia. It is known mostly as a biofouler of many electrical and nuclear power plants across the country. As water is drawn from rivers, streams, and reservoirs for cooling purposes so are *Corbicula* larvae. Once inside the plant, this mussel can clog condenser tubes, raw service water pipes, and firefighting equipment.It was first introduced to Lake Champlain in 2010. Average width is ~20mm.	Mollusk - Bivalve			X		X	X								Concern - In Basin
Atlantic rangia (*Rangia cuneata*)	Atlantic rangia is a heavy shelled bivalve native to the Gulf of Mexico found mainly in estuaries. It is currently found mostly in Virginia but also in the lower portions of the Hudson River. A combination of low salinity, high turbidity and a soft substrate of sand, mud and vegetation appears to be the most favourable habitat for this clam. Could have been an accidental release with oyster mariculture or perhaps with intracoastal ballast water and ar known to cause biofouling of pies and cooling water systems. Average length is ~40mm.	Mollusk - Bivalve			X		X	X								Concern - Potential
Green floater (*Lasmigona subviridi*)	The green floater was historically found throughout the Atlantic slope drainages in the Hudson, Susquehanna, Potomac, upper Savannah, Kanawha-New, and Cape Fear rivers. However, its range has retracted and it now occurs as disjunct populations in headwaters of coastal and inland rivers and streams of these drainages. It is part of a family that produces larvae that require a fish host. Dispersal may occur through travel of fish host. Average width is ~3cm.	Mollusk - Bivalve			X		X	X		X						Concern - Potential

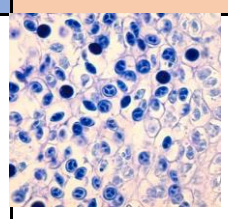
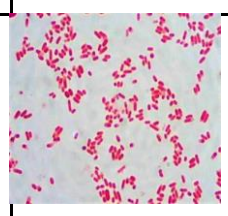
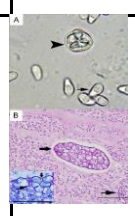
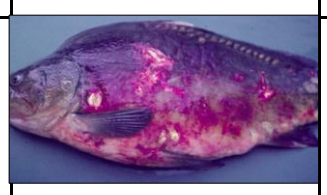
Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Paper pondshell (*Anodonta imbecilis*)	The paper pondshell is a freshwater mussel that favors quiet backwaters and eddies in silt or a mix of silt and fine sand.It currenlty inhabits areas of the Grewat Lake Basin, particularly Michigan. Introduction and distribution through Lake Champlain waterdhed similar to other snail species. Average length is about 5cm.	Mollusk - Bivalve			X		X	X								Concern - Potential
Wabash pigtoe (*Fusconaia flava*)-	The wabash pigtoe is native throughout the Mississippi basin, from western NY west to South Dakota down to Louisiana. It can currently be found in Lakes Huron and Eerie. It migrated naturally and disperses via glochidia larvae; host fishes for glochidia can be white crappie, black crappie, and bluegill.This clam is approximately 4cm wide on avergae.	Mollusk - Bivalve			X		X	X								Concern - Potential
European fingernail clam (*Sphaerium corneum*)	It is native to Eurasia and was introduced to North America and is found in the St Lawrence River system, Kentucky, New York, Vermont, and Quebec and Ontario in Canada. It is found in the demersal zone, up to 40 meters deep, and is tolerant to moderate pollution, but not to desiccation. It is dispersed naturally and can attach to amphibians to be dispersed. Average width is ~10mm.	Mollusk - Bivalve			X		X	X		X						Concern - In Basin
Greater European pea clam (*Pisidium amnicum*)	Clam species in the family Sphaeriidae. It is native to Eurasia, but was introduced to North America. It is found in New Jersey, New York, Minnesota, Pennsylvania, Michigan, and Vermont. It is a freshwater species and in England it requires high levels of calcium and clean water to proliferate. It prefers sand but has also been recorded on mud and gravel. It can survive anoxic conditions under ice cover. It was likley introduced in solid ballast. Disperses passively. Average width is about 15mm.	Mollusk - Bivalve			X		X	X								Concern - In Basin
Pygmy Peaclam *(Pisidium moitessierianum)*	*Pisidium moitessierianum* was observed for the first time in the Great Lakes basin in the Tuscarawas River, which is connected to the Ohio and Erie Canal, in the 1890s. It has also been recorded from Lake St. Clair, the St. Clair River delta, western Lake Erie, and Lake Superior, in 1997–2001 (Grigorovich et al. 2000, Grigorovich et al. 2003a, Korniushin et al. 2001). Moitessier's pea clam occurs in mud, silty sand, sand, silty gravel, and amongst macrophytes. It occurs from 0.5–20 m depth in the littoral zone of lakes and in wide slow rivers. It usually favors oligotrophic water with oxygen content over 50% saturation but it can tolerate some anoxic conditions over winter. Average width is ~1mm.	Mollusk - Bivalve			X		X	X								Not Priority
Fragile papershell (*Leptodea fragilis*)-	The fragile papershell is native to the Ohio and Mississippi basins and has been found in the St. Lawrence drainage. Found in large to moderate rivers with sand, sand and gravel, silty sand, and silty mud botttoms. Spawns in late summer and releases glochidia larvae the following July; host fish is the freshwater drum. Average width is ~20 cm.	Mollusk - Bivalve			X		X	X		X						Not Priority
Fishhook water flea (*Cercopagis pengoi*)*	Native range includes Black, Caspian, Azov, and Aral seas of Europe and Asia. Currently it's established in Lakes Ontario, Michigan, and Eerie. Cercopagis pengoi is a consumer of other zooplankton and, as such, competes with other planktivores. Its long spine makes it less palatable to planktivorous fish and therefore could have a serious effect on the food supply of planktivores. It is introduced to areas by ballast water and boating. Average length is about 10mm.	Crustacean			X		X	X		X						High - Potential
Spiny waterflea (*Bythotrephes longimanus*)*	It is native to Northern Europe and Asia and was introduced to North America through ballast water from ships. It was first found in Lake Huron in 1984, and was then found in all the Great Lakes by 1987. It was first found in Lake Champlain in 2014. It's dispersed by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment. The tail spines of *Bythotrephes* hook on fishing lines, fouling fishing gear. *Bythotrephes* consumes small zooplankton such as small cladocerans, copepods, and rotifers, competing directly with planktivorous larval fish for food; it has been implicated in the decline of Alewife in some places. Average ;ength is ~1.5cm.	Crustacean			X		X	X		X						High - Present
Calanoid copepod (*Eurytemora affinis*)	*Eurytemora affinis* is native to Ponto-Caspian region, the North American Atlantic coast including the Gulf of Mexico, the North American Pacific coast, the western European coast, and parts of Asia, generally in brackish and saltwater regions. it is is epibenthic, inhabiting both the sediments and the water column. Likely introduced in ballast water from the Atlantic Coast or from western European ports in ships arriving in the Great Lakes basin. It does have a diapause stage that can be found in aquatic sediments, but it is most ubiquitous in ballast water samples. Possibly introduced with fish stocking, as it is known to be a probable host and vector for some fish diseases. Average length is ~1mm.	Crustacean			X	X	X									Concern - Potential
Calanoid copepod (*Skistodiaptomus pallidus*)	This calanoid copepod is native to the north central plain states, northeast to New York, southern United States in the Mississippi River basin, Texas, and west to Colorado; though it is listed as non-native in the Great Lakes. It could have been introduced here and also west of it's original range accidentally in bait buckets, in fishing equipment, by recreational boaters, with hatchery stock from the Mississippi River basin, or through dispersal. It is an efficient omnivorous predator, with the ability to prey on rotifers, microzooplankton, algae and practices cannibalism, which may allow populations to persist when resource availability is low and allowing it to reach very high densities to the detriment of other zooplankton. Average length is ~1mm.	Crustacean			X	X	X			X						Concern - Potential

Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Chinese mitten crab (*Eriocheir sinensis*)	The Chinese mitten crab orignally ranges from Pacific coast of China and Korea. It can currenlty be found in parts of MD, NJ, DE, and Ny in the lower Hudson River. It is likely introduced through Ballast water on the West Coast and in the Great Lakes as well. Average length is about 7cm.	Crustacean			X		X		X							Concern - Potential
Japanese fish louse, parasitic copepod (*Argulus japonicus*)	Japanese fishlouse is native to Asia where its common hosts, Goldfish (*Carassius auratus*) and Common carp (*Cyprinus carpio*) , are also native species. It's currently found parts othe midwest and southeast but has been recorded in the Lake Michigan Basin. It was likely introduced in these species through the aquarium industry. This species causes severe tissue damage to its host, which is not limited to the species listed above. Average length is about 5mm.	Crustacean			X		X			X							Concern - Potential
Waterflea (*Daphnia lumholtzi*)	Native range includes Tropical and subtropical lakes in east Africa, east Australia, and the Asian subcontinent of India but has been found in Lake Eerie. D. lumholtzi produces ephippia (resting eggs). All ephippia are resistant to adverse environmental conditions and can lay dormant in sediment for long periods of time delaying hatching until optimal conditions are present. The ephippia of D. lumholtzi have hairs and spines that could grip boats, fish, or other objects and thus aid dispersal but also prevent predation. Average length is ~ 2mm.	Crustacean			X	X	X	X								Concern - Potential
White River Crayfish (*Procambarus acutus*)	*Procambarus acutus* has a disjunct native distribution which includes the Atlantic Slope, as well as the southern Great Lakes drainages to the Gulf of Mexico. Current threats come from populations in the lower Hudson River. Probable introduction include bait bucket or aquaculture releases and likely displace native species in competition for resources. Average lenght is ~10cm.	Crustacean			X	X			X							Concern - Potential
Allegheny crayfish (*Orconectes obscurus*)	It is native to North America and is found on the east coast and in Pennsylvania, Ohio, Texas and Ontario, but is a non-native, invasive species in Lake Champlain. It was introduced to Canada. *O. obscurus* is a freshwater species found in pools and streams with rocky substrate. It is usually found underneath rocks, gravel and boulder sand, but is not normally found in fast flowing portions of streams. It was first found in the Champlain Basin. It mostly disperses via actively moving from one location to another but can be dispersed via natural, passive transport. Average length is ~10cm.	Crustacean			X	X			X							Concern - In Basin
Big water crayfish (*Cambarus robustus*)	The range of the big water crayfish extends from the eastern Midwest of the U.S. to the Northeast, from Michigan to New York (west of the Hudson River) and south to Tennessee but has been found in the Lower Hudson. This species is known to be aggressive toward native species. It was likley introduced to the lower Hudson and elsewhere and spread by release as baut. Average total length is ~15cm.	Crustacean			X	X			X	X						Concern - In Basin
Cyclopoid copepod (*Thermocyclops crassus*)	This cyclopoid copepod species is considered Eurasian in origin. It was first detected in 1991 in Champlain Basin. The species may have reached Lake Champlain via the Seaway, canals, ballast water or overland with recreational vessels. Average length is ~1mm.	Crustacean			X		X									Concern - In Basin
Freshwater amphipod (*Gammarus fasciatus*)	Is native to North America and is natively found in Lakes Erie and Ontario, but is a non-native, invasive species in Lake Champlain. It is a freshwater species and was first found in the Champlain Basin. It disperses via active dispersal by freely swimming from one location to another through canals and locks and via anthropogenic passive dispersal by accidental or bait bucket releases and intentional stocking by humans. Average length is ~5mm.	Crustacean			X	X	X		X							Concern - In Basin
Rusty Crayfish (*Orconectes rusticus*)	It is native to the Ohio River system where it spread to Kentucky, Indiana and Mississippi. It was introduced to many states and water bodies including Lake Champlain by release as bait by anglers.It prefers areas which consist of rocks, logs, or other debris which it uses to construct burrows and outcompetes native crayfish to the point of resource depletion. It was first found in 2005 in the Champlain Canal and Basin. The introduction of even one female carrying viable sperm could start a new population. Average length is ~15cm.	Crustacean			X	X			X							Concern - In Basin

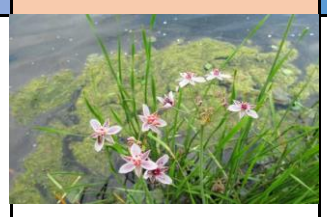
Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Water flea (*Eubosmina coregoni*)	*Eubosmina coregoni* is native to Europe and were likey introduced in ballast water, but possibly also in the digestive system of predatory fish. It is possible that the presence of *E. coregoni* and that of zebra mussel veligers (*Dreissena polymorpha*) in the zooplankton in Lake Ontario could have aided the establishment of the exotic blueback herring (*Alosa aestivalis*). Average length is about 0.5mm.	Crustacean			X		X									Concern - In Basin
Scud (*Echinogammarus ischnus*)	Native Range is the both the Black Sea drainage and the Caspian Sea drainages.It is now widespread in southern Lake Huron, the St. Clair River, the Lake Ontario watershed and the upper St. Lawrence River. It has been recorded at depths ranging surficial to 300 m on mud, silt, sand, rock, *Dreissena* mussels and under wrack and can tolerate highly eutrophic conditions and temperatures. *E. ischnus* was introduced in ballast water. This species may have contributed to declines in some native macroinvertebrates through predation. Average length is ~ 3mm.	Crustacean			X	X	X		X							Not Priority
Alewife (*Alosa pseudoharengus*)*	Alewife is an anadramous fish that is originally from Atlantic Coast from Cape Breton, Nova Scotia, to the St. Johns River, Florida. They migrate up rivers and even small streams to spawn in lakes and quiet stretches of rivers. It has been intentionally stocked in inland waters and the presence of the alewife could restructure a lake's food web, leaving less food for native species by reducing zooplankton populations. Average length is 35cm.	Fish				X				X						High - Present
Sea Lamprey (*Petromyzon marinus*)*	Native to North America and is found from Labrador, Canada to the Gulf of Mexico and from Norway to northern Africa. It is an anadromous species found in the demersal zone of marine, fresh and brackish systems in temperate regions. *P. marinus* was first found in the 1920s in the Champlain Canal. Sea lamprey attack and feed on other fish, particularly important commercial food and gamefish. They swim upstream to spawn and also move to new habitats on host fish. Average length is ~60cm.	Fish				X										High - Present
Eurasian ruffe (*Gymnocephalus cernuus*)*	The Eurasian ruffe, by it's name, is native to Northern Europe and Asia and was introduced through ship ballast. Ruffe hold an advantage over native perch and other fish in their ability to better select moving objects under relatively dim light conditions or at high turbidity. Ruffe has a very sensitive lateral line system and night adapted vision, and is more adapted to foraging under poor light conditions that yellow perch and other native species. Average length is ~25cm.	Fish				X				X						High - Potential
Round goby (*Neogobius melanostomus*)*	Native to the Middle East and was introduced to North America in 1991 via ballast water on ships. It currenlty can be found in the Great Lakes, the Mohawk River, and parts of the St. Lawrence watershed. *N. melanostomus* is known to outcompete native species for habitat and food and preys on native species eggs and young-of-the-year. This goby also has a well developed sensory system that enhances its ability to detect water movement. This allows it to feed in complete darkness, giving it an advantage over other fish in the same habitat. The zebra mussel may have facilitated the invasion of the Round Goby and other Eurasian species by providing an abundant food source .Average length is ~20cm.	Fish				X			X	X						High - Potential
Bighead carp (*Hypophthalmichthys nobilis*)	The bighead carp is initially from southern and central China and is now found throughout the Midwest, but also in Lake Eerie and the Upper Delaware. Bighead carp is a powerful filter-feeder with a wide food spectrum that grows fast and reproduces quickly, which makes this species a strong competitor. Bighead carp were first imported into the US to improve water quality and increase fish production in culture ponds.The diet of this species overlaps with that of planktivorous species (fish and invertebrates) and to some extent with that of the young of virtually all native fishes. The fish are thought to deplete plankton stocks for native larval fishes and mussels. This carp lacks a true stomach which requires them to feed almost continuously. They produce hundreds of thousands of semi-buoyant eggs that need flow to keep from sinking. Average length is ~60cm.	Fish			X	X				X						Concern - Potential
Northern snakehead (*Channa argus*)	The Northern snakehead is native to China, Russia, and parts of Korea but have been found in the lower Hudson. Females produce and release non-adhesive, buoyant eggs and are particularly fecund. The species is capable of survival in poorly oxygenated waters and breathe air. Initial potential pathway of introduction likely involved unauthorized intentional release from aquariums or live food markets. Juveniles eat zooplankton, insect larvae, small crustaceans, and the fry of other fish. Adult snakeheads feed almost exclusively on other fishes, with the remainder of their diet composed of crustaceans, frogs, small reptiles, and sometimes small birds and mammals. Adult snakeheads show significant diet overlap with largemouth bass, with both consuming a large proportion of fundulids and other centrarchids. Average length is ~80cm.	Fish				X			X	X						Concern - Potential
Silver carp (*Hypophthalmichthys molitrix*)	Silver carp originate from Several major Pacific drainages in eastern Asia but eDNA samples indicate that it can be found in PARTS OF lAKE eERIE. They can tolerate salinities up to 12 ppt and low dissolved oxygen (3mg/L). Silver carp feed on both phytoplankton and zooplankton and lay eggs that require current to stay suspended. This species was imported and stocked for phytoplankton control in eutrophic water bodies and also apparently as a food fish.Now they upset native phytoplankton communities and the rest of the foodweb above it. Average length is 100cm.	Fish			X	X				X						Concern - Potential

Organism	*Description*	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Tubenose goby (*Proterorhinus marmoratus*)	The tubenose goby native habitat is in Eurasia, primarily in rivers and estuaries of the Black Sea basin; also in rivers of northern Aegean. It has been found in Lake Eerie and the headwaters of the St. Lawrence River. It is a benthic omnivore, consuming a wide variety of benthic invertebrates and occasionaly larval fishes. This species was introduced in ship ballast water and competes with native species for food. Avergae length is ~13cm.	Fish				X			X	X						Concern - Potential
Asian or common carp (*Cyprinus carpio*)	Native to Europe and Asia,common carp has been introduced throughout world. These fish have shown to be an important seed dispersal vector for aquatic plants, are very active when feeding and movements often disturb sediments increasing turbidity, causing serious problems where the species is abundant. The species also slows growth of SAV by feeding on and uprooting plants. Silt resuspension and uprooting of aquatic plants can disturb spawning and nursery areas of native fishes as well as disrupt feeding of sight-oriented predators, such as bass and sunfish. There is also evidence that common carp prey on the eggs of other fish species. They were introduced by release for aquaculture and commercial fishing. Females are known to lay more than a million eggs in a season; breeds at a temperature range of 15° C to 20°C; eggs hatch in 4 days. Average length is ~ 75cm.	Fish			X	X				X						Concern - In Basin
Black Crappie *(Pomoxis nigromaculatus)*	The black crappie is native to much of the Mississippi basin but intorduced in the Hudson Valley.Originally stocked for sportfishing and prey on juvenile salmonids and contribute to habit alteration. These fish swim to new areas and also lay eggs that adhere to plants. Average length is about 20cm.	Fish				X				X						Concern - In Basin
Blue-back herring (*Alosa aestivalis*)	This anadramous fish is native to the Atlantic Coast from Cape Breton, Nova Scotia, to the St. Johns River, Florida. Ascends coastal rivers during spawning season. It has been introduced in reservoirs in several states, and in the tenneesse river system in Tennessee, intentionally as forage for game fish but put increased pressure on native zooplaknton populations. Average length is ~40cm.	Fish				X				X						Concern - In Basin
Brook silverside *(Labidesthes sicculus*)	This species is native to North America, Gulf of Mexico drainages from Pearl River west to Brazos River including MI River drainage and Great Lakes (not Lake Superior). Occur near surface of lakes, ponds, and quiet pools of creeks and small to large rivers. Usually found in open water. Feed on zooplankton, including copepods, cladocerans, and midge larvae. Accidental introduced by bait bucket release as well as canal connections and stocking for forage and spread through swimming and adhesive eggs that hatch and grow rapidly. Average length is ~7cm.	Fish				X				X						Concern - In Basin
Brown Trout (*Salmo trutta)*	This species is an anadramous fish from Europe, noerhtern Africa, and western Asia. Brown trout have been stocked intentionally in much of the US. Individuals spend 1 to 5 years in fresh water and 6 months to 5 years in salt water. Lacustrine populations undertake migration to tributaries and lake outlets to spawn. Brown Trout have been implicated in reducing native fish populations (especially other salmonids) through predation, displacement, and food competition. Average length is ~80cm.	Fish				X				X						Concern - In Basin
European rudd (*Scardinius erythrophthalmus*)	Native to western Europe to the Caspian Sea and Aral sea.Occurs mainly in nutrient-rich, well vegetated lowland rivers, backwaters, oxbows, ponds and lakes. They lay adhesive eggs on vegetation. This species feeds mainly on plankton, terrestrial insects and plant material. Initially introduced by bait bucket release, rudd can be expected to compete for invertebrate food sources with native fishes. In addition, being omnivorous, the rudd can shift its diet to plants, unlike most native fishes. Average length is ~40cm.	Fish				X				X						Concern - In Basin
Gizzard Shad (*Dorosoma cepedianum*)	Native to parts of North America and Gulf of Mexico draingage, SD and MN. Initially stocked as forage for gamefish and some accidentally with American shad but now disperses actively to new bodies of water and passively with adhesive eggs. It is thought that *D. cepedianum* has entered via the Champlain canal. Competition for food between gizzard shad and other fish species may occur and can significantly increase phytoplankton levels, subsequently increasing turbidity and potentially impacting visual predators. Average length is 35 cm.	Fish				X	X	X		X						Concern - In Basin
Goldfish (*Carassius auratus*)	The native range of the goldfish spans Eastern Asia, including China and perhaps adjacent regions (Japan, Republic of Korea). introductions of C. auratus in the United States were the result of escapes from hatcheries and ponds, escapes and releases of baitfish, and aquarium releases The ominvorous diet includes planktonic crustaceans, phytoplankton, insect larvae, fish eggs and fry, benthic vegetation, and detritus. Foraging goldfish may create high levels of turbidity, which can result in the decline of aquatic vegetation. Average length is about 20cm.	Fish				X				X						Concern - In Basin

Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Rainbow trout (*Oncorhynchus mykiss*)	Sometimes known as steelhead in migratory populations, this is a fish species that is a native to the west coast of the US. It is an anadromous species found in the benthopelagic zone of marine and brackish systems in subtropical regions. It was originally intentionally stocked for sport fishing and is still stocked annually in some locations. The Rainbow Trout hybridizes with other, more rare trout species, thereby affecting their genetic integrity and also compete for food resources. Rainbow trout are strong swimmers that move between waterbodies and by intentional stocking by humans. Average length is ~40cm.	Fish				X				X						Concern - In Basin
Tench (*Tinca tinca*)	Native to Europe, including the British Isles, and parts of western Asia. It is a potamodromous fish species found in the demersal zone of fresh systems. Tench were introduced to the US for use as a food and sport fish. The diet consists mainly of aquatic insect larvae and molluscs and is considered a potential competitor for food with sport fishes and native cyprinids.The species is known to stir up bottom sediments, possibly affecting water quality, but not to the extent of common carp *Cyprinus carpio*. It disperses via active dispersal by freely swimming from one location to another through canals and locks. Average length is ~40cm.	Fish				X				X						Concern - In Basin
White Crappie (*Pomoxis annularis*)	Native to North America and much of the Mississppi basin but not north of Virginia. Originally stocked for sportfishing and prey on juvenile salmonids and contribute to habit alteration. These fish swim to new areas and also lay eggs that adhere to plants. Average length is 30cm.	Fish				X				X						Concern - In Basin
White perch *(Morone americana)*	It is native to North America and is found in the St Lawrence River, Lake Ontario, Quebec to South Carolina, but is a non-native, invasive species in Lake Champlain. It is an anadromous species found in demersal zones of marine, fresh and brackish waters in temperate regions. Inland populations are more common in northern areas. *M. americana* is known to heavily prey on the eggs of walleye and might directly compete with yellow perch and native shiners. It was first found in 1990 in the Champlain Canal and Basin and was thought to have entered via the Champlain Canal. It disperses via active dispersal by freely swimming. Average length is ~50cm.	Fish				X				X						Concern - In Basin
Black bullhead (*Ameiurus melas*)	Native to much of the midwest of north America but not the Atlantic slope. It's been intentionally stocked for sport and as a food fish. Black bullheads are voracious predators of newly hatched gamefish, have been known to be responsible for the decline of of a leopard frog species in AZ, and have been shown to reduce the abundance and diversity ofother native prey species elsewhere. Average length is about 35cm.	Fish				X			X	X						Not Priority
Largemouth bass (*Micropterus salmoides*)	Native to North America and is found in St Lawrence - Great Lakes basin, Hudson Bay, and the Mississippi River from Quebec to Mississippi and south to Texas and southern Florida. It is a non-native, invasive species in Lake Champlain. It is found in the benthopelagic zone of fresh systems in subtropical regions. No records of M. salmoides were found in Vermont prior to 1887. It has been found in the Champlain Canal and Basin and was thought to have entered via the Champlain Canal. It was originally intentionally stocked for sport fishing. Introduced bass usually affect populations of small native fishes through predation, sometimes resulting in the decline or extinction of such species. Average length is ~45cm.	Fish				X				X						Not Priority
Silver lamprey *(Ichthyomyzon unicuspis*)	Native to North America and is found in the St Lawrence River, Quebec and Ontario to the Altamaha River, Hudson River to Manitoba and the Mississippi and Missouri Rivers and in Lake Champlain. It is a potamodromous fish species. Ammocoete larvae burrow into mud or loose sediments and remain there for 4-7 years, feeding on zooplankton and detritus. After emergence and transformation, Silver lampreys travel downstream to larger rivers or lakes to enter parastic adult stage where it feeds on many important gamefish. It disperses via active dispersal by freely swimming from one location to another through canals and locks and on host fish. Average length is ~35cm.	Fish				X										Not Priority
Freshwater hydroid (*Cordylophora caspia*)	*C. caspia* is a freshwater hydroid averaging ~20mm in length. Native to west Asia but now found in various parts of the USA, including th lower Hudson, colonies grow on hard surfaces including rocks, pilings, and dreissenid mussel shells. May benefit from the expansion of zebra and quagga mussels (providing substrate) and from increased salinity in systems impacted by road salt (preference for higher salinity).The hydroid was initally released from aquaria and ballast water. It is known as a 'benthic colonial predator' that preys upon larval insects. This may result in less prey availability for fish. However, *C. caspia* is preyed upon by an introduced nudibranch (Tenellia adspersa).	Other			X		X	X								Concern - Potential
Oligochaete (*Ripistes parasita*)	This aquatic oligochaete is native to Europe and Lake Baikal in Asia but hhas been found in waters between 6 m and 10 m deep in the Great Lakes, both on bare, rocky substrates and amongst macrophyte vegetation.The prevalence of R. parasita at sites near major shipping ports suggests invasion via international shipping. Average length is 5mm.	Other			X	X	X		X							Concern - Potential

Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Whirling disease (*Myxobolus cerebralis*)	Known as whirling disease, *M cerebralis* is common European parasite of Brown Trout. It has been recorded primarily from aquaculture facilities, or waters in the immediate vicinity of such operations in the Lakes Erie, Ontario, and Michigan drainages. In infected salmonids, the disease caused by *M. cerebralis* can result in whirling behavior or tail-chasing; damage to the central nervous system and organs of equilibrium; lesions in the skull, gills, and vertebrae; and sometimes mortality. Rainbow Trout is particularly susceptible to this pathogen. *M. cerebralis* was very likely introduced with nonindigenous salmonids that were stocked in the Great Lakes drainage system. It could have arrived with transfers of rainbow trout from Europe back to North America before 1956. This disease mostly affects fish in hatcheries within the Great Lakes systems, but could change community composition of wild fish populations by replacing susceptible species with resistant ones.	Other			X		X			X						Concern - Potential
Freshwater flatworm (*Schmidtea polychroa*)	Schmidtea polychora is a flatworm of the Dugesiidae family. It is found in North America and Europe. It is a freshwater species which prefers shallow water and solid surfaces. Average length is ~2cm.	Other			X	X	X		X	X						Concern - In Basin
Freshwater jellyfish (*Craspedacusta sowerbyi*)	Native to Asia and was introduced to North America and Europe. It was first found in the Huron River and spread to other states including the northeastern United States, Quebec and Ontario and is a non-native, invasive species in Lake Champlain. It is a freshwater species, found in temperate climates globally, but has been recorded in tropical locations. *C. sowerbyi* was first found in the Champlain Basin. It disperses via active dispersal by freely swimming. Average diameter is ~20mm.	Other			X		X	X								Concern - In Basin
Bacterium (*Escherichia coli*)	*E. coli* (*Escherichia coli*) is a gut bacterium in the family Enterobacteriaceae. While some strains are pathogenic, it is typically considered an indicator of other pathogens, including viruses, associated with animal waste products. Sources are varied, but it is typically associated with fecal contamination of urban runoff, failing septic systems, and domestic animals and wildlfie. It can cause gastrointestinal illness in humans.	Other			X		X			X						Not Priority
Microsporidian parasite (*Heterosporis sutherlandae*)	*Heterosporis sutherlandae* is a microsporidian parasite that is known to infect the skeletal muscles of susceptible fish hosts that are exposed to the parasitic spores by consumption of an infected host or spores in the water column (IDNR 2005, Sutherland 2002, Sutherland et al. 2004). They are believed to be native to Eurasia. It was first found in 1990 in the Great Lakes and was later found in 26 other lakes in Minnesota, Wisconsin, Michigan and Ontario. It can be dispersed via natural passive dispersal through infected fish or contaminated water and has been seen in yellow perch, walleye, pike, perch, burbot, pumpkinseed, sculpin, and rock bass .	Other			X		X			X						Not Priority
Rock snot, diatom (*Didymosphenia geminata*)	Rock snot is a diatom that prefers freshwater with cool, rocky substrates and considered native to parts of North America including part of the Delaware headwaters. It can form massive blooms on the bottom of streams, rivers, and rarely in lakes. It is both epilithic (attaching to stones) and epiphytic (attaching to plants). It was first found in 2008 in the Champlain Basin. *D. geminata* is dispersed via anthropogenic passive dispersal via attaching to watercraft and fishing equipment. It can alter the diversity of local macroinvertebrates at bloom sites. It can remain viable for weeks under seemingly dry conditions. Management of this species includes drying gear for a minimum of 48 hours or cleaning with a solution of bleach.	Other			X		X	X								Not Priority
Spring viraemia of carp or Swim bladder inflammation (*Rhabdovirus carpio*)	Spring viremia of carp, also known as Swim Bladder Inflammation, is a disease of various fishes caused by Rhabdovirus carpio virus. It is native to Europe and the Middle East and was found in North Carolina in 2002, in Wisconsin in 2004, and Lake Ontario in 2006. It is a potential threat to Lake Champlain. It affects carp, pike, guppies, zebrafish, and pumpkinseed and is considered a major threat to infect native fish populations. It disperses naturally and passively through contaminated water.	Other			X		X			X						Not Priority
Viral hemorrhagic septicemia (*Novirhabdovirus*)	Viral hemorrhagic septicemia (*Novirhabdovirus spp.*) is a viral pathogen in the Rhabdoviridae family. It was first found in the Great Lakes in 2009 and is found in the Mississippi River. It is a potential threat to Lake Champlain's native fish populations by causing internal and external hemorhaging and necrosis of the kidneys. It disperses via natural passive dispersal by drifting down waterways.	Other			X		X			X						Not Priority

Organism	Description	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Brazilian elodea (*Egeria densa*)	Brazilian elodea is native to South America and was introduced by the aquarium trade, an dcan now be found in the lower and middle Hudson and parts of west VT. This species has a low light requirement and can thrive in turbid environments. *E. densa* is capable of fragmentation; stems of at least two nodes can break off from the parent colony and disperse by stream flow. Stem fragments can take root in bottom mud or grow as free-floating mats. Dense stands of *E. densa* may restrict water movement, trap sediment, and cause fluctuations in water quality. Severe infestations may impair recreational uses of a water body including navigation, fishing, swimming, and water skiing.	Plant			X			X	X							Concern - Potential
Carolina fanwort (*Cabomba caroliniana*)	Carolina fanwort is native to southern Brazil, Paraguay, Uruguay, northeast Argentina, southern and eastern USA. It grows rooted in the mud of stagnant to slow flowing water including streams, and smaller rivers. It grows well in high nutrient environments with low pH, but in more alkaline waters it tends to lose its leaves. High calcium levels inhibit growth and unlike other aquatic weeds, cabomba can grow well in turbid water. Initially introduced by release from aquaria, It produces seed but vegetative reproduction seems to be its main vehicle for spreading to new waters. Once established, this plant can clog drainage canals and freshwater streams interfering with recreational, agricultural, and aesthetic uses	Plant			X			X	X							Concern - Potential
Parrot's feather (*Myriophyllum aquaticum*)	Parrot's feather orignated in South America. It grows well in shallow wetlands, slow moving streams, irrigation reservoirs or canals, edges of lakes, ponds, sloughs, or backwaters. Although it can grow in moist soil and tolerates a wide-range of water levels, parrot feather grows most rapidly in higher water levels (but has been documented in depths up to 16 ft) and high-nutrient environments. Parrot feather requires rooting in bottom sediments, in habitats where light can penetrate to the bottom favor growth and colonization. Reproduction occurs by fragmentation of emergent and/or submersed shoots, roots, rhizomes, or attached plant fragments. Dense infestations can rapidly overtake small ponds and sloughs, impeding water flow resulting in increased flood duration and intensity. Parrotfeather may also out-compete more desirable native macrophytes and dense beds of parrotfeather have resulted in reductions in dissolved oxygen in the water column, which may be detrimental to fish.	Plant			X			X	X							Concern - Potential
Variable-leaf watermilfoil (*Myriophyllum heterophyllum*)	It is native to North America, historically the southeast and midwest. It is a freshwater species and was first found in Lake Champlain in 2011 at the southern end of the lake. It was initially released aquarium or pond plants. Secondary spread possible through hitchhiking on boats/trailers or waterfowl. *M. heterophyllum* can reproduce via fragmentation and its dispersal methods include natural passive dispersal by drifting through waterways and anthropogenic passive dispersal on watercraft or equipment.	Plant			X			X	X							Concern - In Basin
American water plantain (*Alisma subcordatum*)	The American Water Plaintain is found in reshwater, wetlands, shallow slow water or mud of marshes, ponds lakes and streams. Native (North America); MA to Mn, south to FL and TX, this species can be established effectively by vegetative divisions or seed.. It's fruits containing seeds are buoyant, allowing it to spread. It can be found along the lower and middle Hudson River as well as western VT.	Plant			X			X	X							Concern - In Basin
Common reed (*Phragmites australis*)	Common or Giant Reed (*Phragmites australis*) perennial, terrestrial; freshwater species will occur in most wetland habitats. It grows 1-6 meters tall, and forms dense stands which include both live and standing dead stems from previous year's growth. Forms a dense network of roots and rhizomes that can extend downward over a meter. It was likely introduced via solid ballast and or packing material from shipping. It has been internationally introduced to some locations as a filter plant in wastewater treatment lagoons and used for erosion control.	Plant		X	X			X	X	X						Concern - In Basin
Curly leaf pondweed *(Potamogeton crispus)*	This is native to Eurasia, Africa, and Australia. CLP will occur most water body types including lakes, ponds, rivers, streams, canals, drains, ditches ,rice fields, and even very small water bodies. It is most typical of eutrophic or mesotrophic waters and so is able to colonize anthropogenic systems but will also occasionally occur in oligotrophic lakes. The species has spread across much of the United States, presumably by migrating waterfowl, intentional planting for waterfowl and wildlife habitat, and possibly even as a contaminant in water used to transport fishes and fish eggs to hatcheries. Potamogeton crispus can outcompete native species for light and space early in the growing season; often reducing plant diversity and altering predator/prey relationship.	Plant			X			X	X		X					Concern - In Basin
European frogbit (*Hydrocharis morsus-ranae*)	It is native to Europe and was introduced to the eastern United States for ornamental purposes. It prefers freshwater and typically occurs in shallow, mesotrophic or meso-eutrophic water in the sheltered bays of lakes or in ponds, canals, and ditches.common frog-bit expands by produces stolons, which can produce juvenile plants. In the autumn, the ends of the stolons produce turions (vegetative buds that survive through the winter), which break off the main plant, sink to the bottom of the waterbody, and go dormant. In the spring, the turions float to the surface and begin growing. About half of H. morsus-ranae propagules are still able to float after being in the water 6 months; indicating that dispersal via waterways is probably essential to the expansion of this species. A single H. morsus-ranae plant can create 100-150 turions in a single growing season. The free-floating growth form can lead to densely tangled floating mats, which can crowd and shade out native aquatic vegetation. It can dominate wetlands where it occurs, and the dense mats may effect wildlife as well as native plants.	Plant			X			X	X							Concern - In Basin

Organism	*Description*	Taxa	Photo	Mode of Transport							Alternative Level of Prevention					Priority
				Wind	Water-drifting	Water-swimming	Boat-bilge, ballast	Boat-hull, trailer	Movement Along Substrate	other	1	2	3	4	5	
Flowering rush (*Butomus umbellatus*)	Wetland species in the Butomaceae family. It is native to Eurasia, Asia and Africa. It has naturalized throughout southern Canada and the northern United States, Ireland, and some of the British Isles. It is a species that can grow on wet mud and is emergent in shallow water to permanently submerged in deep or fast-flowing water.Water level fluctuations may promote the spread of *B. umbellatus* , allowing populations to expand when water levels are low and the soil surface is exposed and warmed. It is most often found on nutrient-rich, calcareous clay substrates and will occur in a variety of water bodies such as rivers, lakes, streams, ditches, and canals. It is intolerant of salt or brackish water. It was intentionally brought to the US as an ornamental and can displace native riparian vegetation while also being an obstacle to boat traffic. it spreads locally by rhizomes and by fragmentation of the root system.	Plant			X		X	X		X						Concern - In Basin
Greater water cress (*Rorippa amphibia*)	Plant species in the Brassicaceae family. It is native to Europe and exotic to Lake Champlain. It is a freshwater species and typically occurs on the margins of mesotrophic to eutrophic water bodies, such as ponds, lakes and large lowland rivers. R. amphibia seeds are dispersed naturally via drifting down waterways and by animals and anthropogenically on watercraft, equipment or by people.	Plant			X		X	X								Concern - In Basin
Slender leaf naiad (*Najas flexilis*)	Plant species in the Hydrocharitaceae family. It is native to North America and is widespread across North America, Asia and Europe, but is a non-native, invasive species in Lake Champlain. It is a freshwater species that grows in still or slow-moving, circumneutral to basic water of rivers and lakes. *N. flexilis* is dispersed via natural passive dispersal by seeds drifting down waterways.	Plant			X		X	X		X						Concern - In Basin
Yellow flag iris (*Iris pseudacorus*)	It is native to Eurasia and was introduced to North America as an ornamental plant. It is a freshwater species that occurs in shallow water or saturated soils in marshes, along the shores of lakes or ponds with stagnant or slow flowing waters, and occasionally in ditches. Plants are highly tolerant to anoxic conditions and are able to grow vigorously in water/wet soil with a wide range of pH values. The buoyant seeds of I. pseudacorus are naturally dispersed via the water current and germinate on shorelines. This iris also forms thick, tuberous rhizomes that spread radially to produce large clonal populations of up to several hundred flowering “individuals”. These populations form dense, underwater mats of vegetation.	Plant			X		X	X								Concern - In Basin
Yellow floating heart (*Nymphoides peltatum*)	It is native to Eastern asia and the Mediterrainean. It was introduced as an ornamental plant. It is a freshwater species that typically occurs in naturally eutrophic, calcareous, slow-moving rivers and large ditches. *N. peltatum* can reproduce from plant fragments, hairy seeds that float, and can be dispersed naturally by attaching to animals.	Plant			X		X	X		X						Concern - In Basin
Brittle naiad (*Najas minor*)	It is native to Eurasia and was introduced to much of North America, including Lake Champlain, by shipping and accidentally with cultivars like rice. It is a freshwater species and occurs in a variety of lakes, pools, rivers, and streams, and will occasionally occur in ditches and rice fields. Although this annual can reproduce by fragmentation, the primary means of reproduction appears to be by one-seeded fruits. Najas minor can form dense, monospecific stands in shallow water that inhibit the growth of native species of aquatic macrophytes and hinder swimming, fishing, boating, and other forms of water contact recreation.	Plant			X		X	X		X						Concern - In Basin
Ribbon-leaved water plantain (*Alisma gramineum*)	American water plantain (*Alisma subcordatum)* is a plant species in the family Crambidae. It is native from Massachusetts to Minnesota, south to Florida and Texas, but generally not Lake Champlain. It can be found in fresh and wetland systems and prefers shallow, slow-moving waters -including ponds, lakes and streams. *A. subcordatum* has fruits that contain buoyant seeds and is dispersed via natural passive means and through fragmentation	Plant			X		X	X								Not Priority

Appendix D – Site Visit Notes and Photos

Status Report #03

Project:	Lake Champlain Invasive Species Barrier Study	**Project No:**	Contract No. W912DS-14-D-0001 Task Order No. W912DS18F0103
Date:	30 Nov. 2018	**Report No:**	3

Status Report #03 focuses on the Lake Champlain Canal site visit conducted on 30 Oct. 2018. Refer to page 6 of this report for a summary of the site visit activities and findings.

PROJECT STAKEHOLDERS/MEETING PARTICIPANTS:
The table below maintains a running list of project participants, partners and stakeholders. This table will be added to as new personnel become involved in the process. The column labeled "Attendance" will be update with each progressive Status Report, indicating the date of the latest telephone conference and the project team members participating.

Table 1 - PROJECT STAKEHOLDERS/MEETING PARTICIPANTS

Name	Org.	Role	Email	Phone	Attendance (30-Oct-18)
Diana Kohtio	USACE NYD	USACE PM	Diana.M.Kohtio@usace.army.mil	917-790-8619	Yes
Rifat Salim	USACE NYD	USACE staff Proj. Mang.	Rifat.Salim@usace.army.mil	917-790-8215	Yes
Matthew Cosby	USACE NYD	USACE staff Program Mang.	Matthew.G.Cosby@usace.army.mil	917-790-8080 917-882-8767	Yes
Catherine Alcoba	USACE NYD	USACE staff	Catherine.J.Alcoba@usace.army.mil		No
Daria Mazey	USACE	USACE staff	Daria.S.Mazey@usace.army.mil		No
Matthew Bates	USACE ERDC	USACE staff	Matthew.E.Bates@usace.army.mil	978 318-8795 562-537-2295	Yes
Igor Linkov	USACE ERDC	USACE staff	Igor.Linkov@usace.army.mil		No
Margaret Kurth	USACE ERDC	USACE staff	mkurth.erdc@gmail.com		No
Working Group					
Meg Modley	Lake Champlain Basin Program CEWIIP	Project Partner	MModley@lcbp.org	802-372-3215 802-999-5066	Yes
Fred Dunlap	NYSDEC	Project Partner	fred.dunlap@dec.ny.gov	518-897-1241	Yes

Table 1 - PROJECT STAKEHOLDERS/MEETING PARTICIPANTS					
Name	**Org.**	**Role**	**Email**	**Phone**	**Attendance (30-Oct-18)**
James Candiloro	NYS Canal Corporation	Project Partner	James.Candiloro@nypa.gov		No
Joseph Moloughney	NYS Canal Corporation	Project Partner	JOSEPH.MOLOUGHNEY@CANALS.NY.GOV	518-449-6036 518-225-2877	Yes
Mark Miller	NYS Canal Corporation	Project Partner	MARK.MILLER@CANALS.NY.GOV	518-499-6040 518-275-9726	Yes
Tom McDonald	NYS Canal Corporation	Project Partner	TOM.MCDONALD@CANALS.NY.GOV	518-499-6056	Yes
Andrew Milliken	USFWS	Project Stakeholder	Andrew_milliken@fws.gov	802-662-5301 413-835-5538	Yes
Michael Murphy	HDR	Proj. Manager	Michael.Murphy@hdrinc.com	201-335-9452	Yes
Michael Vecchio	HDR	Design Lead	Michael.Vecchio@hdrinc.com	201-335-6038	Yes
Kim Lukas	HDR	Proj. Engineer	Kimberly.Lukas@hdrinc.com	201-335-9373	Yes
Frank Brilhante	HDR	GIS Manager	francisco.brilhante@hdrinc.com	201-335-9339	Yes
Jeremy Cook	HDR	Economist	Jeremy.Cook@hdrinc.com	402-399-1237	
Geoff Goll	Princeton Hydroscience	Project Principal	ggoll@princetonhydro.com	908-751-1135 609-915-9425	No
Jack Szczepanski	Princeton Hydroscience	Senior Biologist	jszczepanski@princetonhydro.com	908.237.5660, x129 -office	Yes
Paul Cooper	Princeton Hydroscience	Biologist	pcooper@princetonhydro.com	908-237-5660	No

PROJECT SCHEDULE:
The table below presents the overall project schedule and milestone events, as the project progresses the table will be refined to provide greater detail on the immediately upcoming events and note which tasks or meetings have been completed as of the date of this Status Report.

Table 2 - PROJECT SCHEDULE			
Project Milestone	**Based on Proposed Schedule**	**Currently Scheduled Date(s)**	**Status**
Notice to Proceed (NTP)	15 Aug 2018	15 Aug 2018	Completed
Project Team Kick Off Meeting	22 Aug 2018	22 Aug 2018	Completed
Project Status Meeting – 1	1 Oct 2018	1 Oct 2018	Completed
Collaboration Telephone Conference with Parties (USACE, NYSDEC, NYSCC, LCBP, USFWS, A/E)	10 Oct 2018	10 Oct 2018	Completed

Table 2 - PROJECT SCHEDULE			
Project Milestone	**Based on Proposed Schedule**	**Currently Scheduled Date(s)**	**Status**
Recon Site Visit	18 Oct 2018	30 Oct 2018	Completed
Task 1 – Existing Conditions Analysis 1) Existing Conditions 2) Future w/o Project 3) Species Inventory	Oct 2018	December 2018	In-progress
Task 2 – Development and Assessment of Alternatives 1) Preliminary dispersal barrier alternatives 2) Prepare/attend initial formulation working group meeting 3) Preparation of final selected alternatives 4) Alternatives formulation assessment and write up	November 2018 December 2018		Incomplete
Task 3 – Cost Benefit Analysis 1) Participation in 2nd formulation group meeting 2) Develop Costs	February 2019		Incomplete
Task 4 – Recommended Plan Report Preparation 1) Draft Report & Appendices 2) Main Report preparation with final designs	July 2019		Incomplete
End of POP	~ July 2019		Incomplete

DATA INVENTORY:
The table below lists the documents received by the A/E from USACE and additional documents collected by the A/E for consideration of existing background data or studies prepared by others that may be of beneficial use in preparing the subject study. These documents will be reviewed by the A/E team and utilized in the preparation of this report as conditions warrant.

Table 3 - DATA INVENTORY			
#	**Document Description**	**Author**	**Date**
1	USACE New York District, Canal Barrier PMP	USACE	June 2013
2	*Feasibility of Champlain Canal Aquatic Nuisance Species Barrier Options*	*Sea Grant Lake Champlain, NOAA*	*14-Nov-05*
3	Champlain Canal Public Stakeholder Mtg Summary	NYSDEC / LCBP / NYSCC / USACE / others	6-Nov-08

Table 3 - DATA INVENTORY			
#	**Document Description**	**Author**	**Date**
4	Champlain Canal Public Stakeholder Statements	Lake George Assoc. / Lake Champlain Citizens Advisory Committee / NYSFOLA / Vt. DEC	8-Nov-08
5	Feasibility Study of Control Methods for Prevention of Spiny Water Flea Spread from Great Sacandaga Lake to Lake Champlain	HDR	22-Feb-10
6	Evaluation of Physical Separation Alternatives for the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System Technical Report & Appendix	HDR	25-Jan-12
7	*LAKE CHAMPLAIN WATERSHED ENVIRONMENTAL ASSISTANCE PROGRAM (SECTION 542 of WRDA 2000) Lake Champlain Canal Planning Study - Vermont and New York PMP*	*USACE*	*Jun-17*
8	*Great Lakes and Mississippi River Inter Basin Study GLMRIS Report*	*USACE*	*1-Jan-14*
9	Summary of Technical Evaluations - prepared for Chicago Area Waterway System Advisory Committee	HDR / Cambridge Systematics	Nov-15
10	Champlain Canal as a non-indigenous species corridor article	UVM	15-Aug-17
11	Plans of Record of Lock C8, Lock C9 and Channel (21 drawing plates)	New York State Canal Corp	1910 - 1920
12	Rehabilitation of Lock C9 (4 drawing plates)	NYS Canal Corp	1998
13	Lake Champlain Basin Aquatic Nuisance Species Management Plan	LCBP / VDEC / NYSDEC	January 2005
Note: *Italicized* documents listed above indicates these are referenced in the USACE SOW.			

ADDITIONAL DOCUMENT / DATA REQUESTS:

1) ~~Historic vessel traffic on canal.~~ (Received)
2) Any planned improvements along the canal.
3) Additional Plans of Record for Glens Falls Feeder Canal
4) ~~Water Surface Elevations for Lock C9~~ (Received)
5) CADD files for Empire State Trail along the west side of the Canal.
6) CADD Files for NYSCC R.O.W.
7) Utility data – including water, sewer, gas, stormwater, communications
8) Information regarding impacts of Lake Champlain water on the Hudson River ecosystem, i.e. introduction of invasive species
9) Electrical service schematics / drawings for Locks 9 and 8
10) Record drawings for Wood Creek spillway

11) Record Drawings for Argyle Street diversion
12) Lockage data for Locks C8 & C9 (including vessel type, 2009-2018)
13) Record drawings for historical powerhouse at Lock 8

PROJECT PROGRESS:

1. Initial project Kick-off meeting held 22 Aug 2018.
2. Working Parties Collaboration Meeting #1 held on 10 October 2018
3. A/E team is collecting and reviewing existing reports and plans in preparation of the Existing Conditions report.
4. The site reconnaissance visit was conducted on 30 Oct. 2018
5. The submittal of the Draft Existing Conditions Report is targeted for Mid-December 2018.
6. The development of the Draft Alternatives Analysis report is targeted for January 2019.
7. The Project Delivery Team (PDT) will target Mid-February 2019 for the Alternatives Briefing meeting to be held in the Albany NY area.

ACTION ITEMS:

Table 4 - ACTION ITEMS

#	Item	Responsibility	Status
1	Schedule Pre-Site Visit Collaboration Conference Call	Michael Murphy	Complete
2	Schedule Recon Site Visit, coordinate date with parties, submit site access permit.	Michael Vecchio	Complete
3	Begin process of coordinating dates for the Alternative Screening Meeting	Michael Murphy	In Progress
4	Request additional existing conditions information from NYSCC	Kimberly Lukas	In Progress

DISCUSSION ITEMS:

1. The NYS Canal system is a national historic landmark. Any proposed changes to the system need to be planned in coordination with SHPO.
2. The Champlain Hudson Power Express System project is no longer planned to occur within the NYSCC R.O.W. the project alignment has been shifted to the west along the existing rail road corridor. Need to track the status of this application and confirm route past the canal system.

ADDITIONAL NOTES:

1. <Add Additional Notes>

SITE RECONNAISSANCE

The combined project delivery team and primary stakeholder parties conducted a site visit on October 30, 2018 at the Lake Champlain Canal, focusing on the study area of Locks C8, C9, and the Feeder Canal from the Hudson River at Glens Falls, NY. Additional sites were visited in the vicinity of Lock C7 as it became apparent that canal between Lock C8 and C7 might become part of the solution set. The following paragraphs and photographs summarize the activities and findings during the site visit. The agenda and maps used during the site visit are attached as Attachments 1 and 2 respectively. The attendees of the site visit are noted in Table 1 at the beginning of this report and in the attached meeting handout sheets.

1. **Lock C9:** The team met at Lock C9 at 08:30, had introductions, performed a health and safety meeting and reviewed the day's agenda. The team viewed the facilities, observed a lockage and operation of the closure gates (Photo 1), and inspected the spillway to Wood Creek (Photo 2).

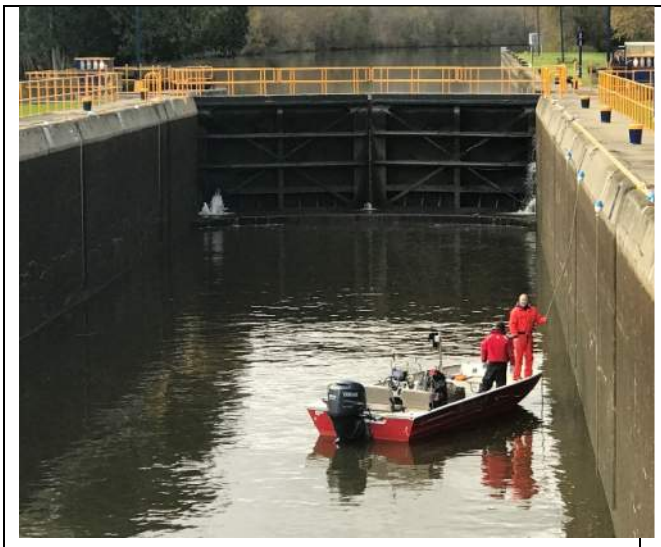


Photo 1: Boat locking through C9

Photo 2: Spillway from upstream of C9 to Wood Creek

2. **Lock C8:** Viewed facilities at C8, including historic water wheel electrical generator (Photo 3) which is no longer in service and mechanical closure gate system (Photo 4). There is an existing culvert adjacent to the water wheel that may serve as the location of an alternative spillway if it is determined that the overflow weir at Lock C9 is to be modified and reverse the direction of the Canal C8-C9 overflow to the Hudson River via a new weir at Lock C8 and working in conjunction with a modification to the overflow culvert located between Lock C8 and C7.

Photo 3: Historic water wheel

Photo 4: Mechanical closure gate at lock C8

3. **Canal between Lock C8 and Lock C9:** The team toured the canal via boat provided by SUNY Plattsburgh (Photo 5) and partially on-foot / by vehicle to observe the canal conditions and the feeder canal confluence (Photo 6).

Photo 5: Boating the canal between Locks C8 and C9

Photo 6: Feeder Canal confluence with Champlain canal, Lock 8 Way bridge spanning the feeder canal

4. **Old Champlain Canal:** The team drove the length of the Old Champlain Canal to the Feeder to determine if flow from this canal enters the Champlain Canal at any locations other than the primary feeder canal. Based on the observations it is believed that the Old Champlain Canal does not flow north to reconnect to the Champlain Canal north of Lock 9, essentially the old canal dead ends at several locations along its northern reaches and therefore does

not provide a bypass channel for invasive from the Hudson River basin into the Lake Champlain Basin.

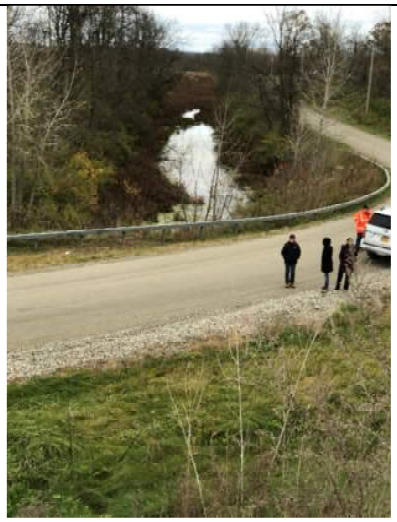


Photo 7: Old Champlain Canal

Photo 8: Old Champlain Canal railroad culverts

5. **Lock C7:** The Hudson River meets the Champlain Canal at Lock C7 (Photo 9). The team inspected a Canal Corporation maintenance yard (Photo 10) adjacent to the lock. It was noted this area may potentially be considered in an alternative design for siting a spillway to discharge water from the C7-C8 Canal into the Hudson River.

Photo 9: Confluence of the Canal with the Hudson River

Photo 10: Hudson River – Left; Canal upstream of Lock C7 – Right

6. **Argyle Street Drain**: Located along the Canal between Locks C7 and C8, just south of the Argyle Street Bridge (Photo 12) exists a drainage structure (Photo 11) that is used to dewater the canal during non-navigational periods. The project team has an interest in possibly modifying the Argyle St. drainage structure to also operate as an overflow weir, should the

study determine that redirecting the overflow for Lock C9 to Lock C8 is a viable alternative. The PDT is requesting record drawings from NYSCC for the Argyle Street drain structure.

Photo 11: Argyle Street canal drain inlet headwall	Photo 12: Argyle Street bridge in the background canal drainage structure in the foreground

7. **Glens Falls Feeder Canal Inlet Headworks:** To get a full understanding of how the Champlain Canal system works the team visited the inlet headworks system located on the left bank of the Hudson River in Glens Falls, NY. At the end of the day the team held a brief site visit close-out meeting. Adjourned at 15:00.

Photo 13: Feeder Canal Inlet Headworks facing upstream	Photo 14: Feeder Canal Inlet Headworks facing downstream

Attachments (2) 1) Site Visit Agenda
2) Site Visit Maps

Attachment 1 - Site Visit Agenda

Agenda

Project: Lake Champlain Invasive Species Barrier Study (LCISBS)

Subject: Canal Site Visit

Date: Tuesday, October 30, 2018

Location: Lock C8 & C9, Queensbury, NY

Meeting Agenda

1) **Date of Site Visit:**
   a. Thursday October 30th
   b. Meeting Location Lock C9,
   c. Meeting Time 8:30 AM

2) **Attendees:**

	Name	Attendance	Response
a.	Murphy, Michael M.	Meeting Organizer	Accepted
b.	Kohtio, Diana M.	Required Attendee	Accepted
c.	Salim, Rifat	Required Attendee	Accepted
d.	Cosby, Matthew	Required Attendee	Accepted
e.	MModley@lcbp.org	Required Attendee	Accepted
f.	James.Candiloro@nypa.gov	Required Attendee	Accepted
g.	fred.dunlap@dec.ny.gov	Required Attendee	Accepted
h.	Milliken, Andrew	Required Attendee	Accepted
i.	Joseph Moloughney	Required Attendee	Accepted
j.	Mark Miller	Required Attendee	Accepted
k.	Jack Szczepanski	Required Attendee	Accepted
l.	Vecchio, Michael	Required Attendee	Accepted
m.	Lukas, Kimberly	Required Attendee	Accepted
n.	Brilhante, Francisco J.	Required Attendee	Accepted
o.	Thomas McDonald	Required Attendee	Accepted

3) Itinerary

a. Meet at Lock C9
b. Team Introductions
c. Health & Safety Briefing
d. Review Purpose of Site Visit, Areas to be Visited and Information Requests
e. Inspection of Lock C9, surface features and controls building
f. Boat trip from Lock C9 to Lock C8
g. Inspection of Lock C8, surface features and controls building
h. Boat trip from Lock C8 to Lock C9
i. Lunch (bring your own lunch)
j. Inspect Wood Creek, east of canal (walking/driving)
k. Inspect Old Canal, west of canal (walking/driving)
l. Inspect Feeder Canal inlet works (drive to site inspect on foot)
m. Hold Close out meeting near Feeder Canal inlet.

4) Purpose of the site visit:

a. Tour the historic canal infrastructure
b. Photograph canal works
c. Gain understanding of Lock operations
d. Observe layout and spatial constraints at the Locks
e. Interview Lock Operators

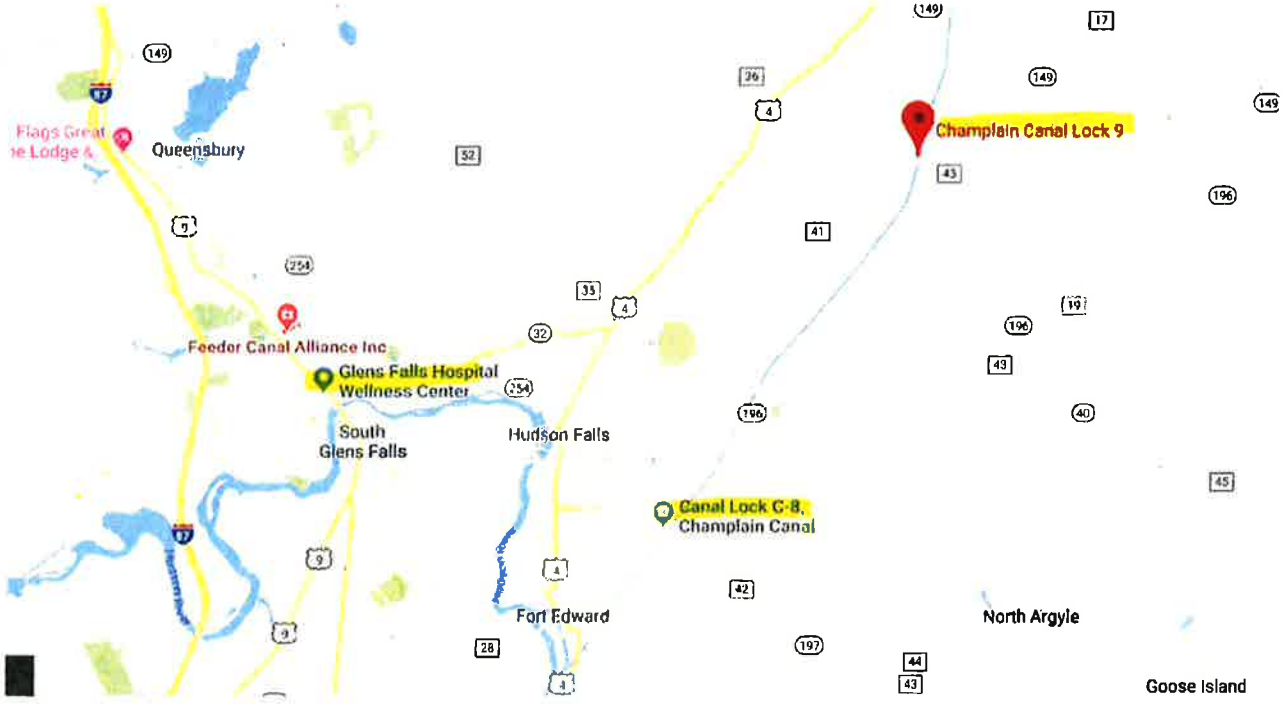
5) Locations to be visited:

a. Lock C9 (Primary location of interest)
b. Lock C8
c. Canal between C8 & C9
d. Glens Falls Feeder Canal
e.

6) **Requests for information:**
   a. Historic vessel traffic on canal. (Done)
   b. Any planned improvements along the canal.
   c. Additional Plans of Record for Glens Falls Feeder Canal
   d. Water Surface Elevations for Lock C9 (done)
   e. CADD files for Empire State Trail along the west side of the Canal.
   f. CADD Files for NYSCC R.O.W. (Done)
   g. Operations manual for Lock passage
   h. Other items to be determined.

Michael M. Murphy, P.E.
Vice President | Professional Associate
HDR
1 International Boulevard
10th Floor
Mahwah, NJ 07495

D 201.335.9452 M 845.304.9637
michael.murphy@hdrinc.com
hdrinc.com/follow-us



Health and Safety Plan Sign off Sheet
Lake Champlain Canal Site Visit 30 Oct. 2018

Name	Org.	Role	Email	Phone	Signature
Michael Murphy	HDR	Proj. Manager	Michael.Murphy@hdrinc.com	201-335-9452 9472	
Michael Vecchio	HDR	Design Lead	Michael.Vecchio@hdrinc.com	201-335-~~9038~~ 916.467.6036	
Kim Lukas	HDR	Proj. Engineer	Kimberly.Lukas@hdrinc.com	201-335-9373	
Frank Brilhante	HDR	GIS Manager	francisco.brilhante@hdrinc.com	201-335-9339	
Meg Modley	Lake Champlain Basin Program CEWIIP	Project Partner	MModley@lcbp.org	802 372-3215 802 999-~~5016~~	
James Candiloro	NYS Canal Corporation	Project Partner	James.Candiloro@nypa.gov	518 470 1079	
Joseph Moloughney	NYS Canal Corporation	Project Partner	JOSEPH.MOLOUGHNEY@CANALS.NY.GOV	518-449-6036 518-225-2877	
Mark Miller	NYS Canal Corporation	Project Partner	MARK.MILLER@CANALS.NY.GOV	518 4496040 518 275 9726	
Tom McDonald	NYS Canal Corporation	Project Partner	TOM.MCDONALD@CANALS.NY.GOV	(518) 449-6056	✓
Fred Dunlap	NYSDEC	Project Partner	fred.dunlap@dec.ny.gov	518-897-1241	✓
Jack Szczepanski	Princeton Hydroscience	Senior Biologist	jszczepanski@princetonhydro.com	908.237.5660, x129 -office	
Diana Kohtio	USACE NYD	USACE PM	Diana.M.Kohtio@usace.army.mil	917-790-8619	
Rifat Salim	USACE NYD	USACE staff Proj. Mang.	Rifat.Salim@usace.army.mil	917-790-8215	
Matthew Cosby	USACE NYD	USACE staff Program Mang.	Matthew.G.Cosby@usace.army.mil	917-790-8080 917-882-8767	✓
Andrew Milliken	USFWS	Project Stakeholder	Andrew_milliken@fws.gov	802-662-5301 413-835-5538	
Matthew Bates	USACE ERDC	Decision Analyst	Matthew.e.bates@usace.army.mil	562-537-7795	

Topics of Discussion during Site Visit – Lake Champlain Canal – 30 Oct. 2018

1) Review of canal passage fees.
2) Operating dates of the canal system.
3) Operating times for the canal, do they have staff 24/7?
4) Flow status of Old Champlain Canal, does this flow freely to the new canal north of C9?
5) Type / frequency of vessel, i.e. commercial barge, recreational boat, etc.? (Note this info was not provided in the data set from the NYS Canal Corp., only total # of vessels and their time of lockage)
6) Annual operating costs for Locks 8/9
7) Is there an O&M Manual for lock operation (assuming non-confidential) available?
8) Who is the electrical service provider for the Lock 8/9 location? Reminder to photograph / document the circuit panels during site visit
9) Time to fill each lock?
10) Time to drain each lock?
11) Average time lock is open during lockage?
12) How do diversions around the lock work?
    a. Can they be done manually?
    b. Do they occur during high flows/storms i.e. emergency bypass?
    c. Are diversions around the locks done via open channels or can they occur via some sub-surface piping or pumps?
13) Is a Champlain canal mile route available?
    a. GIS route or mile points
14) Is flow measured anywhere along the canal route?
15) Regarding lockage data sent does multiple records at the same data and time indicate multiple vessels?
16) Is the Canal drained annually in its entirety? If so, when / how is this performed?

Health and Safety Plan Sign off Sheet
Lake Champlain Canal Site Visit 30 Oct. 2018

Name	Org.	Role	Email	Phone	Signature
Michael Murphy	HDR	Proj. Manager	Michael.Murphy@hdrinc.com	201-335-9452	
Michael Vecchio	HDR	Design Lead	Michael.Vecchio@hdrinc.com	201-335-6038	
Kim Lukas	HDR	Proj. Engineer	Kimberly.Lukas@hdrinc.com	201-335-9373	
Frank Brilhante	HDR	GIS Manager	francisco.brilhante@hdrinc.com	201-335-9339	
Meg Modley	Lake Champlain Basin Program CEWIIP	Project Partner	MModley@lcbp.org		
James Candiloro	NYS Canal Corporation	Project Partner	James.Candiloro@nypa.gov		
Joseph Moloughney	NYS Canal Corporation	Project Partner	JOSEPH.MOLOUGHNEY@CANALS.NY.GOV	518-449-6036 518-225-2877	
Mark Miller	NYS Canal Corporation	Project Partner	MARK.MILLER@CANALS.NY.GOV		
Tom McDonald	NYS Canal Corporation	Project Partner	TOM.MCDONALD@CANALS.NY.GOV	(518) 449-6056	
Fred Dunlap	NYSDEC	Project Partner	fred.dunlap@dec.ny.gov	518-897-1241	
Jack Szczepanski	Princeton Hydroscience	Senior Biologist	jszczepanski@princetonhydro.com	908.237.5660, x129 -office	
Diana Kohtio	USACE NYD	USACE PM	Diana.M.Kohtio@usace.army.mil	917-790-8619	
Rifat Salim	USACE NYD	USACE staff Proj. Mang.	Rifat.Salim@usace.army.mil		
Matthew Cosby	USACE NYD	USACE staff Program Mang.	Matthew.G.Cosby@usace.army.mil	917-790-8080 917-882-8767	
Andrew Milliken	USFWS	Project Stakeholder	Andrew_milliken@fws.gov	802-662-5301 413-835-5538	

Overview of Health and Safety Plan Critical Items:

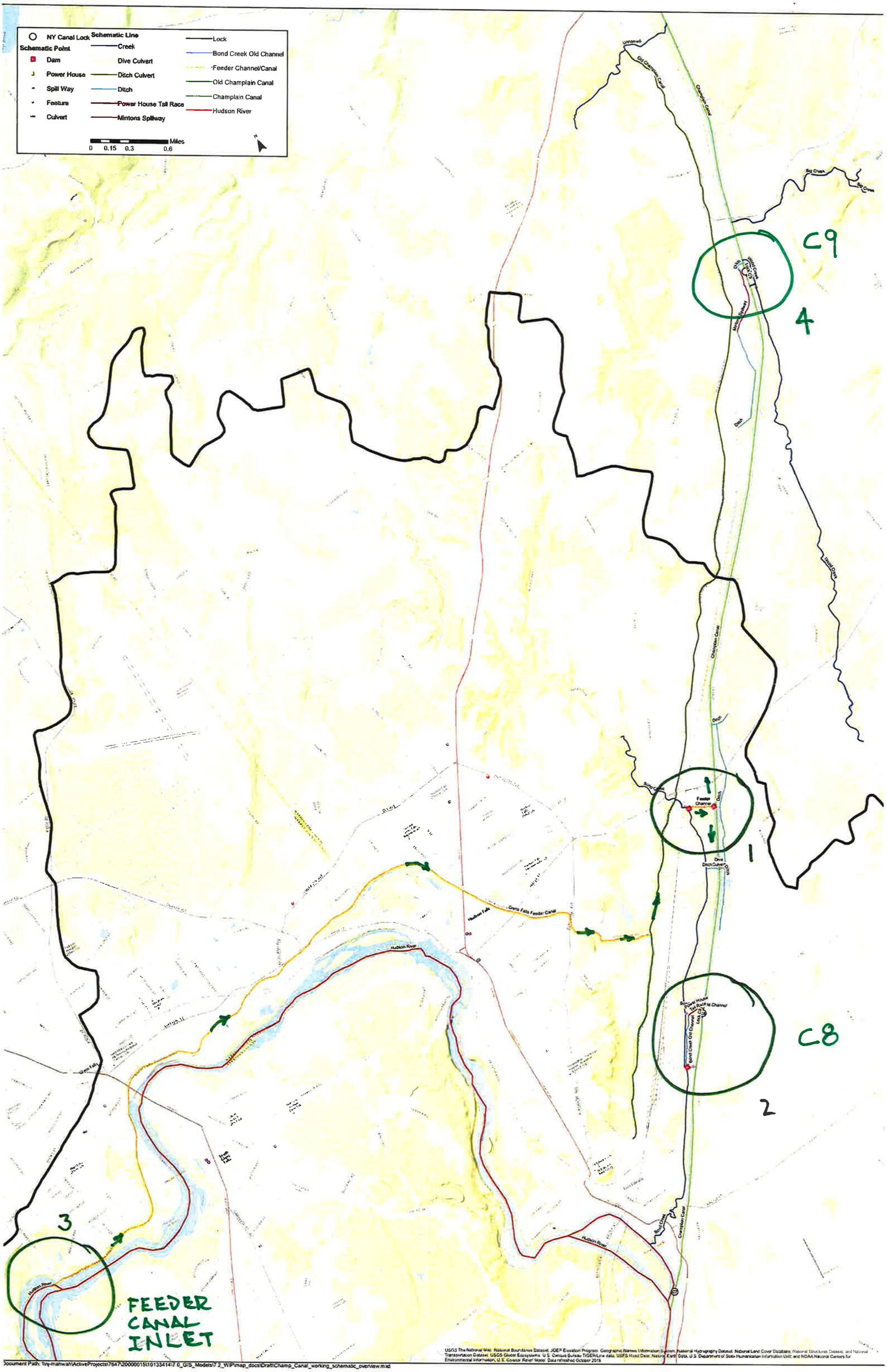
Waterway precautions

1. Obey all signage and instructions from boat captain
2. Be alert and aware of slips, trips and falls, especially on wet surfaces
3. Do not stick hands or feet outside of boat to avoid pinch points
4. Always wear a Personal Flotation Device when on or near the water
5. Dress warmly and in layers, including sturdy boots with rubber soles

Landside precautions

1. Wear PPE as appropriate for conditions; safety vest, hard hat, protective lenses, ear protection, boots.
2. Be aware of your surroundings when walking near roadways, traffic.
3. Be careful when walking along river embankments, could be steep & slippery
4. When walking through wooded areas be careful of tree limbs, poison ivy, thorny vegetation, tripping hazards.
5. Be aware of possible contact with animals, reptiles or insects.
6. Stay warm and use the buddy system.

Attachment 2 - Site Visit Maps



USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed October 2019.

Document Path: \\ny-mahwah\Active Projects\7647\2000001\5\101334147.0_GIS_Models\7.2_WP\map_docs\Draft\Champ_Canal_working_schematic_overview.mxd

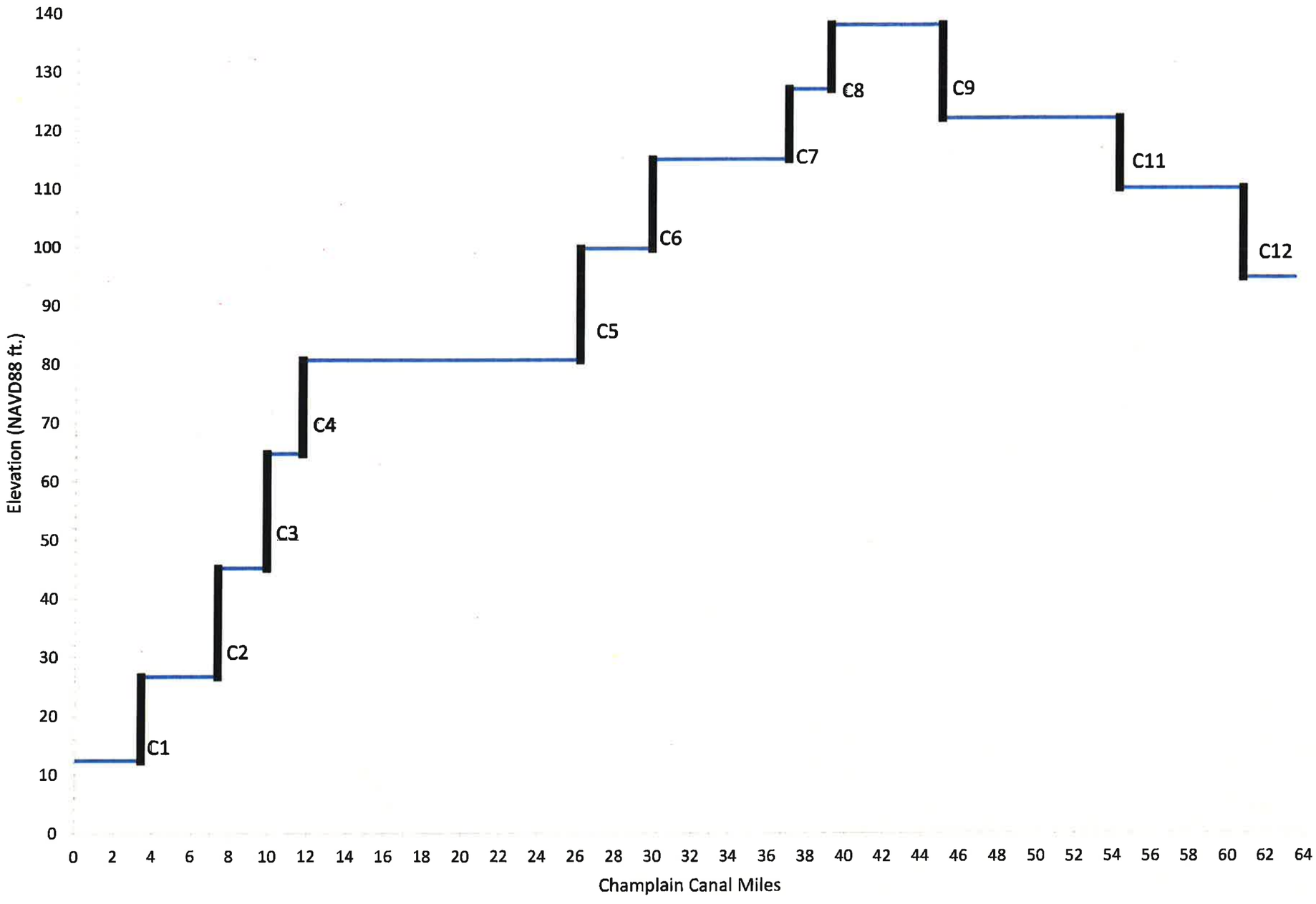
C9

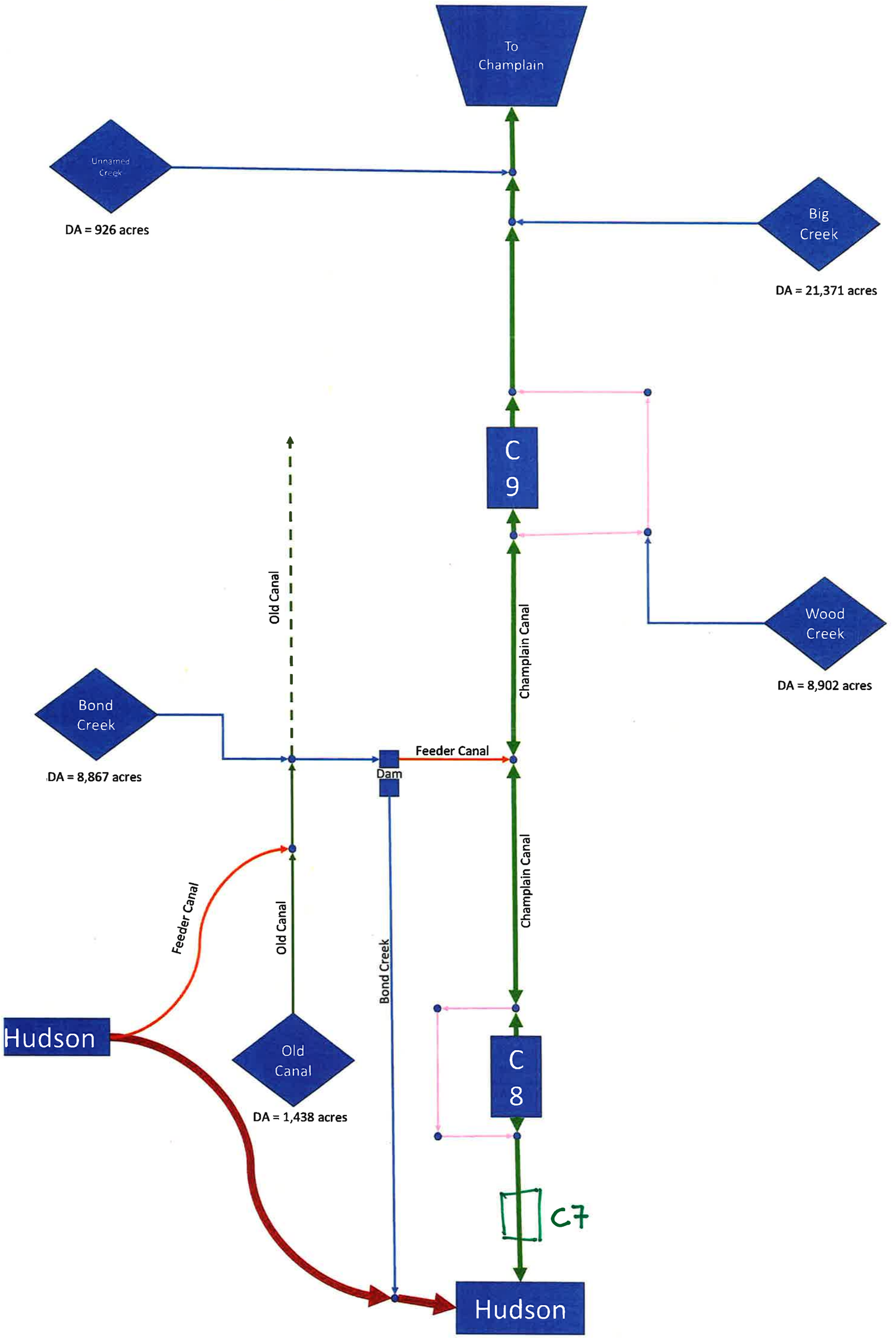
C8

Power House Tail Race
Bond Creek Old Channel
Lock C8
C8
Bond Creek Old Channel

FEEDER CANAL

Lock Elevation Profile




To Champlain
Unnamed Creek
DA = 926 acres
Big Creek
DA = 21,371 acres
C 9
Old Canal
Champlain Canal
Wood Creek
DA = 8,902 acres
Bond Creek
DA = 8,867 acres
Feeder Canal
Dam
Champlain Canal
Feeder Canal
Old Canal
Bond Creek
Hudson
Old Canal
DA = 1,438 acres
C 8
C7
Hudson

Appendix E

Alternative Plan Layouts

Appendix E1 - Alternative 1 – Raise Weir

Appendix E2 - Alternative 2 – Raise Weir & Physical Barrier

Appendix E3 - Alternative 3 – Raise Weir, Back Pump & Alternate Makeup Water

Appendix E4 - Alternative 4 – Raise Weir, Intake Screens, Small Boat Lift

Appendix E5 - Raise Weir, Marine Boat Lift

Appendix E6 - Raise Weir, Chlorination Treatment Chamber

NOTE: HUDSON RIVER BASIN WATERS AND LAKE CHAMPLAIN BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

TO LOCK C8

TO LOCK C11

GRID NORTH

CANAL LOCKAGE OPERATION TO BE MODIFIED TO REDUCE THE NUMBER OF EXCHANGES. SEE MEASURE 7.

STORAGE SHED

PARKING LOT

OIL TANK

CONCRETE HEADWALL

LOCK HOUSE

HUDSON RIVER BASIN WATER

LAKE CHAMPLAIN BASIN WATER

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

SIGNAL LIGHT

MATCH TO STA. 825+85

SIPHON SPILLWAY

REPAIR LOCK SEALS. SEE MEASURE 9.

ABANDONED RAILROAD BED

EDGE OF WATER

ABANDONED RAILROAD BRIDGE ABUTMENT

20'-0"

WOOD CREEK

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 1

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP

LOCATION OF PROJECT: SMITH'S BASIN

TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9

CONTRACT NUMBER:

DATE: 06/18/12

DRAWING NUMBER: 1

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

ACCESS ROAD

18'±

55'±

OE

E

T

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 1

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP

LOCATION OF PROJECT: FORT EDWARD

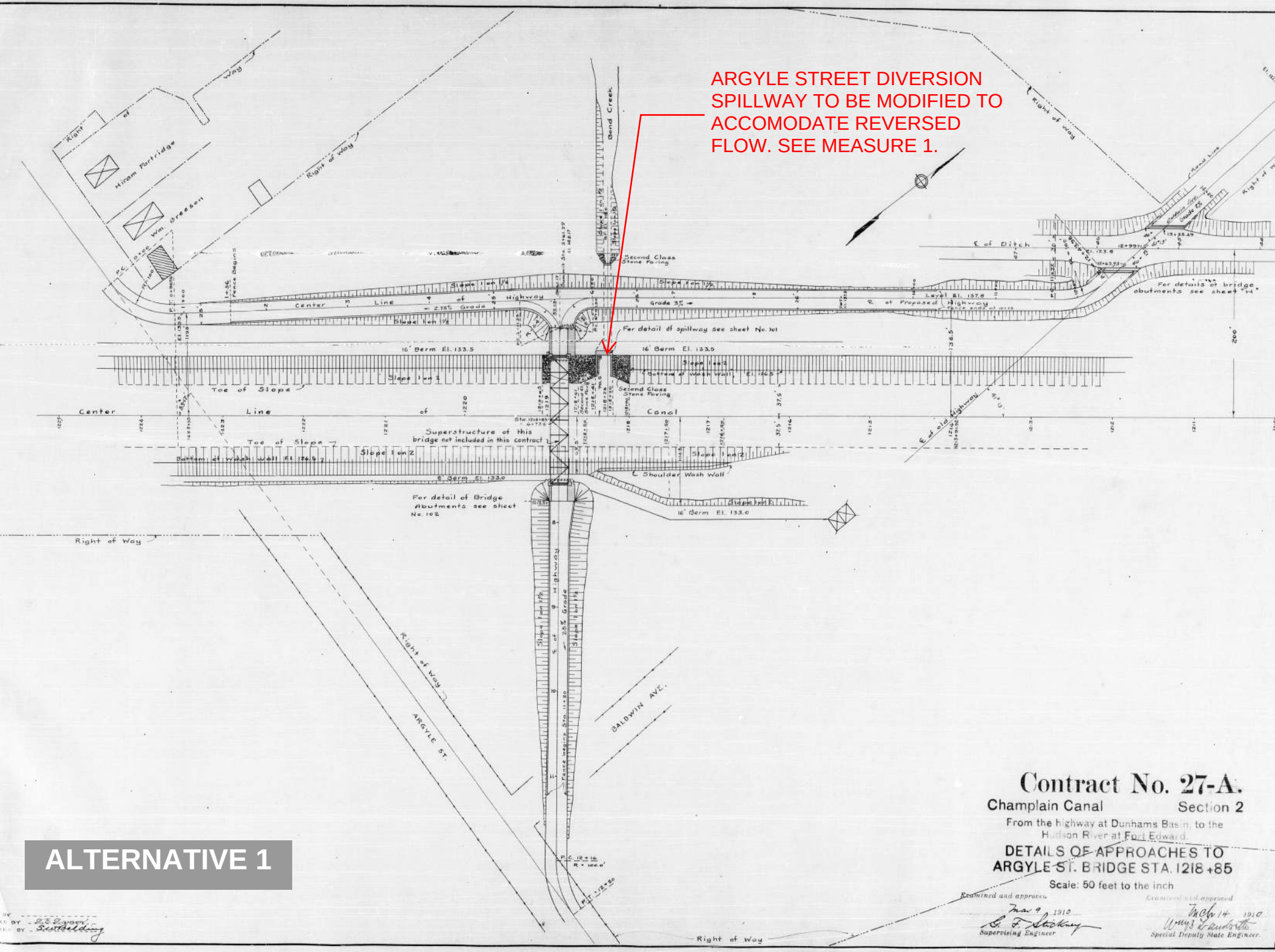
TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C8

CONTRACT NUMBER:

DATE: 06/17/12

DRAWING NUMBER: 1

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON


ARGYLE STREET DIVERSION SPILLWAY TO BE MODIFIED TO ACCOMODATE REVERSED FLOW. SEE MEASURE 1.
Contract No. 27-A.
Champlain Canal
Section 2
From the highway at Dunhams Basin, to the Hudson River at Fort Edward.
DETAILS OF APPROACHES TO ARGYLE ST. BRIDGE STA. 1218+85
Scale: 50 feet to the inch
Examined and approved
Mar 9 1910
G. F. Stockwell
Supervising Engineer
Examined and approved
March 14 1910
Special Deputy State Engineer.
ALTERNATIVE 1

TO LOCK C8

NOTE: HUDSON RIVER BASIN WATERS AND LAKE CHAMPLAIN BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

PRIMARY BACKPUMP MAKEUP WATER FROM LAKE CHAMPLAIN BASIN TO BE PUMPED INTO LOCK C9. SEE MEASURE 2.

GRID NORTH

TO LOCK C11

BOAT CLEANING WASHWATER STORAGE TANK (MEASURE 5)

STORAGE SHED

PARKING LOT

OIL TANK

LOCK HOUSE

PUMP

CONCRETE HEADWALL

HUDSON RIVER BASIN WATER

LAKE CHAMPLAIN BASIN WATER

SIGNAL LIGHT

MATCH TO STA. 825+85

SIPHON SPILLWAY

BOAT LIFT AND CLEANING STATION FOR SMALL, RECREATIONAL VESSELS ONLY. WASHWATER TO BE PUMPED TO STORAGE TANK ADJACENT TO CANAL. SEE MEASURE 5.

REPAIR LOCK SEALS. SEE MEASURE 9.

ABANDONED RAILROAD BED

EDGE OF WATER

ABANDONED RAILROAD BRIDGE ABUTMENT

BERM. SEE MEASURE 4.

20'-0"

WOOD CREEK

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE

EXAMPLE CANTILEVER ARM BOAT LIFT FOR SMALL VESSELS

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 2

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
APPROVED BY: A.DENNISTON

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP
LOCATION OF PROJECT: SMITH'S BASIN
TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9
CONTRACT NUMBER:
DATE: 06/18/12
DRAWING NUMBER: 1

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

ACCESS ROAD

18'±

55'±

OE

T

E

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 2

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

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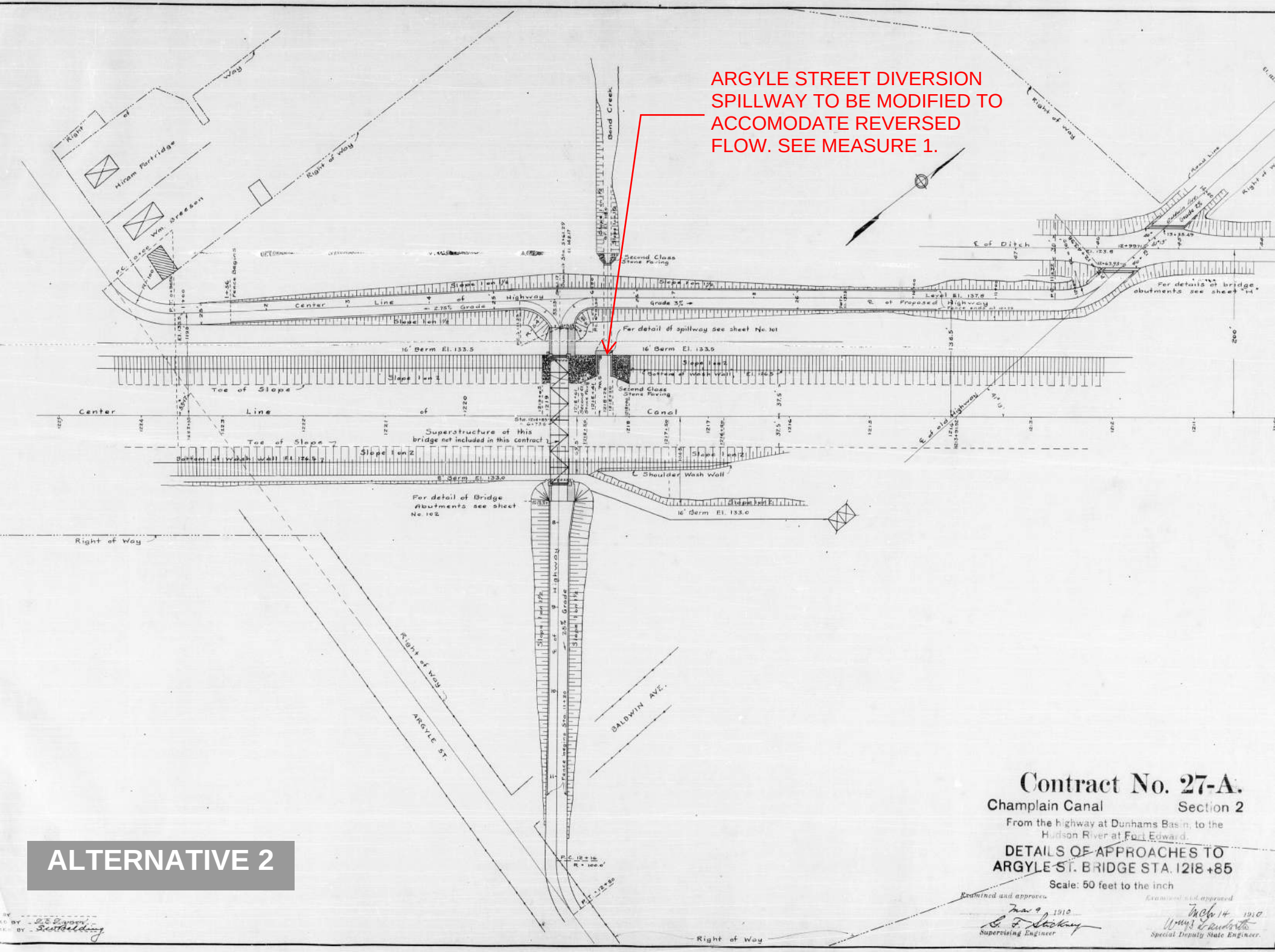
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Scale: 50 feet to the inch
Examined and approved
Mar 9 1910
S. F. Stockwell
Supervising Engineer
Examined and approved
March 14 1910
Special Deputy State Engineer.
ALTERNATIVE 2

NOTE: HUDSON RIVER BASIN WATERS AND LAKE CHAMPLAIN BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

TO LOCK C8

CANAL LOCKAGE OPERATION TO BE MODIFIED TO REDUCE THE NUMBER OF EXCHANGES. SEE MEASURE 7.

SAND & GRAVEL BED FILTRATION SYSTEM. SEE MEASURE 8.

PUMP TO STORAGE TANK

STORAGE TANK. SEE MEASURE 8

PRIMARY MAKEUP WATER FROM LAKE CHAMPLAIN BASIN TO BE PUMPED INTO STORAGE TANK WHEN AVAILABLE. SEE MEASURES 2 & 3.

GRID NORTH

TO LOCK C11

STORAGE SHED

PARKING LOT

OIL TANK

LOCK HOUSE

CONCRETE HEADWALL

30'

SECONDARY INTAKE WITH WEDGE WIRE SCREEN. SEE MEASURE 6.

HUDSON RIVER BASIN WATER

TREATED WATER

LAKE CHAMPLAIN BASIN WATER

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

DISCHARGE

INTAKE

SPILLWAY TO ALLOW WATER FROM LOCK C9 TO OVERTOP INTO THE C8/C9 BASIN. SEE MEASURE 8.

PUMP STATION TO TRANSFER WATER FROM LOCK C9 TO C8/C9 CANAL. SEE MEASURE 8.

REPAIR LOCK SEALS. SEE MEASURE 9.

SIGNAL LIGHT

MATCH TO STA. 825+85

SIPHON SPILLWAY

EDGE OF WATER

ABANDONED RAILROAD BED

ABANDONED RAILROAD BRIDGE ABUTMENT

EDGE OF WATER

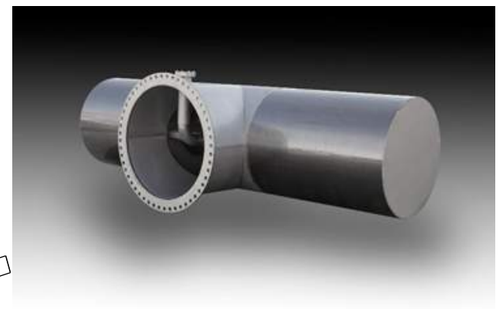
20'-0"

WOOD CREEK

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE



EXAMPLE WEDGEWIRE INTAKE SCREEN

EXAMPLE STORAGE TANK

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 3

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

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ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

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LOCATION OF PROJECT: SMITH'S BASIN
TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9
CONTRACT NUMBER:
DATE: 06/18/12
DRAWING NUMBER: 1

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

SA

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

OE

18'±

ACCESS ROAD

E

30

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

55'±

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 3

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
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NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

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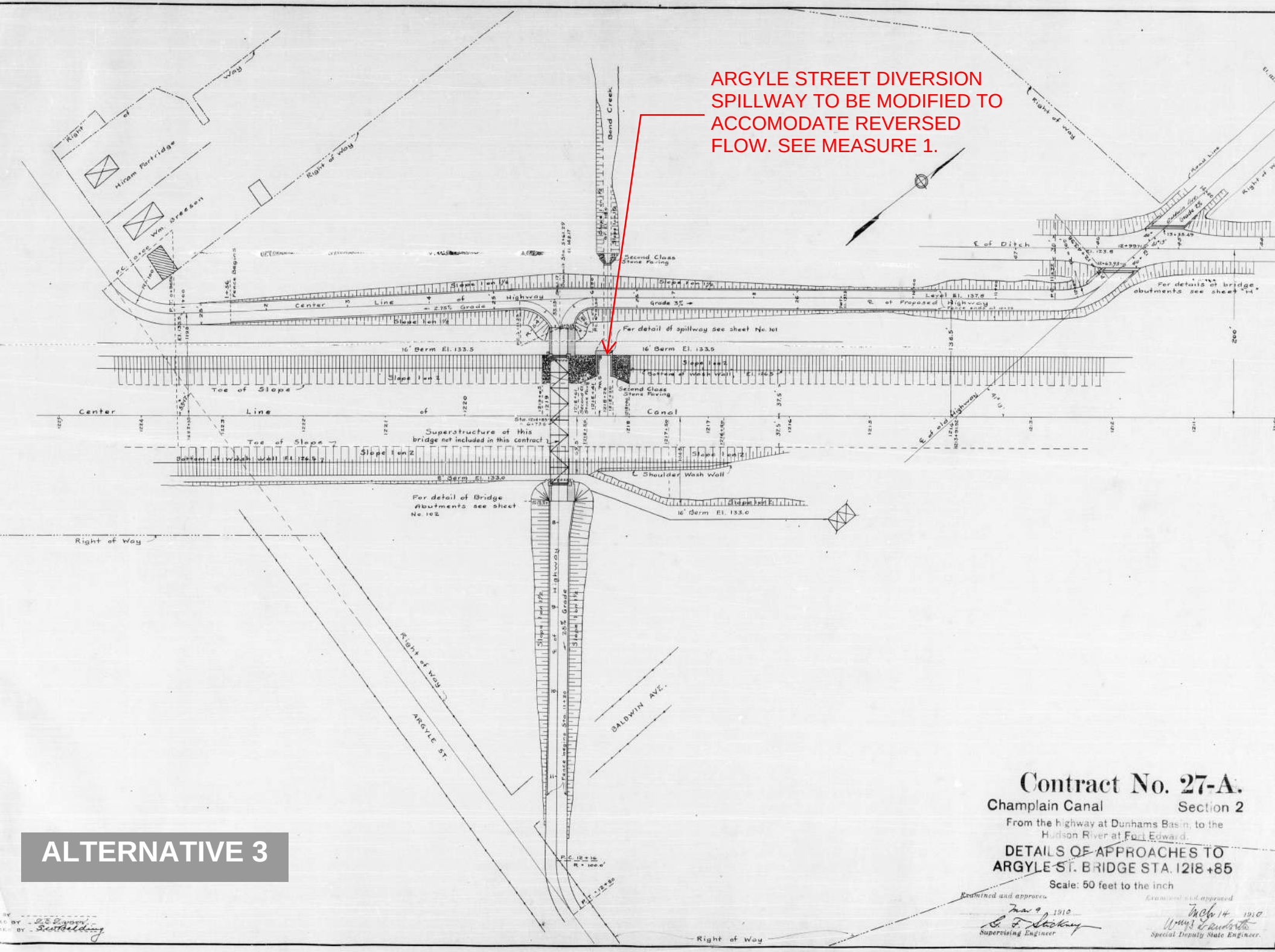
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Supervising Engineer
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March 14 1910
Special Deputy State Engineer.
ALTERNATIVE 3

NOTE: HUDSON RIVER BASIN WATERS AND LAKE CHAMPLAIN BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

TO LOCK C8

TO LOCK C11

GRID NORTH

CONNECTION TO EXISTING CONCRETE BOX CULVERTS WITH WEDGE WIRE INTAKE SCREENS. SEE MEASURE 6.

BOAT CLEANING WASHWATER STORAGE TANK (MEASURE 5)

STORAGE SHED

PARKING LOT

OIL TANK

LOCK HOUSE

CONCRETE HEADWALL

HUDSON RIVER BASIN WATER

TREATED WATER

LAKE CHAMPLAIN BASIN WATER

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

REPAIR LOCK SEALS. SEE MEASURE 9.

BOAT LIFT AND CLEANING STATION FOR SMALL RECREATIONAL VESSELS ONLY. WASHWATER IS CAPTURED WITHIN A FLOATING WASH BASIN WHICH IS PUMPED TO STORAGE TANK ADJACENT TO CANAL. SEE MEASURE 5.

SIGNAL LIGHT

ABANDONED RAILROAD BED

ABANDONED RAILROAD BRIDGE ABUTMENT

SIPHON SPILLWAY

20'-0"

EDGE OF WATER

WOOD CREEK

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE

EXAMPLE CANTILEVER ARM BOAT LIFT FOR SMALL VESSELS

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 4

REVISIONS			
DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP

LOCATION OF PROJECT: SMITH'S BASIN

TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9

CONTRACT NUMBER:

DATE: 06/18/12

DRAWING NUMBER: 1

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

SA

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

OE

18'±

ACCESS ROAD

E

30

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

55'±

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 4

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

REVISIONS

DATE	DESCRIPTION	BY	SYM.

NEW YORK STATE CANAL CORPORATION
ALBANY DIVISION CANAL HQ
ROUTE 9W, INTER. 23, ALBANY, NY 12209

TITLE OF PROJECT: UTILITY LOCATION MAP

LOCATION OF PROJECT: FORT EDWARD

TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C8

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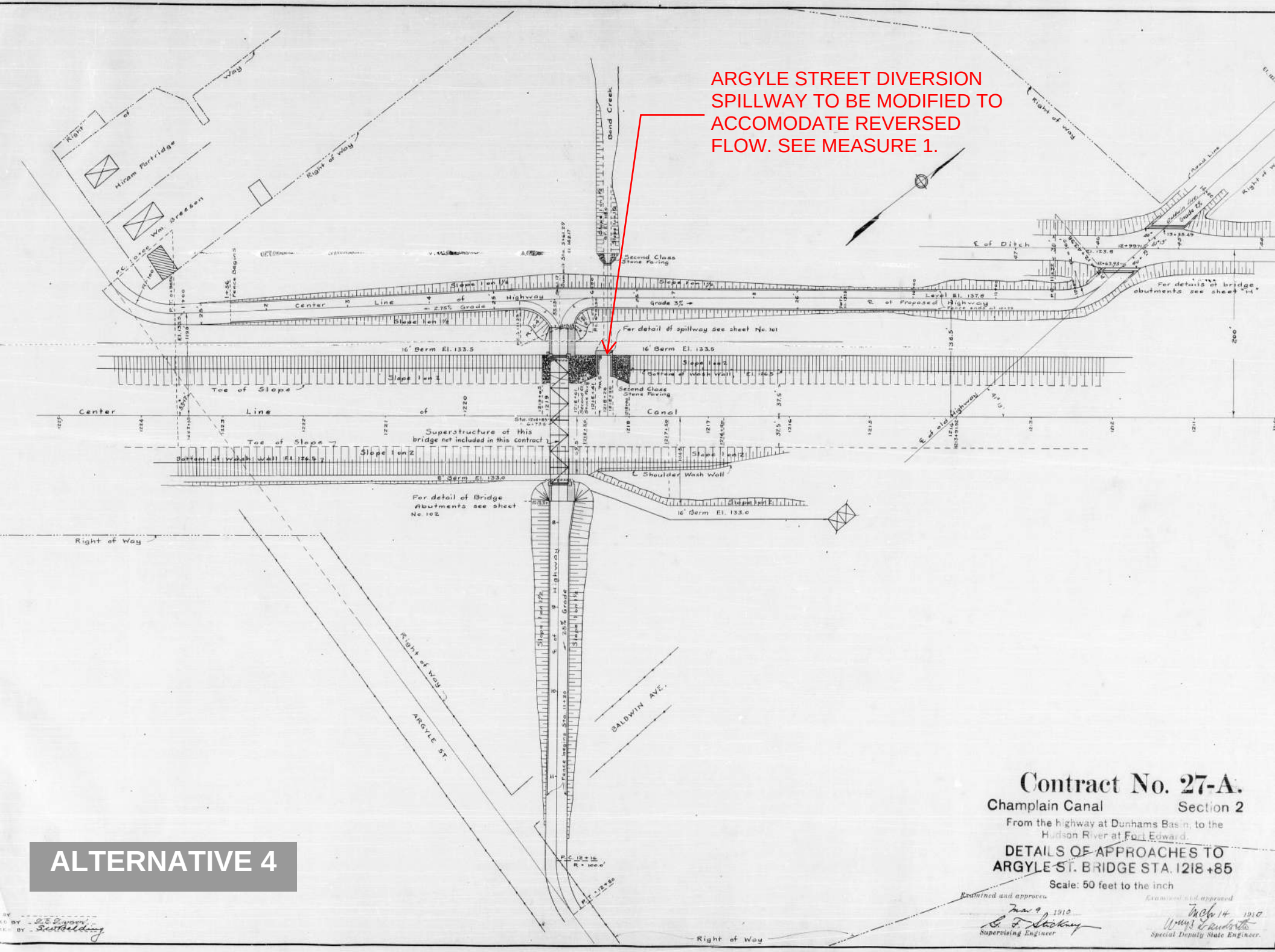
DRAWING NUMBER: 1



ALTERNATIVE 4

NOTE: HUDSON RIVER BASIN WATERS AND LAKE Cchamplain BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

TO LOCK C8

TO LOCK C11

GRID NORTH

STORAGE SHED

PARKING LOT

BOAT CLEANING WASHWATER STORAGE TANK (MEASURE 5)

CONCRETE HEADWALL

OIL TANK

150-ft.

150-ft.

LOCK HOUSE

HUDSON RIVER BASIN WATER

LAKE CHAMPLAIN BASIN WATER

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

EXTEND BULKHEAD. FILL BEHIND BULKHEAD WALL.

TOW PATH BOAT LIFT AND CLEANING STATION FOR ALL VESSELS. WASHWATER TO BE PUMPED TO STORAGE TANK ADJACENT TO CANAL. SEE MEASURE 5.

REPAIR LOCK SEALS. SEE MEASURE 9.

SIPHON SPILLWAY

20'-0"

EDGE OF WATER

WOOD CREEK

SIGNAL LIGHT

MATCH TO STA. 825+85

ABANDONED RAILROAD BED

ABANDONED RAILROAD BRIDGE ABUTMENT

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE

LARGE BOAT HOIST LIFT. MAXIMUM 100-FT. LONG BOATS (NO BARGES)

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 5

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

REVISIONS			
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LOCATION OF PROJECT: SMITH'S BASIN

TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9

CONTRACT NUMBER:

DATE: 06/18/12

DRAWING NUMBER: 1

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

ACCESS ROAD

18'±

55'±

OE

E

T

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 5

REVISIONS

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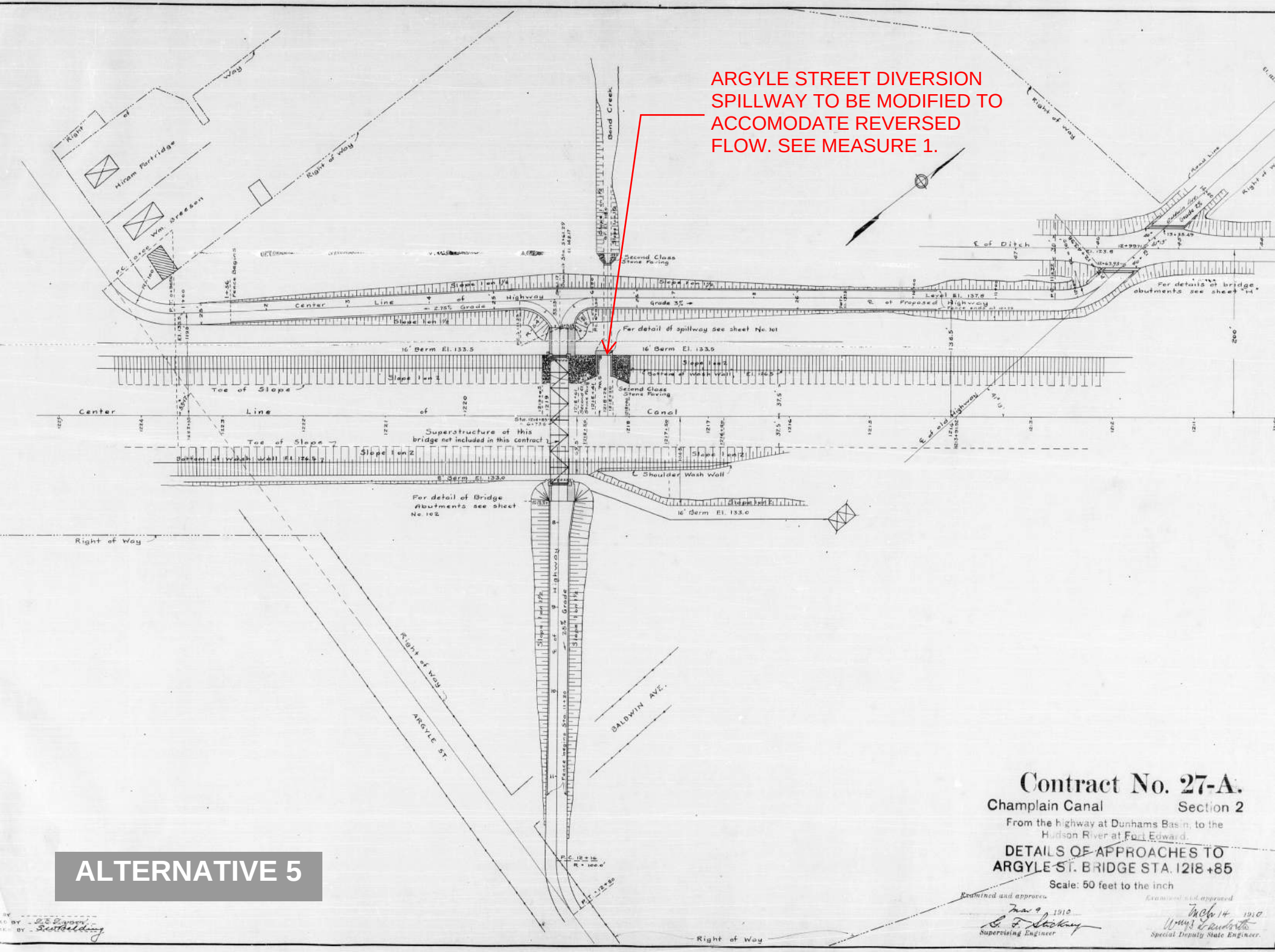
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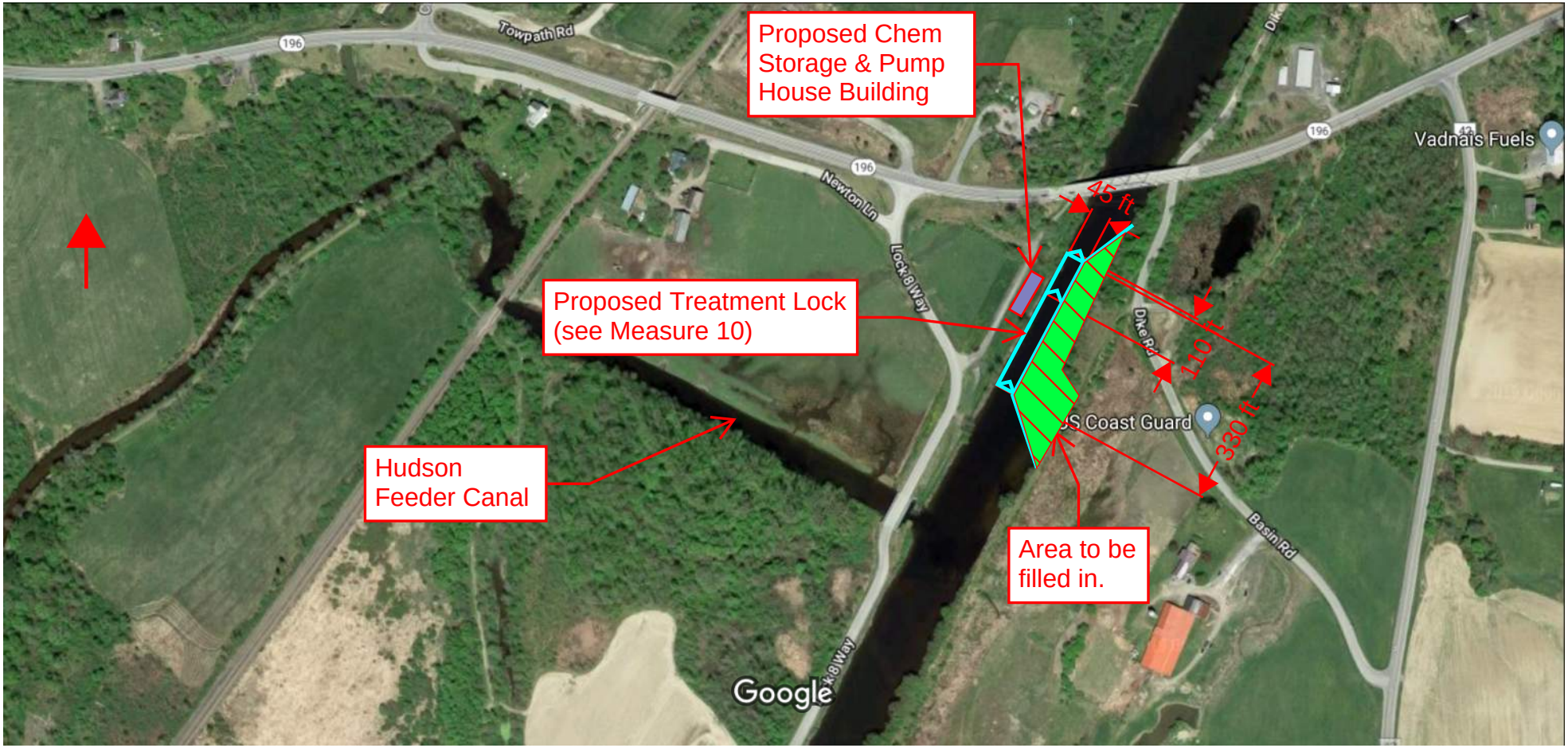
Examined and approved
March 14 1910
Special Deputy State Engineer.
ALTERNATIVE 5

Google Maps

Lock 8 Way

Treatment Lock Location



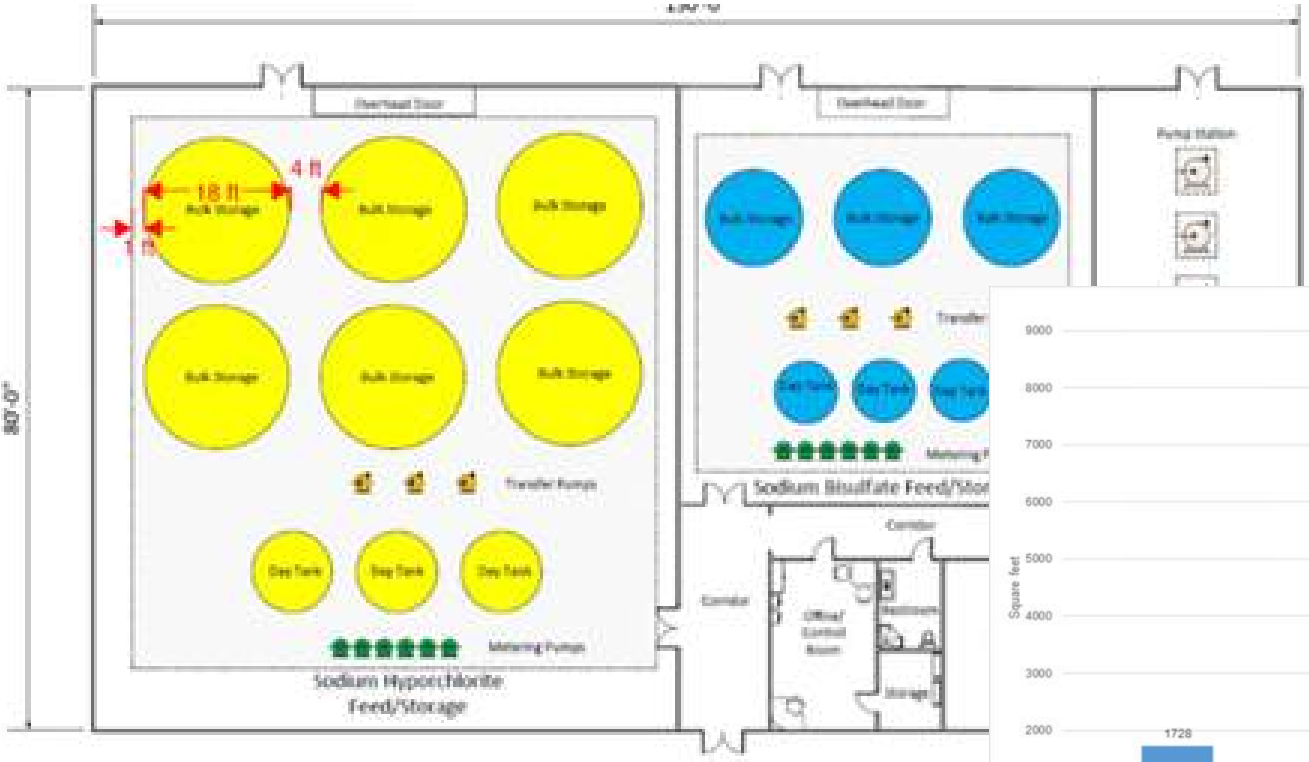
Imagery ©2019 Google, Map data ©2019 200 ft

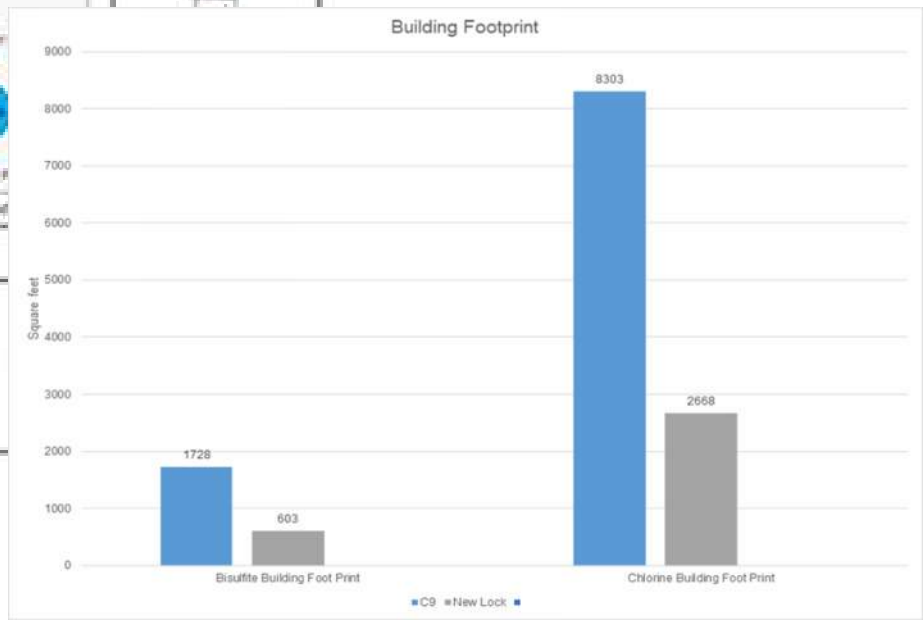
Notes:

1. Proposed treatment chamber lock to be 45-ft wide, 330-ft long and 12-ft deep.
2. Treatment lock will have three sets of gates, one at each end and one intermediate set of gates to allow for three chamber lengths, 110-ft, 220-ft and 330-ft. This configurations allows for scaling of the treatment chamber to vary with the size of the vessel.
3. Chemical storage and pump house approximately 33-ft wide by 100-ft long, 3,300-sf.

ALTERNATIVE 6

Alternative 6 - Chlorine Lock Treatment System
Chemical Storage Building Sizing

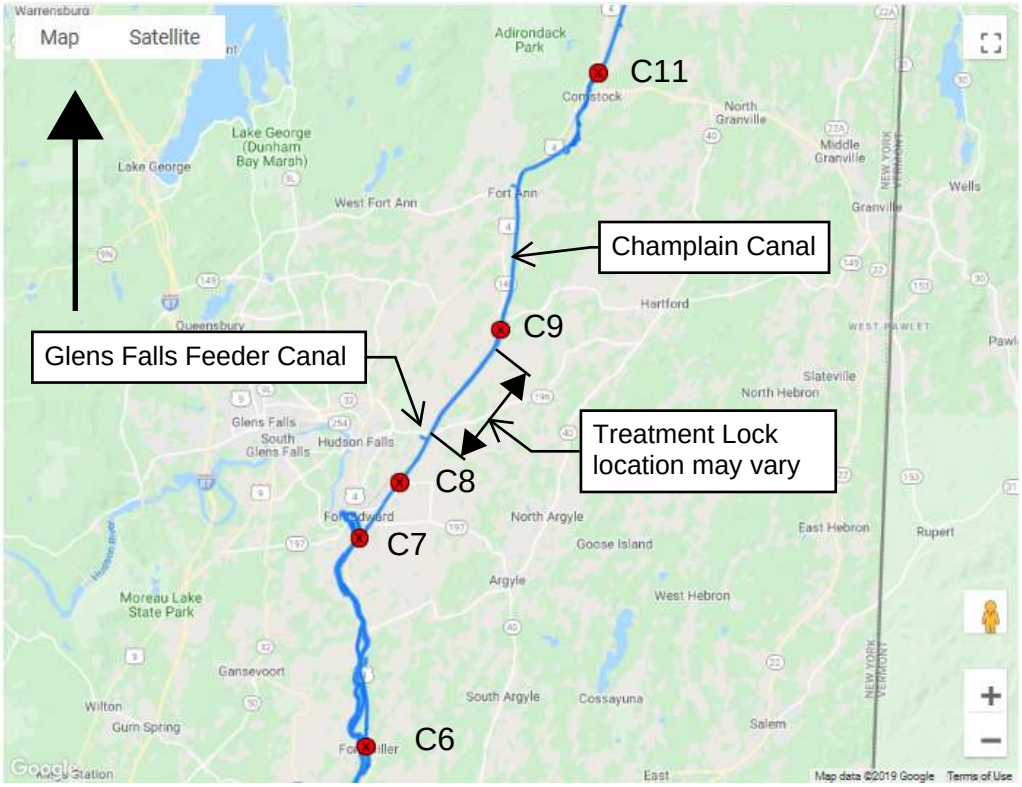




EXAMPLE TREATMENT BUILDING SIZE
80' X 150' = 12,000-SF.

REQUIRED BUILDING SIZE
603-SF + 2,668-SF = 3,271-SF
APPROXIMATE BUILDING SIZE
33' X 100' = 3,300-SF

ALTERNATIVE 6



http://www.canals.ny.gov/maps/index.html

ALTERNATIVE 6

NOTE: HUDSON RIVER BASIN WATERS AND LAKE CHAMPLAIN BASIN WATERS ARE PARTIALLY CO-MINGLED DESPITE DESIGNATIONS SHOWN BELOW.

GRID NORTH

TO LOCK C8

TO LOCK C11

STORAGE SHED

PARKING LOT

OIL TANK

SA

LOCK HOUSE

CONCRETE HEADWALL

30

E

T

HUDSON RIVER BASIN WATER

LAKE CHAMPLAIN BASIN WATER

RAISE WOOD CREEK SPILLWAY WEIR ELEVATION. SEE MEASURE 1.

REPAIR LOCK SEALS. SEE MEASURE 9.

MATCH TO STA. 825+85

SIGNAL LIGHT

SIPHON SPILLWAY

20'-0"

EDGE OF WATER

WOOD CREEK

ABANDONED RAILROAD BED

ABANDONED RAILROAD BRIDGE ABUTMENT

STA. 825+85

PILE DOCKING, ± 548.0'

MATCH LINE

25 0 25 50 75 100'

1" = 75'

ALTERNATIVE 6

REVISIONS			
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NEW YORK STATE CANAL CORPORATION
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LOCATION OF PROJECT: SMITH'S BASIN

TITLE OF DRAWING: UTILITY LOCATION MAP LOCK C9

CONTRACT NUMBER:

DATE: 06/18/12

DRAWING NUMBER: 1

DESIGN SUPERVISOR: STEVE SWEENEY
DESIGNED BY: Z.ALAM
DRAFTED BY: Z.ALAM
CHECKED BY: A.DENNISTON
CHECKED BY: A.DENNISTON

TO LOCK C7

TO LOCK C9

OVERFLOW TO C8/C7 CANAL

GRID NORTH

STORAGE SHED

WATERWAY CHANNEL

LOCK HOUSE

OIL TANK

℄ ACCESS ROAD

ACCESS ROAD

18'±

55'±

OE

E

T

HUDSON RIVER BASIN WATER

HUDSON RIVER BASIN WATER

PROPOSED SPILLWAY SET AT ELEVATION OF EXISTING WOOD CREEK SPILLWAY. OVERFLOW WILL ENTER EXISTING WATERWAY CHANNEL AND DISCHARGES TO THE CANAL BETWEEN LOCKS C8 AND C7. REFER TO MEASURE 1.

25 0 25 50 75 100'

1" = 50'

ALTERNATIVE 6

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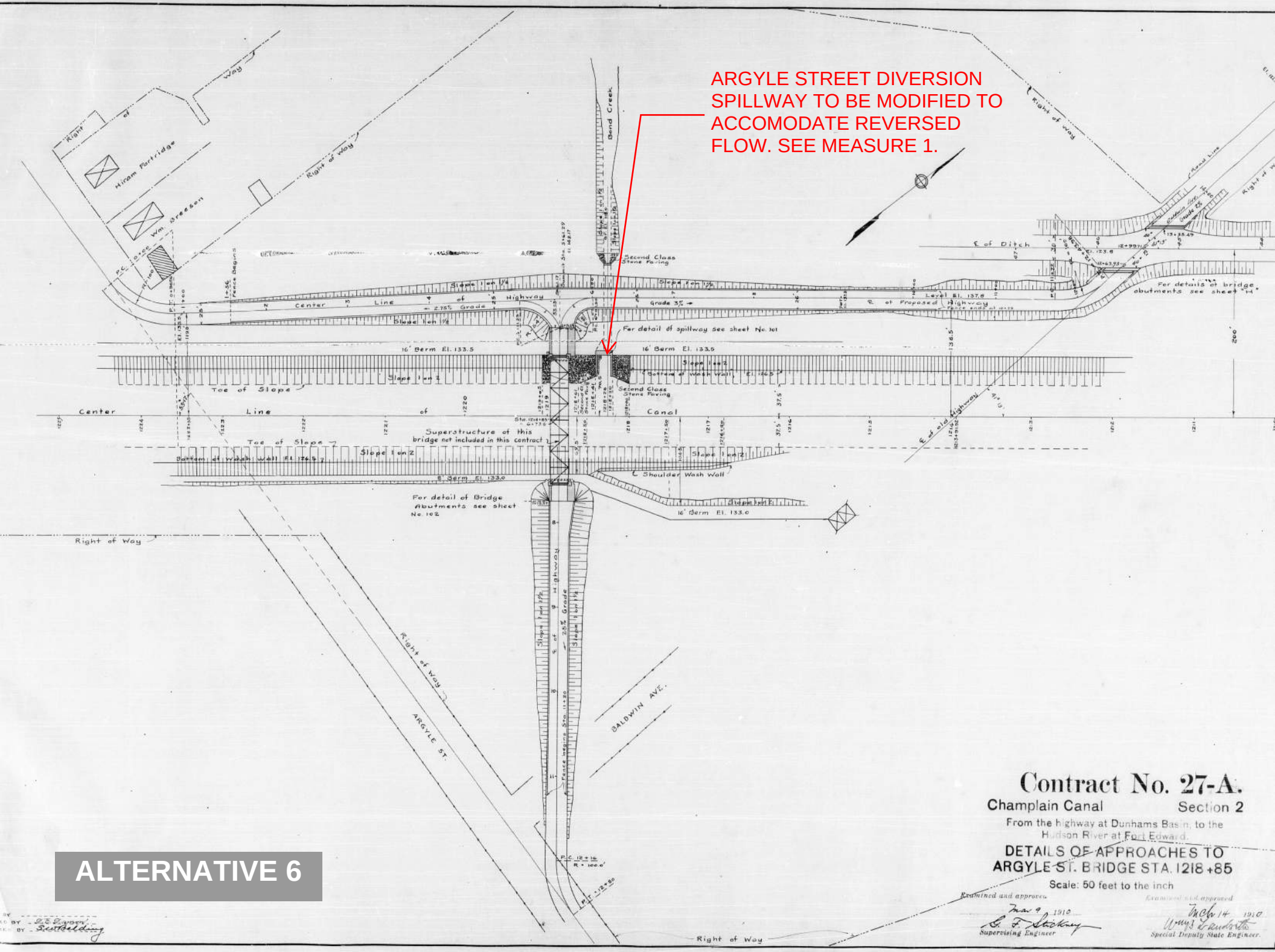
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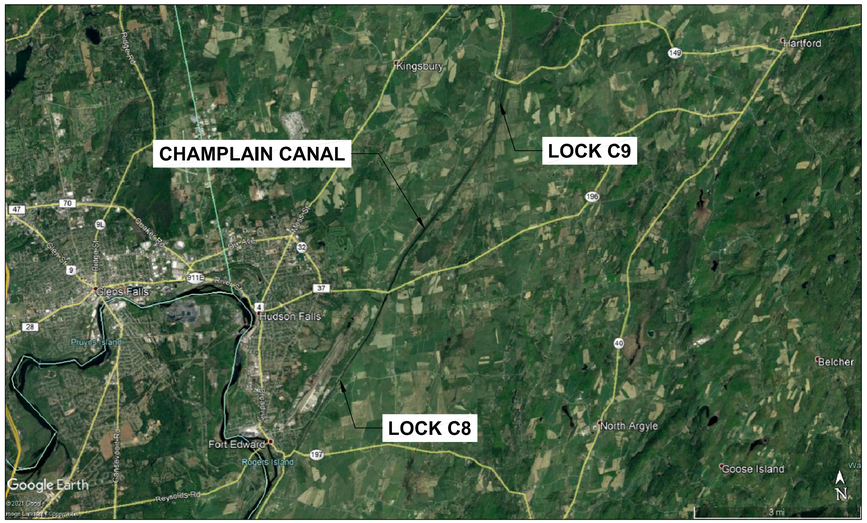
ALTERNATIVE 6

Appendix F – Preferred Alternative Concept Plan Layouts

Appendix F1 – Alternative 2

Appendix F2 – Alternative 4

Appendix F3 – Alternative 5



PROJECT VICINITY MAP

PROJECT LOCATION MAP

US ARMY CORPS
OF ENGINEERS
NEW YORK

Lake Champlain Invasive Species Barrier Study

Conceptual Design of Preferred Alternatives

United States Army Corps of Engineers - New York District
Contract W912DS-14-D-0001

HDR Project No. 10133414

Fort Edward, New York to Fort Ann, New York
June 2021

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NOTES:

1) ORTHOGRAPHIC PHOTOS WERE OBTAINED FROM NYS GIS CLEARINGHOUSE WASHINGTON COUNTY 2017
2) CONTOURS ARE BASED ON USGS NATIONAL ELEVATION DATA SET USGS NED 1/3 ARC-SECOND N43W074 1 X 1 DEGREE ARCGRID 2018
3) ALL ELEVATIONS, UNLESS OTHERWISE NOTED, ARE IN NAVD88

ISSUE	DATE	DESCRIPTION
0	-	-

PROJECT MANAGER - MICHAEL MURPHY

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

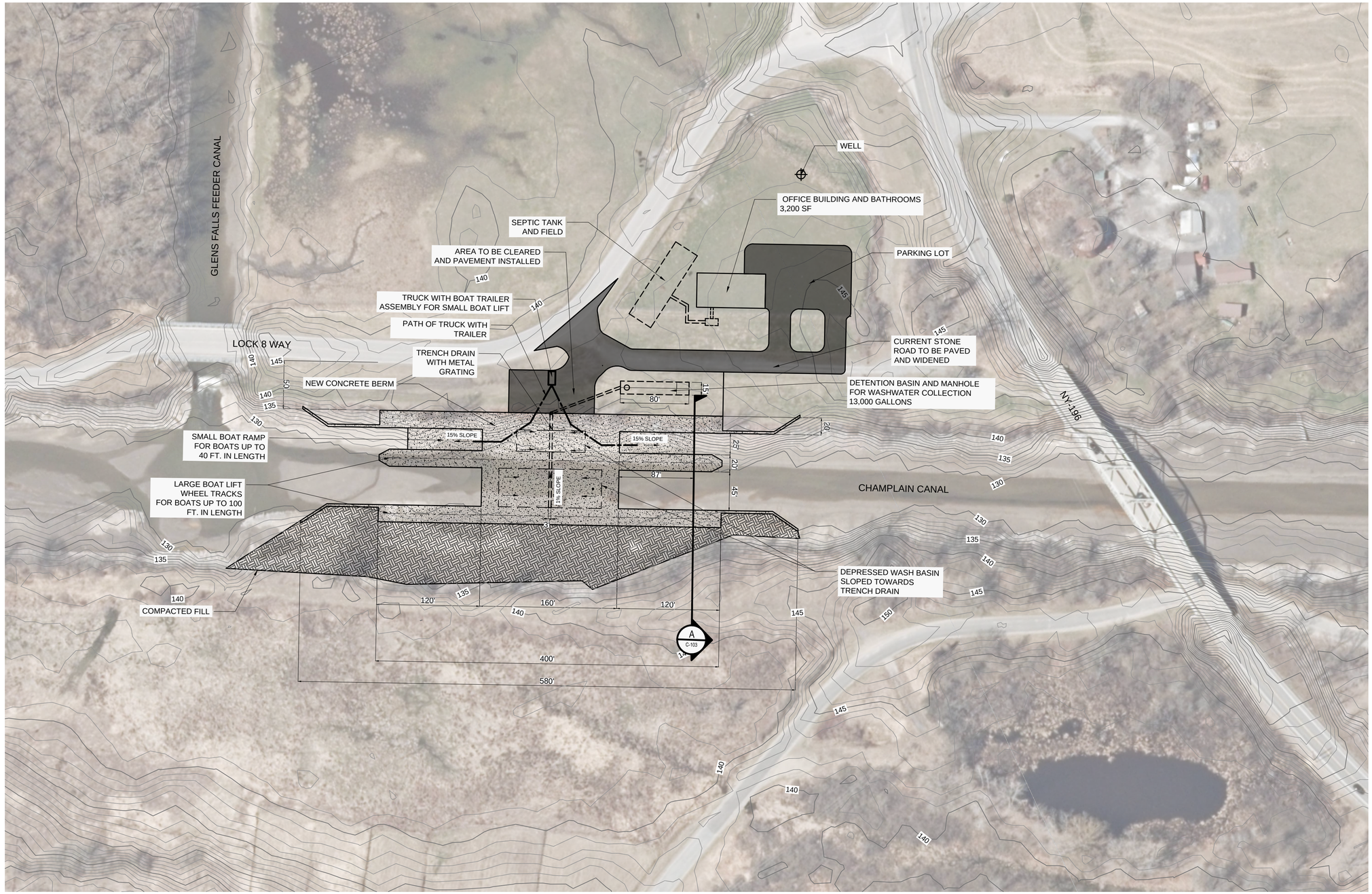
ALTERNATIVES 2, 4, 5 PLAN
NEW SPILLWAY AT LOCK C8

0 1" 2"

FILENAME -

SCALE 1" = 30'

SHEET **C-101**



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0	-	-

PROJECT MANAGER - MICHAEL MURPHY

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

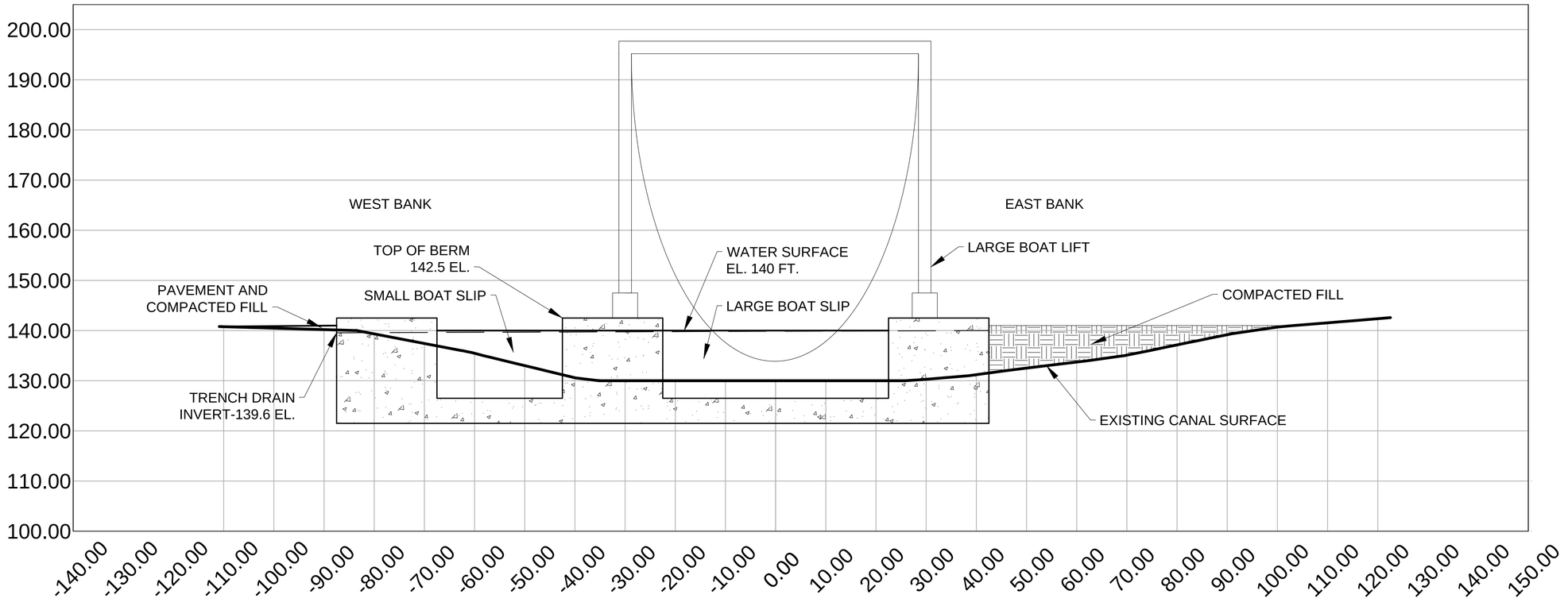
ALTERNATIVE 2 PLAN BERM LOCATION

0 1" 2"

FILENAME -

SCALE 1" = 60'

SHEET C-102



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0	-	-

PROJECT MANAGER - MICHAEL MURPHY

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

ALTERNATIVE 2
BERM SECTION VIEW

0 1" 2"

FILENAME -

SCALE N.T.S

SHEET C-103

NOTES:

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0	-	-

PROJECT MANAGER - MICHAEL MURPHY

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

ALTERNATIVE 4 PLAN SMALL BOAT LIFT AT LOCK C9

0 1" 2"

FILENAME -

SCALE 1" = 60'

SHEET C-104

NOTES:

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ISSUE	DATE	DESCRIPTION
0	-	-

PROJECT MANAGER - MICHAEL MURPHY

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

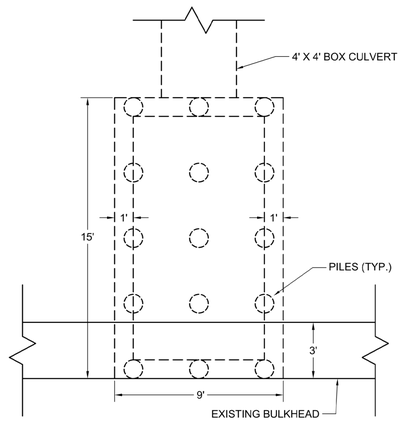
ALTERNATIVE 5 PLAN LARGE BOAT LIFT AT LOCK C9

0 1" 2"

FILENAME -

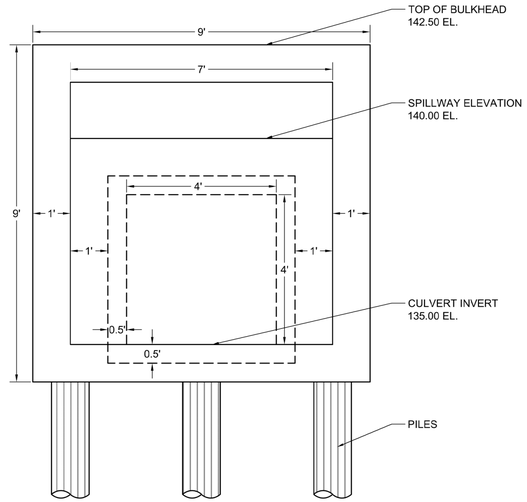
SCALE 1" = 60'

SHEET C-105



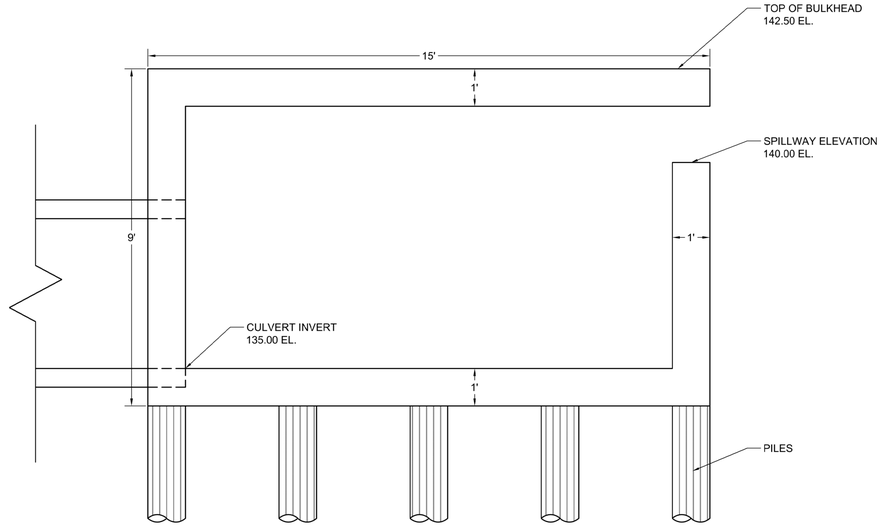
PLAN VIEW

0' 4' 8'
SCALE IN FEET



ELEVATION VIEW

0' 2' 4'
SCALE IN FEET



SECTION VIEW

0' 2' 4'
SCALE IN FEET

NOTES:

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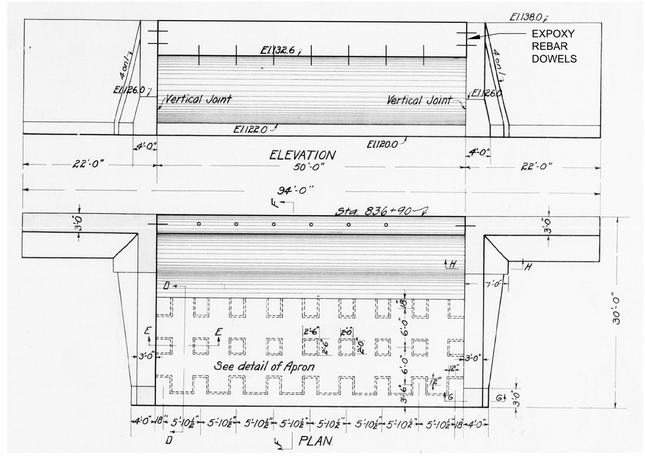
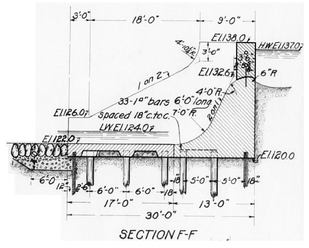
1 / C-501 CANAL DRAIN STRUCTURE - ALTERNATIVES 2, 4, 5

SCALE: AS NOTED

NOTES:
1) ELEVATIONS SHOWN ARE IN REFERENCE TO NAVD88.
2) PILE SPACING AND LAYOUT ARE CONCEPTUAL.





2 / C-501 WOODCREEK WEIR RAISING - ALTERNATIVES 4, 5

NOT TO SCALE

NOTES:
1) ELEVATIONS SHOWN ARE IN REFERENCE TO CANAL BARGE DATUM.
2) APPLY WEIR RAISING TO ALTERNATIVES 4 AND 5.
3) INSTALL CONCRETE WALL EXTENSION TO EXISTING SPILLWAY STRUCTURE.
4) UNDERLYING DETAIL DRAWINGS ARE REFERENCED FROM NYSCC AS-BUILT DRAWINGS.

PROJECT MANAGER - MICHAEL MURPHY

ISSUE	DATE	DESCRIPTION
0	-	-

PROJECT NUMBER 10133414

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING

USACE CHAMPLAIN CANAL

SITE DETAILS

0 1" 2"

FILENAME -

SCALE -

SHEET C-501

Appendix G – Preferred Alternative Cost Estimates

Appendix G1 – Alternative 2

Appendix G2 – Alternative 4

Appendix G3 – Alternative 5

USACE NYD Lake Champlain Canal AIS Barriers
CONCEPTUAL COST ESTIMATE
Alternative #2

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL COST	CATEGORY COST
MEASURE 1 - REVERSE FLOW C9 TO C8					
Concrete Channel / Pipe	LF	120	$340.00	$ 40,800	
Concrete Bulkhead	CY	20	$236.00	$ 4,720	
Headwall	EA	1	$8,500.00	$ 8,500	
Junction Box	EA	1	$7,925.00	$ 7,925	
Repair Parking Lot Pavement	EA	8	$1,465.00	$ 11,720	
Timber Piles (assumed 40-ft long)	VLF	400	$26.00	$ 10,400	
Rip Rap	SY	67	$105.00	$ 7,035	
			SUBTOTAL	*$ 91,100*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 109,411**
MEASURE 4 - PHYSICAL BARRIER					
Compacted Structural Backfill	CY	6,600	$7.55	$ 49,830	
Concrete Berm, Finger Dykes, Small Boat Ramp, & Retaining Wall	CY	31,400	$236.00	$ 7,410,400	
Timber Piles (assumed 40-ft long)	VLF	24,000	$26.00	$ 624,000	
			SUBTOTAL	*$ 8,084,230*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 9,709,160**
MEASURE 5 - BOAT LIFT AND CLEANING STATION					
Large Boat Lift	EA	1	$550,000.00	$ 550,000	
Trench Drain	LF	110	$210.00	$ 23,100	
6" Diameter Corrug. HDPE Type S Pipe	LF	84	$7.05	$ 592	
Washwater Storage Tank (Concrete Septic Tank)	EA	1	$29,400.00	$ 29,400	
Pickup Truck	EA	1	$45,000.00	$ 45,000	
Boat Trailer up to 14' boat	LS	1	$1,000.00	$ 1,000	
Boat Trailer up to 25' boat	LS	1	$3,000.00	$ 3,000	
Boat Trailer up to 27' boat	LS	1	$6,000.00	$ 6,000	
Boat Trailer up to 40' boat	LS	1	$8,000.00	$ 8,000	
Parking Lot Pavement	EA	37	$1,465.00	$ 54,205	
Bituminous Roadway 24' Wide	LF	1,065	$151.00	$ 160,815	
			SUBTOTAL	*$ 881,112*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 1,058,216**
OTHER					
Garage for operations, restrooms & offices	SF	3,200	$174.62	$ 558,781	
Sub surface sewage disposal system	LS	1	$20,000.00	$ 20,000	
Water Supply well	LS	1	$9,900.00	$ 9,900	
			SUBTOTAL	*$ 588,681*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 707,006**
SUB-TOTAL (UNADJUSTED)				$ 9,554,023	
TOTAL (ADJUSTED FOR LOCATION)					**$ 11,583,793**
MOBILIZATION	Approx. 4% OR $10,000 MINIMUM			*$ 382,000*	**$ 463,000**
ENGINEERING FEES =	Approx.6%			*$ 573,000*	**$ 492,000**
CONTINGENCY =	Approx. 25%			*$ 2,389,000*	**$ 2,317,000**
PERMITTING =	Approx. 4%			*$ 382,000*	**$ 232,000**
SOIL EROSION CONTROLS =	Approx. 2%			*$ 191,000*	**$ 232,000**
CONSTRUCTION INSPECTION FEE =	Approx. 4%			*$ 382,000*	**$ 463,000**
CONSTRUCTION MANAGEMENT =	Approx. 6%			*$ 573,000*	**$ 695,000**
IMPROVEMENTS GRAND TOTAL (for year 2019, Rounded to nearest $1K)				**$ 14,426,000**	**$ 16,478,000**
IMPROVEMENTS GRAND TOTAL (for year 2021 escalated by 5.3% for inflation, Rounded to nearest $1K)				**$ 15,191,000**	**$ 18,245,000**
Based on RSMeans 2019 Site Work and Landscape Cost Data					

USACE NYD Lake Champlain Canal AIS Barriers
CONCEPTUAL COST ESTIMATE
Alternative #4

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL COST	CATEGORY COST
MEASURE 1 - REVERSE FLOW C9 TO C8					
Concrete Channel / Pipe	LF	120	$340.00	$ 40,800	
Concrete Bulkhead	CY	20	$236.00	$ 4,720	
Headwall	EA	1	$8,500.00	$ 8,500	
Junction Box	EA	1	$7,925.00	$ 7,925	
Rip Rap	SY	67	$105.00	$ 7,035	
Timber Piles (assumed 40-ft long)	VLF	400	$26.00	$ 10,400	
Raise Wood Creek Spillway	CY	34	$235.00	$ 7,990	
Repair Parking Lot Pavement	EA	8	$1,465.00	$ 11,720	
			SUBTOTAL	*$ 99,090*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 119,007**
MEASURE 5 - BOAT LIFT AND CLEANING STATION					
Jib Crane	EA	2	$200,000.00	$ 400,000	
Concrete Washbasin	CY	30	$236.00	$ 7,080	
Washwater Storage Tank (Concrete Septic Tank)	EA	1	$29,400.00	$ 29,400	
Pickup Truck	EA	1	$45,000.00	$ 45,000	
Boat Trailer up to 14' boat	LS	1	$1,000.00	$ 1,000	
Boat Trailer up to 25' boat	LS	1	$3,000.00	$ 3,000	
Boat Trailer up to 27' boat	LS	1	$6,000.00	$ 6,000	
Boat Trailer up to 40' boat	LS	1	$8,000.00	$ 8,000	
Retaining Wall	CY	545	$236.00	$ 128,620	
Crane Lift Pier Foundation	CY	570	$236.00	$ 134,520	
Timber Piles (assumed 40-ft long)	VLF	7,200	$26.00	$ 187,200	
Bituminous Roadway 24' Wide	LF	1,065	$151.00	$ 160,815	
Compacted Fill for Boat Trailer loading and unloading platform	CY	1,100	$7.55	$ 8,305	
Dredging Boat Area	BCY	8,000	$16.05	$ 128,400	
			SUBTOTAL	*$ 1,247,340*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 1,498,055**
MEASURE 6 - WEDGE WIRE INTAKE SCREENS					
Intake Screen	SF	96	$1,000.00	$ 96,000	
Wire Screen Support Structure	EA	2	$18,000.00	$ 36,000	
			SUBTOTAL	*$ 132,000*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 158,532**
SUB-TOTAL (UNADJUSTED)				$ 1,478,430	
TOTAL (ADJUSTED FOR LOCATION)					**$ 1,775,594**
MOBILIZATION	Approx. 4% OR $10,000 MINIMUM			*$ 59,000*	**$ 71,000**
ENGINEERING FEES =	Approx.6%			*$ 89,000*	**$ 75,000**
CONTINGENCY =	Approx. 25%			*$ 370,000*	**$ 355,000**
PERMITTING =	Approx. 4%			*$ 59,000*	**$ 36,000**
SOIL EROSION CONTROLS =	Approx. 2%			*$ 30,000*	**$ 36,000**
CONSTRUCTION INSPECTION FEE =	Approx. 4%			*$ 59,000*	**$ 71,000**
CONSTRUCTION MANAGEMENT =	Approx. 6%			*$ 89,000*	**$ 107,000**
IMPROVEMENTS GRAND TOTAL (for year 2019, Rounded to nearest $1K)				**$ 2,233,000**	**$ 2,527,000**
IMPROVEMENTS GRAND TOTAL (for year 2021 utilizing US Inflation Calculator, Rounded to nearest $1K)				**$ 2,352,000**	**$ 2,315,000**
Based on RSMeans 2019 Site Work and Landscape Cost Data					

USACE NYD Lake Champlain Canal AIS Barriers
CONCEPTUAL COST ESTIMATE
Alternative #5

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL COST	CATEGORY COST
MEASURE 1 - REVERSE FLOW C9 TO C8					
Concrete Channel / Pipe	LF	120	$340.00	$ 40,800	
Concrete Bulkhead	CY	20	$236.00	$ 4,720	
Headwall	EA	1	$8,500.00	$ 8,500	
Junction Box	EA	1	$7,925.00	$ 7,925	
Timber Piles (assumed 40-ft long)	VLF	400	$26.00	$ 10,200	
Rip Rap	SY	67	$105.00	$ 7,035	
Repair Parking Lot Pavement	EA	8	$1,465.00	$ 11,720	
Raise Wood Creek Spillway	CY	34	$236.00	$ 8,024	
			SUBTOTAL	*$ 98,924*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 118,808**
MEASURE 5 - BOAT LIFT AND CLEANING STATION					
Boat Hoist	EA	2	$800,000.00	$ 1,600,000	
Concrete Pads for Boat Hoist	CY	980	$236.00	$ 231,280	
Washwater Barge	EA	2	$1,000,000.00	$ 2,000,000	
Tugboat	EA	2	$1,000,000.00	$ 2,000,000	
Concrete Bulkhead Wall	CY	200	$236.00	$ 47,200	
Compacted Structural Backfill	CY	1,310	$7.55	$ 9,891	
			SUBTOTAL	*$ 5,888,371*	
	TOTAL AFTER LOCATION ADJUSTMENT				**$ 7,071,933**
SUB-TOTAL (UNADJUSTED)				$ 5,987,295	
TOTAL (ADJUSTED FOR LOCATION)					**$ 7,190,741**
MOBILIZATION	Approx. 4% OR $10,000 MINIMUM			*$ 239,000*	**$ 288,000**
ENGINEERING FEES =	Approx.6%			*$ 359,000*	**$ 306,000**
CONTINGENCY =	Approx. 25%			*$ 1,497,000*	**$ 1,438,000**
PERMITTING =	Approx. 4%			*$ 239,000*	**$ 144,000**
SOIL EROSION CONTROLS =	Approx. 2%			*$ 120,000*	**$ 144,000**
CONSTRUCTION INSPECTION FEE =	Approx. 4%			*$ 239,000*	**$ 288,000**
CONSTRUCTION MANAGEMENT =	Approx. 6%			*$ 359,000*	**$ 431,000**
IMPROVEMENTS GRAND TOTAL (for year 2019, Rounded to nearest $1K)				**$ 9,039,000**	**$ 10,230,000**
IMPROVEMENTS GRAND TOTAL (for year 2021 utilizing US Inflation Calculator, Rounded to nearest $1K)				**$ 9,519,000**	**$ 11,433,000**
Based on RSMeans 2019 Site Work and Landscape Cost Data					

Appendix H – Multi-Criteria Decision Analysis Report

Prepared by the USACE

Champlain Canal Invasive Species Barrier Study

Appendix H. The Multi-Criteria Decision Analysis

Prepared for:

U.S. Army Corps of Engineers

New York District,

26 Federal Plaza, Room 1843

New York, NY 10378

Prepared by:

U.S. Army Corps of Engineers

Engineer Research and Development Center

Risk and Decision Science Team

696 Virginia Rd

Concord, MA 01742

The USACE Engineer Research and Development Center (ERDC) was brought on by the Champlain Canal Barrier Project to conduct stakeholder engagement and to complete a Multi-Criteria Decision Analysis (MCDA) using said stakeholder input to choose the best construction alternative of those developed by the architectural and engineering firm (A&E).

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Appendix H1. MCDA Methods

ERDC developed a Multi-Criteria Decision Analysis (MDCA) to evaluate the alternatives by soliciting stakeholder views to characterize and compare three alternatives for a canal barrier to impede aquatic invasive species (AIS) from entering Lake Champlain through the Champlain Canal. An MCDA first asks "what matters in making this decision?" – the answers provided by stakeholders constitute the criteria of the MCDA model, which can be organized into criteria categories, and sub-criteria of those categories. For example, "water turbidity" (sub-criteria) is one of many possible ways to characterize "environmental impacts" (criteria category). The MCDA scores of the criteria categories are comprised of the scores for the sub-criteria chosen to represent those categories. These sub-criteria do not have to be comprehensive, for example, they do not have to represent every possible environmental impact, but they should be able to characterize the stakeholders concerns that are differentiated between the alternatives under consideration.

The MCDA model also asks "how much do these criteria matter in selecting an alternative?" because some criteria may be far more important than others, for example if water turbidity has little consequence for the environment compared to water temperature. Sub-criteria must be weighed relative to other sub-criteria in their category, and the categories themselves must be weighed relative to each other. These are the "weights" used in the model.

Finally, the MCDA model asks "How will each alternative perform for each of these criteria?" For the identified criteria, each must be scored based on how successfully it will perform. For example, for turbidity, the MCDA model requires participants to estimate how turbid the water will be as the result of each alternative. These are the "scores" used in the model. Note that they must be translated to have values between 0-1 (see the value function description below).

Ultimately, the MCDA model uses the equation:

$$\sum_{cc}(weights_{sc} * scores_{sc})_{cc} * weights_{cc}$$

Where:

sc = sub-criteria
cc = criteria categories

The MCDA framework to evaluate the Champlain Canal Basin barrier for AIS reduction relied on stakeholder engagement to answer these three questions, often iteratively, and to build the MCDA evaluation of three alternatives for the barrier.

Appendix H2. Developing the Model Sub-Criteria and the Weighting Survey

The ERDC team began the process of populating the MCDA by hosting two stakeholder workshops in 2018 and 2020, firstly to introduce the MCDA concept and subsequently to solicit criteria that could be used to evaluate the alternatives developed by the A&E Team. During the 2020 meeting, stakeholder breakout groups brainstormed criteria and presented their ideas to a larger group, where an overall criteria list was compiled. At this time, a subset of stakeholders also volunteered to participate in the Technical Committee which would evaluate the alternatives. Finally, the stakeholders voted to pursue consideration for three of the six alternatives presented at the 2020 meeting: alternatives 2, 4, and 5. The designs for these alternatives would be refined and the Technical Committee would use the MCDA framework to evaluate their merit according to stakeholder values.

After the 2020 stakeholder meeting, ERDC organized the sub-criteria into 6 criteria categories: 1) Environmental impacts, 2) Effectiveness at eliminated aquatic invasive species (AIS), 3) Vessel and boater accessibility, 4) Community impacts, 5) Broader impacts, and 6) Operations and maintenance. Each category comprised at least 2 sub-criteria, for a total of 26 criteria. This activity involved reviewing the notes of the three chairs of the breakout sessions where criteria were brainstormed to understand the intention of decision criteria like “security” and “resilience.”

With this criteria hierarchy, ERDC developed a weighting survey to allow the stakeholders to collectively compare the importance of each sub-criteria with the other sub-criteria in its category as well as the importance of each criteria category in relationship to the other five categories. The survey solicited scores 0-10 for each criterion and sub-criteria. The survey used Google Forms, and was completed by all the stakeholders.

The following sub-criteria had average weights of less than 4.7 out of 10, and were subsequently cut from the analysis:

1. Minimizes traffic congestion to main roads during construction (community impacts)
2. Minimizes shift of commercial transit to land transit (broader system impacts)
3. Minimizes odor and noise for nearby residents during construction (community impacts)

This brought the list of sub-criteria to 23 sub-criteria.

The list of 23 sub-criteria was presented to the Technical Committee at the Technical Committee Meeting #1 in January, 2021. Upon reviewing the criteria, the Technical Committee deemed some

criteria not useful in differentiating between the remaining alternatives. For example, whether amenities would be available to boaters would not depend on which alternative was selected; amenities were equally possible to build regardless of the alternative. Therefore, several sub-criteria were removed from the final list. Additionally, the sub-criteria "Maximizes preservation of historic canal system and its ability to transport boats" was divided into two sub-criteria: "Historic preservation of existing canal corps assets" and "Canal's ability to transport all boats." Furthermore, several criteria were refined: what had formerly been "Maximizes economic benefits for communities near the barrier" became "Job loss or creation for communities near the barrier." Finally, through discussions the stakeholders concluded that some sub-criteria were redundant.

Ultimately, the following sub-criteria were removed from the MCDA analysis:

1. Restores system to a more natural hydrological state
2. Maximizes the number of Aquatic Invasive Species dispersal modes that are addressed
3. Creates new amenities for boaters to use during passage
4. Creates new opportunities to provide education to the community
5. Creates new recreational amenities for the local community

After this meeting, the six criteria categories and nineteen sub-criteria were finalized, and members of the Technical Committee submitted weights to differentiate between the criteria that had been split into two criteria. Other weights were adjusted within categories in accordance with the deletions to ensure that all category weights added up to one. The final hierarchy is shown below.

	Criteria	Weight Within Category	Category Weight	Overall Weight
Environmental Impacts	Increase of water temperature on Lake Champlain Side of Barrier	0.20	0.19	0.04
	Dissolved oxygen on Lake Champlain Side of Barrier	0.24		0.05
	Turbidity after construction on Lake Champlain Side of Barrier	0.24		0.05
	Wetland Impacts by New Water Withdrawals to Maintain Canal Levels	0.32		0.06
Effectiveness at Eliminated AIS	Quantity of untreated water that moves between basins	0.37	0.23	0.08
	Percent of uncleaned vessels that move between the basins	0.36		0.08
	Time to implementation	0.27		0.06
Vessel & Boater Accessibility	Is easy to use for boaters	0.50	0.15	0.08
	Additional time that boaters must wait to move between basins	0.50		0.07
Community Impacts	Odor and noise for nearby residents after construction	0.24	0.13	0.03
	Job loss or creation for communities near the barrier	0.30		0.04
	Hazards to human health and safety	0.46		0.06
Broader System Impacts	Historic preservation of existing canal corps assets, modified as needed to address AIS	0.31	0.14	0.04
	Canals Ability to Transport All Boats	0.40		0.06

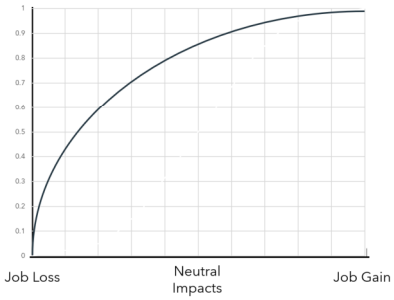
	Minimizes potential for resource conflicts (water, energy)	0.29		0.04
Operation and Maintenance Requirements	Maintains operating conditions despite extreme events (flood, drought)	0.27	0.16	0.04
	Energy use	0.23		0.04
	Operations and maintenance requirements	0.26		0.04
	Need for security measures	0.24		0.04

Appendix H3. Value Functions

Value functions are graphs in which the x-axis comprises the possible values of a given sub-criteria, and the function translates them to a "score" on the y-axis, which ranges between 0-1. This way, all the sub-criteria can be scored from 0-1, and thus be comparable. The criteria categories do not need value functions because their scores are the sums of their sub-criteria.

Prior to the January 2021 Technical Committee meetings, ERDC developed drafts of the value functions through a collaborative process between team members, using some suggestions that stakeholders had provided during the June 2020 meeting. Each value function needed an x-axis range, a function shape (linear, exponential, etc.) and had to be graphed such that the best possible value(s) would receive a score of 1, and the worst possible value(s) would receive a score of 0.

Job Loss or Creation for Communities Near the Barrier



At the Technical Committee Meeting #1 in January 2021, the Technical Committee members reviewed the value functions assembled by ERDC. In addition to suggesting edits for the criteria themselves, described above, the Technical Committee members had several edits for the value functions. ERDC implemented these changes and sent the new value functions for the Technical Committee to review. Several members had further edits, and ERDC compiled, reconciled, and implemented these changes before sending out a final version of the value functions. The Technical Committee members were able to use the final version of the sub-criteria value functions to score the alternatives prior to the Technical Committee Meeting #2 in March 2021.

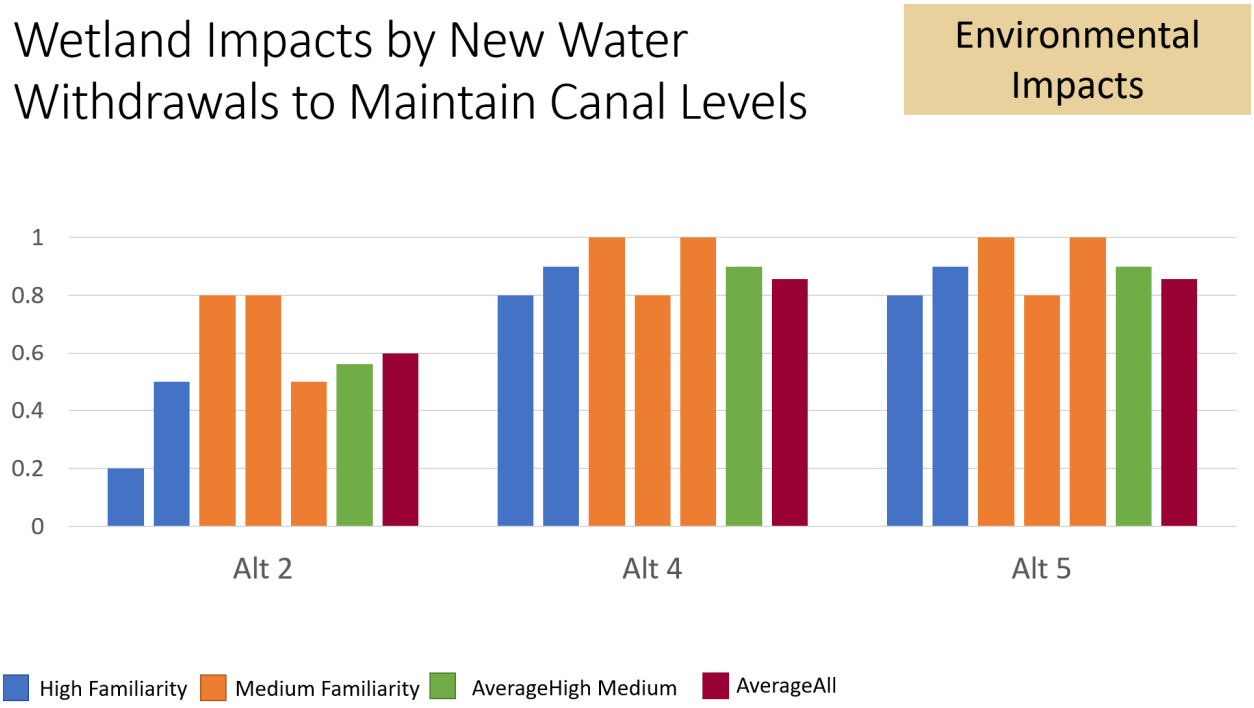
Appendix H4. The Technical Committee Finalizes the Sub-Criteria Scores

The Technical Committed used the value functions to score all the sub-criteria with scores 0-1. Note that the criteria categories' scores are the sum of their sub-criteria scores, and thus do not need separate scores. All seven technical committee members submitted their scores for each sub-criteria for the three alternatives using the scoring sheet shown below.

	D	E	F	G	H
1	Sub-Criteria	Topic Familiarity	Score: Alt 2	Score: Alt 4	Score: Alt 5
2	Increase of water temperature				
3	Dissolved oxygen				
4	Turbidity after construction				
5	Wetlands Impacts				
6	Quantity of untreated water that moves between basins				
7	Number of Aquatic Invasive Species dispersal modes that are addressed				
8	Number of uncleaned vessels that move between the basins				
9	Time to implementation				
10	Is easy to use for boaters				
11	Time that boaters must wait to move between basins				
12	Creates new amenities for boaters to use during passage				
13	Odor and noise for nearby residents after construction				
14	Economic impacts for communities near the barrier				

Sheet1

At the Technical Committee Meeting #2 in March 2021, ERDC presented the scores provided by the Technical Committee for Alternatives 2, 4 and 5. Scores were presented without names to invite discussion about why people chose certain scores, especially where large discrepancies existed. The graph provides an example of how the scores were presented: only scores with high and medium familiarity were graphed, with the green bar showing the average of those scores and the red bar showing the average of all scores (i.e. including scores of people who had ranked themselves as having low familiarity with the topic).



The Technical Committee discussed each sub-criteria in turn, with members explaining the factors that determined their scores. Many members expressed a willingness to revise scores given their new

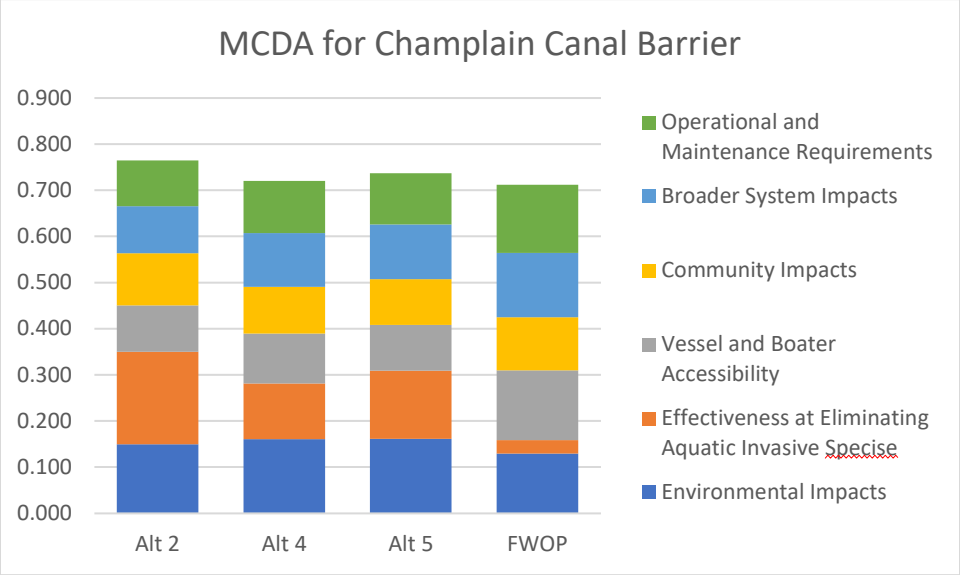
understanding of specific sub-criteria. Following the discussions in Technical Meeting #2, ERDC compiled the notes from the discussion, invited the Technical Committee members to edit the notes, and then forwarded the final version to all members. Five members chose to revise some of their scores, two members kept the same scores they had initially provided.

These scores were finalized again in September 2021 after new information became available about the implementation of Alternatives 4 and 5. In October 2021, the Technical Committee provided another iteration of scores that accounted for a Future Without Project (FWOP), which for some sub-criteria affected the range of the x-axis, necessitating that the scores for the other alternatives also change.

Appendix H5. Discussion of MCDA Results

To generate the MCDA, ERDC multiplied the sub-criteria weights by the average of the Technical Committee members' submitted scores for each sub-criteria, as calculated by averaging the medium and high familiarity scores of the seven Technical Committee members for each sub-criteria. The sub-criteria weights were themselves a product of the criteria category weights and the inter-category sub-criteria weights.

The values produced could be summed to demonstrate the benefits of each alternative's construction, as well as the benefits provided by the FWOP.



Category	ALT 2	ALT 4	ALT 5	FWOP
Environmental Impacts	0.149	0.161	0.161	0.129
Effectiveness at Eliminating Aquatic Invasive Species	0.200	0.121	0.147	0.029
Vessel and Boater Accessibility	0.101	0.108	0.100	0.151
Community Impacts	0.113	0.101	0.099	0.115

Broader System Impacts	0.102	0.116	0.118	0.140
Operational and Maintenance Requirements	0.099	0.114	0.111	0.147

Alternative 2 scores highest, with a score of 0.765 out of 1. The FWOP score is the lowest, at 0.712. Alternatives 4 and 5 score similarly between Alternative 2 and the FWOP, differentiated primarily by alternatives 5's higher score for Effectiveness at Eliminating AIS.

Compared to the alternatives, the FWOP scores poorly in Effectiveness at Eliminating AIS, where it receives the lowest score of any category, despite the comparatively high weight given to this criteria category by the stakeholders. The FWOP also scored slightly lower for Environmental Impacts compared to the other alternatives, due to water withdrawals and anticipated turbidity.

The FWOP has higher scores for the other four categories. In particular, it scores very high for Vessel and Boater Accessibility, where its two sub-criteria received perfect scores. All sub-criteria of Operations and Maintenance scored better for the FWOP than any of the alternatives. The FWOP had slightly more beneficial Community Impacts due to the fact there would be no construction and because it does not require a boat lift, which Technical Committee members felt could introduce safety issues. The FWOP scored better for Broader System Impacts because it would best preserve the historical infrastructure of the canal and most easily transport all boats.

It is worth noting that these sub-criteria for Broader System Impacts were devised to compare the construction alternatives against each other, and not against a FWOP. It is possible that because of a desire to approximate the status quo while eliminating AIS, the weights may not reflect what the stakeholders would have weighed the options if they had known that the actual status quo would be under consideration, and favored by the weights of these criteria. This artifact may have also caused the Vessel and Boater Accessibility category to be weighted unduly high because of an assumption that it would not be compared with the actual status quo. Stakeholders may want to preserve favorable aspects of designs without the overall design, and due to the addition of the FWOP later in the project analysis, these choices may have become conflated.

Appendix H6. Stakeholder Engagement Participants

Listed below are the participants in the MCDA components of the project

Stakeholders (June 2020 Meeting)

- Steven Pearson, NYSDEC
- Erin Vennie-Vollrath, The Nature Conservancy
- Joe Moloughney, NYS Canal Corporation
- Ellen Marsden, University of Vermont
- Mark Malchoff, Lake Champlain Sea Grant
- Meg Modley, Lake Champlain Basin Program
- Eric Howe, Lake Champlain Basin Program
- Kimberly Jensen, Vermont Department of Environmental Conservation
- Andrew Milliken, U.S. Fish and Wildlife Service
- Nicole Balk, NYSDEC

- Howard Goebel, New York Power Authority
- Shivam Jumani, Buro Happold Consulting Engineers, P.C
- Roger Phinney, Eastern NY Marine Trades Association

Technical Committee (January and March 2021 Meetings)

- Steven Pearson
- Erin Vennie-Vollrath
- Meg Modley
- Mark Malchoff
- Howard Goebel
- Michael Murphy (A&E Team)
- Jack Szczepanski (A&E Team)

Appendix I – Champlain Canal Invasive Species Barrier Study Cost-Effectiveness Analysis and Incremental Cost Analysis

Prepared by the USACE

Champlain Canal Invasive Species Barrier Study Cost-Effectiveness Analysis and Incremental Cost Analysis

Darixa D. Hernandez-Abrams and S. Kyle McKay

Dec 2021

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What are cost-effectiveness and incremental cost analyses (CEICA)?

Cost-effectiveness and incremental cost analyses are project planning tools that support decision-making by systematically comparing costs and benefits of different project alternatives. In environmental restoration planning, CEICA compares non-monetary environmental outputs relative to monetary costs of restoration actions or plans (Robinson et al. 1995). Restoration plans are compared to a future without project (FWOP) scenario to determine the relative "benefits" of each action.

The cost-effectiveness analysis allows decision-makers to filter out which plans are most efficient at providing environmental benefits on a *per cost* basis. Plans are *not* cost-effective if they meet any of these criteria:

1). The same output produced by the plan can be produced by a different plan at lower cost.

2). A larger output can be produced by another plan at the same cost.

3). A larger output can be produced by another plan at less cost.

The incremental cost analysis is then conducted on the cost-effective plans to provide information on the change in cost between plans (i.e., the additional costs of selecting one plan vs another). This technique sequentially compares each plan to all higher cost plans to reveal changes in unit cost as output levels increase and eliminates plans that do not

efficiently provide benefits on an *incremental unit cost basis*. Specifically, this analysis examines the slope of the cost-effectiveness frontier to isolate how the unit cost ($/unit) increases as the magnitude of environmental benefit increases. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish the objective relative to unit costs and are typically referred to as "best buys." Importantly, all "best buys" are cost-effective, but all cost-effective plans are not best buys.

Champlain Canal Invasive Species Barrier Study Background

The Champlain Canal Invasive Species Barrier Study is a multi-agency project authorized by Section 542 of the Water Resources Development Act of 2000 and identified in Section 5146 of WRDA 2007. The study area, defined as the Lake Champlain Watershed, covers Lake Champlain (435 square miles in surface area) and the 11 major tributary watershed draining into the lake covering 8,234 square miles in New York, Vermont, and Quebec. Aquatic invasive species (AIS) present in the surrounding Great Lakes, Erie Canal, and Hudson River (e.g., hydrilla, round goby, Asian clam, quagga mussel, Asian carp, and snakehead) are a threat to Lake Champlain because of their potential movement from the Hudson River or the Great Lakes through the Erie Canal to Lake Champlain and the economic and ecological impacts they may cause. Similarly, there are 51 aquatic non-native and invasive species (about 12-13 of the 51 species) in Lake Champlain. If any new AIS become established in Lake Champlain, they may move to the surrounding Hudson River, St. Lawrence River and Great Lakes. The goal of the Champlain Canal Invasive Species Barrier study is to assess the costs, benefits, and effectiveness of different management alternatives that could accomplish hydrological separation of the Lake Champlain drainage from the Hudson River drainage system. The management alternatives were assessed through an iterative process where multidisciplinary stakeholders chose the following alternatives:

- Future without project (FWOP): "No action" plan where current activities to limit the transfer of aquatic invasive species remain the same.
- Alternative 2 (Alt2): A plan to raise the weir elevation at the Wood Creek Spillway and construct a berm south of Wood Creek Spillway to create a physical separation between the Hudson River and Lake Champlain drainage systems.
- Alternative 4 (Alt4): A plan to raise the weir elevation at the Wood Creek Spillway, install a cleaning station storing washwaters in a tank, and install a small boat lift to reduce Hudson River water from entering Lake Champlain without impeding any vessel traffic.
- Alternative 5 (Alt5): A plan to raise the weir elevation at the Wood Creek Spillway, install a large boat lift, cleaning station and washwater storage tank to reduce Hudson River water entering Lake Champlain without impeding any vessel traffic.

The alternative benefits used to conduct the CEICA were obtained from a multi-criteria decision analysis (MCDA) conducted to evaluate stakeholder views of the efficiency of each alternative to impede interbasin transfer of aquatic invasive species through the Champlain Canal system. The MCDA asked stakeholders "What matters in making this decision?", "How much do these criteria matter in selecting an alternative?", and "How will each alternative perform for each of these criteria?". The answers to these questions were then used to score each criteria based on how well they would perform. Sub-criteria were weighed relative to other sub-criteria in their category (i.e. criteria), and these criteria were then weighted relative to each other. Criteria were normalized to sum to one. The costs to implement each alternative were obtained from construction cost estimates using RS Means and costs from manufacturers. Table 2 describes the benefits and costs inputs used to conduct the Champlain Canal Invasive Species Barrier Study CEICA.

Table 1. Description of benefits and costs used in CEICA.

Benefits Criteria and Costs	Subcriteria
Environmental Impacts	Impacts on water temperature, dissolved oxygen, turbidity, and wetlands
Effectiveness at Eliminating Transfer of Aquatic Invasive Species	Untreated water quantity, percent uncleaned vessels, and time to implementation
Vessel Accessibility	Easy to use for boaters and additional waiting time to move between basins
Community Impacts	Odor and noise, job loss or creation, hazards to human health and safety
System Impacts	Historic preservation, ability to transport all boats, and minimizes potential for resource conflict
Operation and Maintenance	Maintains operating conditions despite extreme events, energy use, operations and maintenance requirements, and need for security measures
Total Score	Sum of benefits for each subcriteria in each alternative
Total Cost ($M)	Sum of costs for each alternative

Table 2. Champlain Canal Invasive Species Barrier Study benefits and costs used in CEICA. Criteria are shown as weighted (w)

	FWOP	Alt2	Alt4	Alt5
Environmental Impacts (w)	0.129	0.149	0.161	0.161
Aquatic Invasive Species (w)	0.029	0.200	0.121	0.147
Vessel Accessibility (w)	0.151	0.101	0.108	0.100
Community Impacts (w)	0.115	0.113	0.101	0.099
System Impacts (w)	0.140	0.102	0.116	0.118
Operational and Maintenance (w)	0.147	0.099	0.114	0.111
Total (w)	0.712	0.765	0.721	0.737

Total Cost ($M)	0.000	18.300	2.400	11.400

CEICA for the Champlain Canal Invasive Species Barrier Study

We conducted two forms of CEICA to assess project alternatives. For both analyses, the total monetary cost of each alternative is used in millions of dollars. In the first analysis, project benefits were assessed using the weighted benefits output from the MCDA, including the FWOP. In the second analysis, benefits were only considered relative to effectiveness at removing AIS with the logic that this is the primary objective of the project

Weighted Benefits

This analysis conducts the CEICA with weighted MCDA outputs (Table 3 and Figure 1). From this analysis, the following observations can be made. The cost-effectiveness analysis (Figure 1A) shows that all plans, except alternative 5, may be considered as "best-buys". The reason for this is that the unit cost for every alternative, except alternative 5, increases linearly as the magnitude of benefits increases. Alternative 5 does not efficiently provide benefit on an incremental unit cost basis and was therefore eliminated by the incremental cost analysis. Alternative 2 has the highest incremental cost per benefit and Alternative 4 has a lower incremental cost per benefit (Table 3; Figure 1B). Alternative 2 (yellow) provides more benefits at a higher cost, while alternative 4 (teal) provides less benefits at a lower cost. However, when comparing the incremental cost per benefit provided between Alt2 and Alt4, we see that for the amount of benefit (0.721 Alt4 vs 0.765 Alt2), the incremental cost per unit is not a lot higher in Alt2 ($266.7/unit Alt4 vs $361.4/unit Alt2).

Table 3. Incremental cost analysis summary for weighted MCDA outputs.

Alternative	Benefit	Cost	Incremental Cost per Unit
FWOP	0.712	0	0
Alt4	0.721	2.4	266.7
Alt2	0.765	18.3	361.4

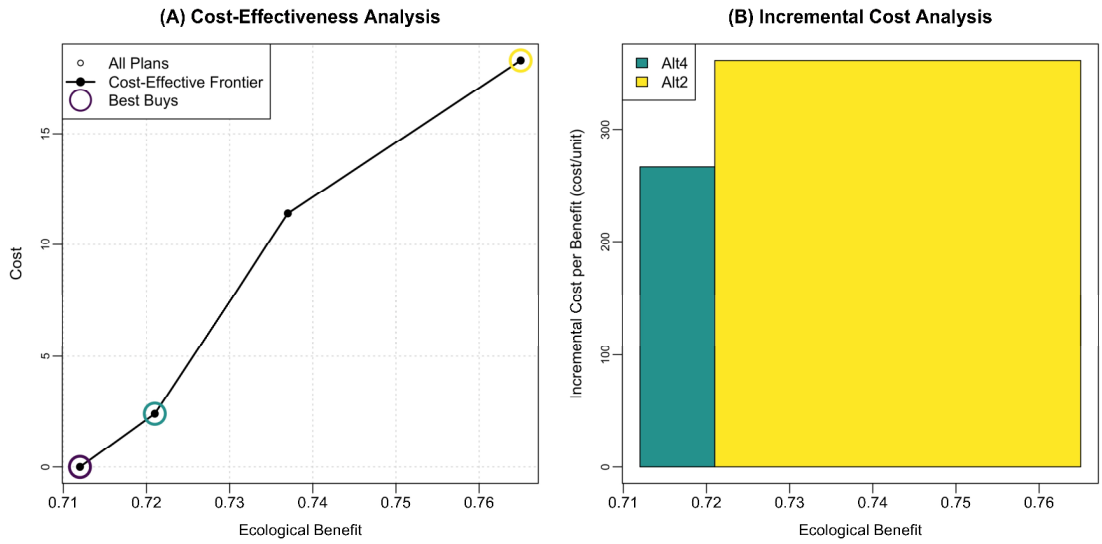

Figure 1. CEICA summary for weighted MCDA outputs.

But, CEICA may provide an incomplete view of project outcomes. Figure 2 shows the relative distribution of weighted benefits between criteria in each alternative, including the FWOP. The FWOP plan would have the least amount of benefits in limiting AIS movement (red orange box), while Alt2 would provide the greatest amount of benefits in limiting movement of AIS. On the other hand, Alt5 provides more benefits in limiting movement of AIS than Alt4 and FWOP.

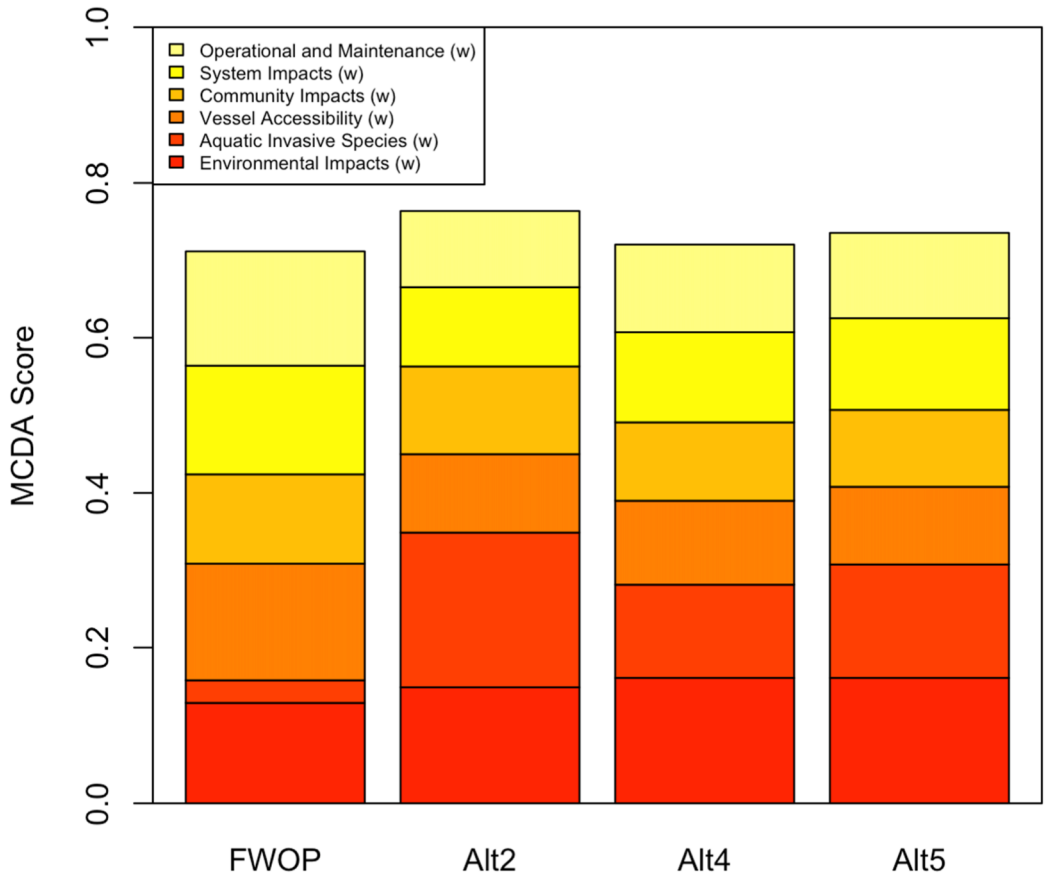

Figure 2. Distribution of weighted MCDA outputs across categories.

Effectiveness at Removing AIS Benefits

This analysis conducts CEICA with only the MCDA weighted scores for effectiveness at removing AIS. Table 4 and Figure 3 summarize the CEICA. Results show that all plans are best buys except Alt5. This means that the cost per level of benefit provided by Alt5 was higher than the rest, therefore not considered a "best buy". Alternative 2 has a much higher incremental cost per unit compared to Alt4 ($201.3/unit Alt2 vs $26.1/unit Alt4) for removing AIS at a higher level of benefit (0.2 Alt2 vs. 0.121 Alt4).

Table 4. Incremental cost analysis summary for weighted AIS MCDA outputs.

Alternative	Benefit	Cost	Incremental Cost per Unit
FWOP	0.029	0	0
Alt4	0.121	2.4	26.1
Alt2	0.2	18.3	201.3

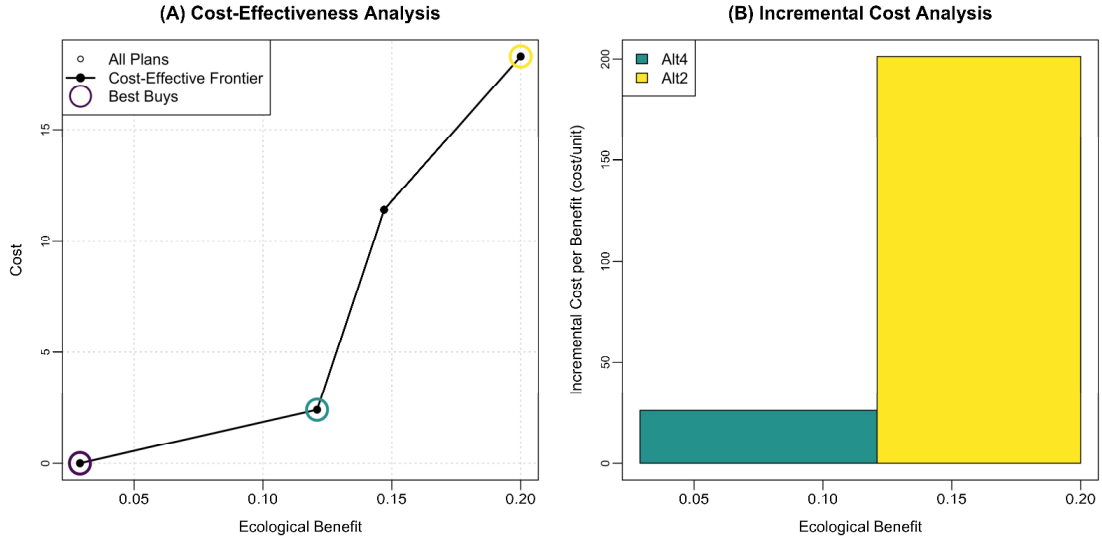

Figure 3. CEICA summary for weighted AIS MCDA outputs.

Summary

We analyzed alternatives for the Champlain Canal Invasive Species Barrier Study by conducting CEICA using project construction costs, weighted benefits, and weighted effectiveness at preventing AIS movement criteria. When looking at the weighted benefits (Table 3; Figure 1), we can see that the cost per benefit for each alternative increases as the amount benefit provided increases. However, the cost of Alt5 is greater for the magnitude of ecological benefit it provides; therefore, it is not considered a "best buy" plan. Alternative 2 and Alt4 can then be compared resulting in Alt2 having greater ecological benefit at a higher cost per unit. However, the incremental cost per unit for Alt2, having 6.10% more ecological benefit, is not a lot higher than Alt4 ($266.7/unit Alt4 vs $361.4/unit Alt2). The relative distribution of benefits (MCDA scores, Figure2) provides additional information telling us that alternative 2 provides more benefits specific to the removal of AIS than any of the other alternatives. CEICA conducted on just the effectiveness at limiting AIS movement criteria (Table 4; Figure 3) also resulted in the elimination of Alt5 from the "best buy" plans. This left Alt4 and Alt2 as providing the most return on investment when evaluating the effectiveness at removing AIS criteria. When comparing the effectiveness at eliminating AIS in Alt4 and Alt2, figure 3A-B and table 4 show that Alt2

has a much greater incremental cost per unit ($26.1/unit Alt4 vs $201.3/unit Alt2). Thus, Alternative 4 could be identified as a potentially advantageous action through the lens of CEICA. However, the final recommended alternative may depend on the willingness to pay for the amount of benefit provided by the larger alternative (Alt2) and/or other qualitative difference between the plans not captured in either the MCDA or CEICA.

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