HUDSON RIVER PCBs SUPERFUND SITE ARCHAEOLOGICAL DATA RECOVERY OF UNDERWATER RESOURCE U-2

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ABSTRACT

The General Electric Company (GE) contracted with URS Corporation (URS) to conduct a Phase III data recovery of Underwater Resource U-2 (U-2) within a 6-day field session in May of 2009. Resource U-2 was a shipwreck site located in the Hudson River, near Rogers Island in Fort Edward, Washington County, New York. This study was conducted as a component of the overall activities being performed pursuant to the Cultural and Archaeological Resources Assessment (CARA) Work Plan for the Hudson River PCBs Superfund Site (URS 2003). The CARA Work Plan is part of the Administrative Order on Consent for Remedial Design (RD AOC), executed by GE and the United States Environmental Protection Agency (EPA) in 2003. It was developed to address cultural and archaeological resources associated with the Upper Hudson River that could be impacted by implementation of the remedy selected by EPA for the Hudson River PCBs Superfund Site, which calls for the dredging and disposal of PCB-containing sediments meeting certain specified criteria from the river between Fort Edward and the Federal Dam in Troy (USEPA 2002). The goal of the Phase III data recovery of U-2 was to mitigate the adverse effects of dredging on this shipwreck site via the documentation. This effort included the dredging of sediments and debris from atop the shipwreck, and the subsequent documentation of the newly exposed vessel remains, which were spread across approximately 0.01 acre of river bottom.

In total, 18 dives and 739 minutes of bottom time were used to locate the site and dredge sediment from the wreck. An additional eight dives and 474 minutes of bottom time were used to document vessel remains. Documentation included the creation of detailed plan and profile maps of the 13 by 35 foot (4 by 10.7 meter) site, fastening patterns, a list of scantlings, and an in-depth study of the daggerboard box assembly.

Analysis of the vessel remains indicates that Resource U-2 likely represents an early sailing canal boat constructed between 1822 and 1825. This assessment is based on the construction elements and general design of ship. U-2 maintained a flat bottom, curved turn of the bilge, and straight, parallel sides that are common to early canal boats. The strongest evidence for the identification of canal boat, however, is the vessel's breadth of 13 feet 6 inches, which corresponds with other known early canal boats and is an accommodation to the 15-ft width of the earliest Champlain Canal locks.

The construction date proposed for U-2 is also based on the presence of a daggerboard assembly. Daggerboards were commonly employed between 1806 and 1825. This span, when correlated with the 1819 opening of the first run of the Champlain Canal, indicates that U-2 was likely constructed between 1819 and 1825. This date can be further refined by the assumption that U-2 was not one of the first 10 canal boats constructed for the Champlain Canal between 1819 and 1821, and was instead a part of the first canal boat construction boom that began in 1822.

Historic research and comparison with archaeological correlates indicate that U-2 was likely between 55 and 65 feet in length. The vessel was likely rigged as a schooner or sloop, and was used to transport goods and people through the Champlain Canal system. U-2 is of great significance because it represents a unique canal boat form. The vessel was constructed shortly after the Champlain Canal opened and local shipwrights were experimenting with construction elements and design features that would enable vessels to transport cargo quickly and safely. Some design features of U-2, specifically the curved turn of the bilge and use of a daggerboard, were not perpetuated in later, more standardized canal boat models. Shipwrights worked feverishly to improve their designs, and U-2 was likely considered an anachronism shortly after it was constructed. U-2 is likely the earliest documented example of a watercraft specifically constructed for use within the Champlain Canal system.

ACKNOWLEDGEMENTS

The URS Principal Investigators for this project were J.B. Pelletier and Anthony Randolph from URS's Gaithersburg office. Daniel Cassedy from URS's Morrisville office was the Project Manager with the assistance of Christopher Polglase (URS Gaithersburg), who was the Task Manager. Adam Kane from the Lake Champlain Maritime Museum (LCMM) provided on-site support under the supervision of EPA consultant Ecology & Environment and provided the historic context for this report. The project was overseen by EPA Chief Archaeologist, John Vetter, with assistance from Leonid Shmookler (with EPA consultant Ecology & Environment). Additional assistance in the field was received from staff at Cashman Dredging and Marine Contracting, Co., LLC.

URS wishes to express our appreciation to Dr. Vetter of EPA and Art Cohn and Adam Kane of LCMM for their guidance in scoping the field investigations and the completion of this report.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The General Electric Company (GE) contracted with URS Corporation (URS) to conduct a Phase III data recovery of Underwater Resource U-2 (U-2), a shipwreck site, within a single, 6-day field session in May of 2009. This study was conducted as a component of the overall activities being performed pursuant to the Cultural and Archaeological Resources Assessment (CARA) Work Plan for the Hudson River PCBs Superfund Site (URS 2003). The CARA Work Plan is part of the Administrative Order on Consent for Remedial Design (RD AOC), executed by GE and the United States Environmental Protection Agency (EPA) in 2003. It was developed and to address cultural and archaeological resources associated with the Upper Hudson River that could be impacted by implementation of the remedy selected by EPA for the Hudson River PCBs Superfund Site in a Record of Decision (ROD) issued on February 1, 2002 (USEPA 2002). The selected remedy calls for the dredging and disposal of PCB-containing sediments meeting certain specified criteria from the river between Fort Edward and the Federal Dam in Troy. The ROD provided for that remedy to be conducted in two phases – Phase 1 (the first year of the dredging project, which was conducted in 2009) and Phase 2 (which constitutes the remainder of the dredging project).

The U-2 project benefited from the contribution of numerous people who were supporting EPA and GE. URS serves as a cultural resources consultant to GE and conducts the majority of the archaeological and historical studies required by EPA as part of the remedial activities. EPA is supported by its consultant, Ecology & Environment (E&E), which reviews the cultural resource studies conducted by URS on behalf of GE. The Lake Champlain Maritime Museum (LCMM) is a contractor to E&E specializing in the submerged archaeological resources of the upper Hudson River and Lake Champlain region.

U-2 was a shipwreck site located in the Hudson River in the channel east of Rogers Island in Fort Edward, Washington County, New York (Figures 1-1 and 1-2). The site measured approximately 0.01 acre in size and was situated south of the wastewater treatment plant on the east side of the river.

U-2 was first identified in 2005 during a Phase I archaeological survey of the Phase 1 dredge areas by Dolan Research; an additional evaluation of the wreck was later conducted in 2006 by the LCMM (URS 2005, 2006; LCMM 2007). The vessel was tentatively identified as an early nineteenth century flat bottomed sailing vessel fitted with a centerboard assembly. U-2 was recommended as eligible for listing on the National Register of Historic Places (NRHP) under Criteria C and D, because of unique/diagnostic attributes and the apparent early construction date of the vessel. Because it was situated in an area to be dredged during Phase 1 of the remediation project, an archaeological data recovery plan was developed and implemented as part of an impact mitigation program.

The main goal of the Phase III data recovery investigations was to mitigate the adverse effects of dredging on the site. This was accomplished through the collection of data on U-2 before the resource was removed as debris during dredging, so that relevant research questions about U-2 could be addressed despite that removal. The mitigation efforts included field excavation and documentation, vessel analysis, artifact analysis and conservation, and technical report preparation. The Phase III data recovery was conducted in compliance with the National Historic Preservation Act of 1966 (Public Law 89-665), as amended, and the National Environmental Policy Act of 1969 (Public Law 91-190).

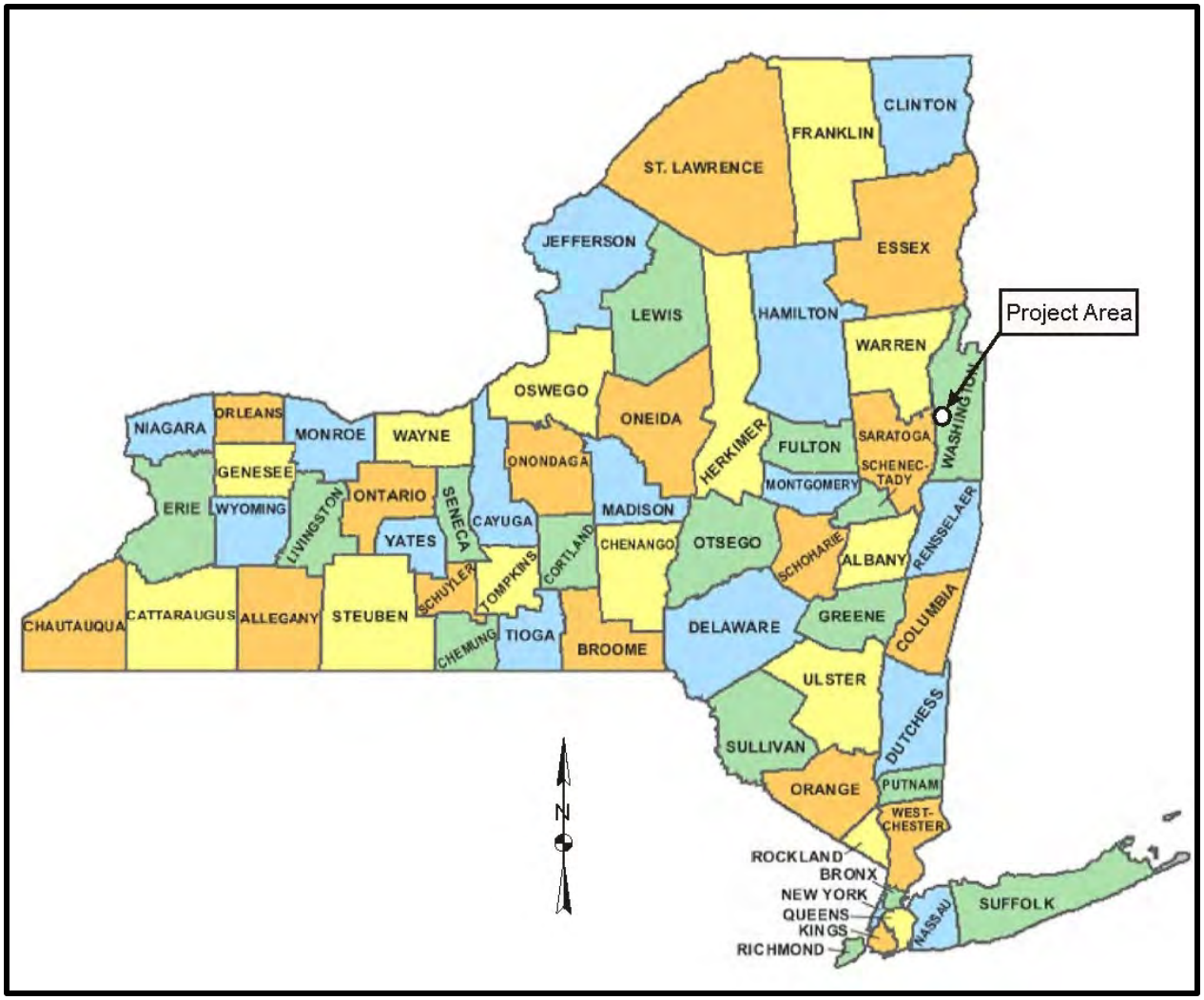

Figure 1-1. Location of Project in Washington County, New York.

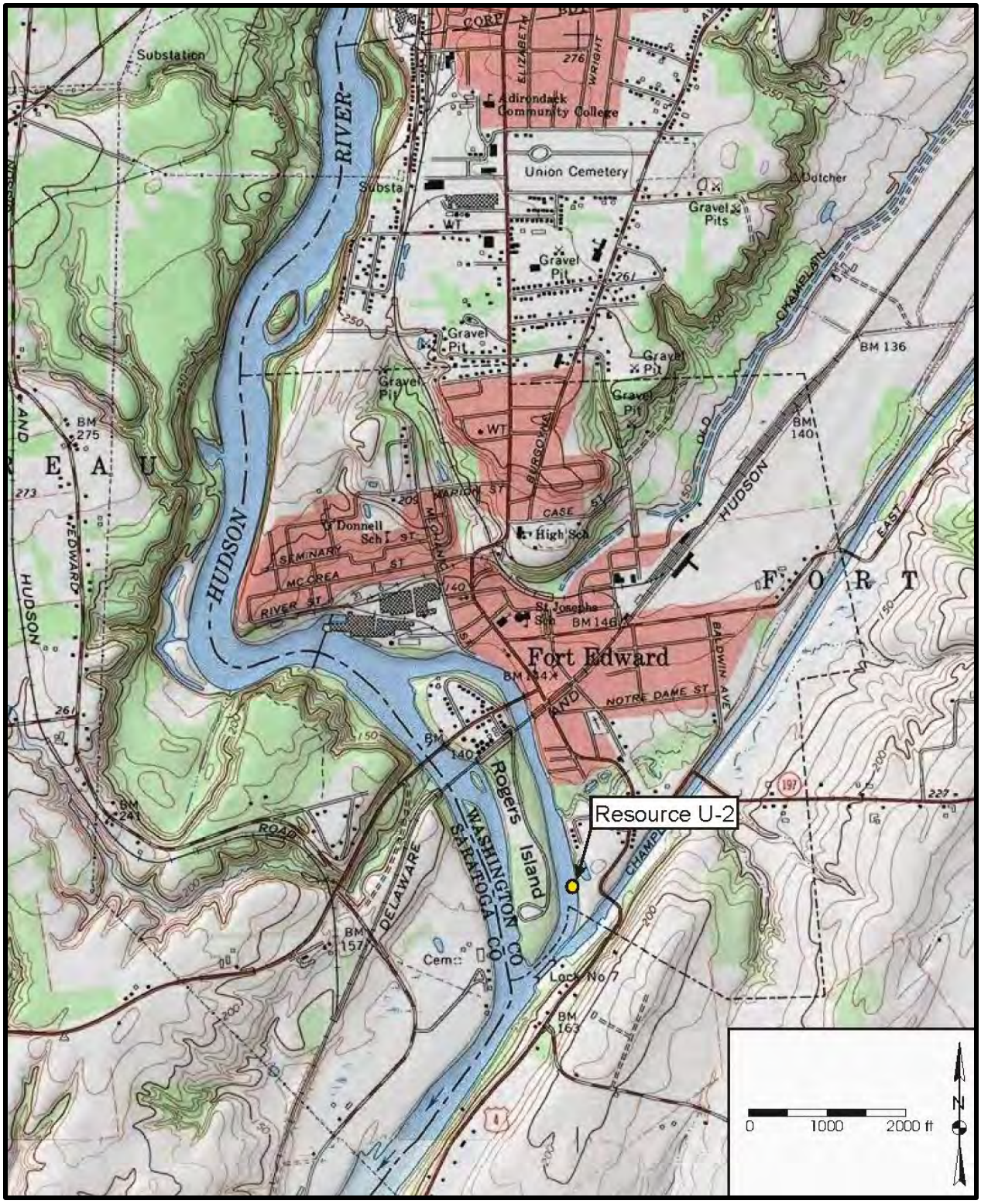

Figure 1-2. Location of Project in Fort Edward, New York.

Phase III field investigations were conducted in May of 2009. Daniel Cassedy served as Project Manager for the archaeological investigations, and Christopher Polglase served as task manager. J.B. Pelletier and Anthony Randolph served as the Principal Investigators; Mr. Pelletier also was the Dive Safety Officer. Carey O'Reilly served as the Laboratory Director. Adam Kane of LCMM accompanied the URS team during the field studies and provided the historic context section of this report at the request of the EPA. Jeffrey Harbison served as Health and Safety Liaison and provided logistical support. Amanda Hale, J.B. Pelletier, and Anthony Randolph served as scientific divers, and Justin Bedard, Bridget Johnson, and Mechelle Kerns-Nocerito served as dive tenders and provided logistical support.

Following this Introduction, the report contains seven sections: Environmental Setting; Historic Context; Previous Investigations; Methods (including research, field, and laboratory methods); Results of Archaeological Investigations; Summary of Findings; and References Cited. Two appendices follow the main body of this report: Appendix A contains the Qualifications of Investigators and Appendix B contains the Artifact Catalog.

2.0 ENVIRONMENTAL SETTING

A brief discussion of the physiographic, geomorphology, soil, biota, and climatic characteristics of the area in which U-2 was found is presented below. This information is designed to provide a context for subsequent discussions focusing on the burial environment of U-2.

2.1 GENERAL PHYSIOGRAPHY

The U-2 project area in Fort Edward Township, Washington County is located within the valley and ridge province of the Hudson Valley in the Appalachian Highlands (USGS 2003). This region is characterized by long, even, steep sided mountain ridges alternating with continuous deep valleys running east to west. It is underlain by folded and faulted Paleozoic sedimentary rocks (Dalton 2003). The valley and ridge province extends from New York to Alabama, nearly 1,200 miles (mi; 1931 Kilometers [Km]; USGS 2003).

Resource U-2 was located in the Hudson River, approximately 100 feet (ft) (30 meters [m]) southeast of Rogers Island in Fort Edward Township, Washington County (Figures 2-1 and 2-2). The site measured approximately 0.01 acre in size and was situated south of the wastewater treatment plant along the eastern bankline of the river in 7 to 10 ft (2 to 3 m) of water.

2.2 HUDSON RIVER GEOMORPHOLOGY

The Hudson River valley was formed several hundred million years ago during the Taconic and Acadian orogenies (Thieler et al. 2006). Crustal deformation and faulting from these events created a series of low valleys, one of which became the proto-Hudson Valley/Basin.

The Hudson Basin was deepened and reshaped during numerous glacial cycles. The event that defined the current disposition of the landform occurred during the most recent glacial period, when the land surface was scraped clean by prograding Laurentide ice sheets. Glacial lakes then filled both the Hudson and Ontario basins. These lakes, which included Lake Albany, Lake Iroquois, and Lake Vermont, trapped glacial meltwater and the associated glacially derived sediments (Thieler et al. 2006).

Waters overtopped the natural moraine levies of these lakes between 11,300 and 10,900 years Before Present (BP). This eventually led to the catastrophic failure of the Harbor Hill Moraine, which was located between Staten Island and Long Island between 12,000 and 10,300 BP (Thieler et al. 2006: 132). The draining of these lakes left a thick layer of sediments along the Hudson Valley floor, and these materials are still being reworked by the Hudson River today.

2.3 SOILS

Soils located immediately to the east and west of the project area are associated with the following soil types: Orthents and Psamments, and Teel silt loam (http://websoilsurvey.nrcs.usda.gov/app/; Table 2-1). These soils represent those found along the east bank of the river adjacent to the project area. The Teel silt loam soils are positioned immediately along the river and are associated with floodplains. They make up the largest soil type in the project area. This soil type is moderately well drained and prone to occasional flooding with a seasonal water table depth of 18 to 24 inches (in; 46 to 61 centimeters [cm]) depending upon local streams.

Figure 2-1. Hudson River Project Area, Facing North.

Figure 2-2. Bankline Opposite of Wreck Site, Facing East.

This soil series is especially well suited to crops, as the soils are easy to till and rarely flood during the growing season (http://websoilsurvey.nrcs.usda.gov/app/)

Orthents and Psamments soils are present in the southernmost part of the adjacent riverbank in a residential area. These soils are found in dredge spoils and consist of a mixture of fine gravel and sand with some silt and clay.

Table 2-1. Soil Characteristics

	Soil Types	
Soil Attributes	**Orthents and Psamments**	**Teel Silt Loam**
Map Identifier	OP	Te
Landform	Dredge spoil	Flood plain
Slope (%)	0 to 15	0 to 2
Drainage Class	Well drained	Moderately well drained
Flooding Frequency	None	Occasional
Typical Soil Profile(s)	A) Orthents Stratum I: 0 to 10 in (0 to 25 cm)-silt loam Stratum II: 10 to 60 in (25 to 152 cm)-loam B) Psamments Stratum I: 0 to 10 in (0 to 25 cm)-fine sand Stratum II: 10 to 60 in (25 to 152 cm)-coarse sand	Stratum I: 0 to 11 in (0 to 28 cm)-silt loam Stratum II: 11 to 25 in (28 to 63 cm)-silt loam Stratum III: 25 to 60 in (63 to 152 cm)-Silt loam

(http://websoilsurvey.nrcs.usda.gov/app/)

2.4 CURRENT LAND USE, FLORA, AND FAUNA

The U-2 project area is located within the Fort Edward Township in Washington County. This general area has been used for various agricultural purposes (i.e., cropland and pasture), while areas to the north and south are largely residential. The natural environment of this part of Washington County is characterized by a freshwater river and a mixed deciduous forest. The area is rated “good” for growing grain and seed crops such as corn, wheat, oats, barley, and sunflowers. It also supports grasses and legumes, such as alfalfa, clover, and canary grass; wild herbaceous plants such as goldenrod, nightshade, and dandelion; hardwood plants such as viburnum, apple, grape, and briers; and coniferous plants such as Norway spruce, white pine, white cedar, and hemlock (USDA 1975).

The upper Hudson River ecosystem consists of a complex food web that begins with zooplankton such as copepods, rotifers, and cladocera (Levinton and Waldman 2010). Ciliates and flagellates are seasonally found in great numbers, based on environmental conditions. These

communities provide food for larval and juvenile fish stock in the fresh water reaches of the Hudson.

The next link in the Hudson River's food chain consists of the oligochaetes and other sediment dwelling microbes, which follow the larvae of the chironomid flies. These creatures feed freshwater mussels found in the cleaner stretches of the river (Figure 2-3). Fresh water mussels (family Unionidea) are the predominant filter feeders on the river.

Fish found in the upper Hudson and its tributaries include catfish (channel catfish, white and brown cats, bullheads), yellow perch and white perch, chain pickerel, trout, northern pike, and small and large mouth bass (Figure 2-4). Seasonal runs of smaller fish, including alewifes, rainbow smelts, and gizzard shad, are the major source of food for these larger predatory species (Levinton and Waldman 2010).

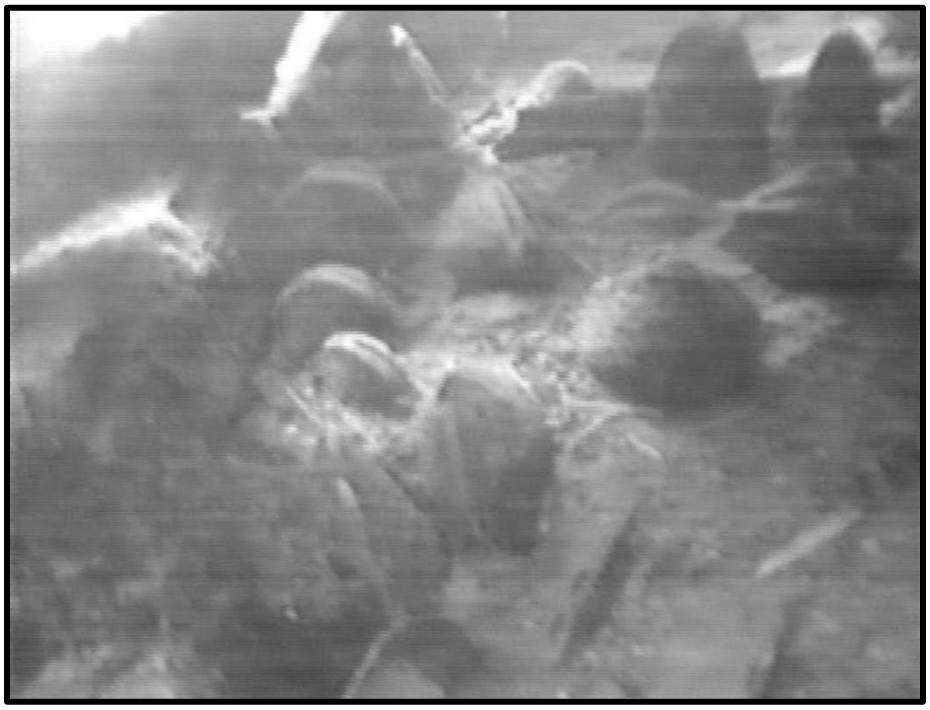

Figure 2-3. Video Image of a Colony of Freshwater Mussels Under Frame 11, Facing East.

Figure 2-4. Video Image of a Juvenile Small Mouth Bass Below the Daggerboard Trunk, Facing East.

2.5 CLIMATE

Washington County has a cool climate with mild summers averaging 70 degrees F in July and cold winters that average 21 degrees F in January (Washington County Department of Planning 2008; USDA 1975). Rainfall averages 36.5 in (92.7 cm) per year and an average snowfall of 57.5 in (146.1 cm) per year (Washington County Department of Planning 2008).

3.0 HISTORIC CONTEXT

Lake Champlain sailing canal boats are a boat type which was used on Lake Champlain, the Champlain Canal and the Hudson River between 1823 and the early 1900s. Sailing canal boats were built to fit within the dimensions of the Champlain Canal locks, but were also sloop or schooner rigged for sailing on Lake Champlain's open waters. Traditional unrigged canal boats were built to similar dimensions, but had no rig or other means of independent propulsion. The design of sailing canal boats changed during the nineteenth century; however, all boats of this vessel type had their masts stepped on the deck for easy removal while transiting the canal and a retractable keel to counter leeway in the form of a centerboard, daggerboard, or leeboard. The following section is designed to place Lake Champlain's sailing canal boats within their historic context, outline the conditions that dictated their hull form and rig, and present a summary of the archaeological examples that have been investigated in Lake Champlain (Table 3-1).

Table 3-1. Timeline of Lake Champlain Canal Development and Shipbuilding Technology

Date	Occurrence
1817	Champlain and Erie Canals are authorized by New York State.
1819	First section of the Champlain Canal is completed from Whitehall to Fort Edward.
1819	First canal boats are constructed; most are built with scow ends. The first sailing canal boats are also built using some of the design features of the traditional lake sloops and schooners found on Lake Champlain and the St. Lawrence and Hudson Rivers.
1823	Champlain Canal is completed, linking navigation from Lake Champlain to the Hudson River.
1825	Erie Canal is completed across New York State.
1835	Northern shipwrights establish standard design features for the rigged and unrigged canal boats.
1835	First enlargement of the Champlain Canal is begun. The process is exceedingly slow because the locks and dredging of the canal prism is done only when the existing system failed and needed extensive repairs.
1843	Construction of the Chambly Canal is completed.
1858	All of the locks on the Champlain Canal are finally enlarged.
1860	Enlargement of the Chambly Canal is completed.
1862	First enlargement of the canal prism on the Champlain Canal is completed.
1864	The second enlargement of the Champlain Canal is begun.
1872	The second enlargement of the locks on the Champlain Canal is completed.
1877	The second enlargement of the canal prism on the Champlain Canal is completed.
1882	Canal tolls are abandoned on the Champlain Canal.
1896	Canal tolls are abandoned on the Chambly Canal.
1903	Construction of the New York State Barge Canal System is authorized.
1916	The New York State Barge Canal is completed.
1916	Construction of larger canal boats to fit the Chambly Canal (108ft [32.9m] in length, 22ft 6in [6.9m] in beam, and 6ft 6in [2m] in draft) begins.
1922	Construction of steel barges at Poughkeepsie, New York begins.
1940	Wooden canal boats largely stop operating on the Champlain Waterway

3.1 CHAMPLAIN CANAL

3.1.1 EARLY CANAL PERIOD (1817-1857)

Though a failed effort to build a canal connecting the Hudson River and Lake Champlain had been attempted by the Northern Inland Lock Navigation Company in the 1790s, it was during the War of 1812 that strong support began to build for an all-water connection between Lake Champlain and the Hudson River. The desire to construct a canal connecting these two waterways arose after an embargo on trade with Canada was imposed during hostilities with the British. As traders were forced to focus their trade to the south, the difficulties in transporting their goods became apparent. Merchandise shipped by sailing vessel on the lake had to be transferred to wagons for the overland trip to the Hudson River where it was once more loaded onto a vessel for transport to New York City. The loading and unloading of vessels and wagons took a considerable amount of time and greatly increased the expense of shipping merchandise to market. The added expense of doing business led businessmen to pressure the government for an all-water connection with the southern markets (Whitford 1906).

It was not until the State of New York took on the task that serious progress was made. After extensive study, and surveying of possible routes, ground was broken for the Champlain Canal in 1817. The 64-mi (103Km) passage that stretched from North Troy to Whitehall, New York opened in October of 1823, though portions of the canal system were in use beginning in 1819.

The portion of the canal from Fort Edward to Whitehall at the southern end of Lake Champlain opened in 1819 (Stone 1901). Over the next few years, there was no canal between Fort Edward and Fort Miller, so canal boats would enter and leave the Hudson River via three locks on their way southward to Waterford (Johnson 1878). Navigation was not ideal. Boats were floated on the “slack water” of the Hudson River (Stone 1901). Frequently the summit level was inadequately fed with water until the state constructed the Fort Edward Feeder, shortly thereafter replaced by the Glens Falls Feeder (Williams 1995). At times, there was too much water; in the fall of 1822, the dam above Fort Edward was partially carried away, causing damage and interrupting navigation, and costing $92,000 to repair (Johnson 1878). Boatmen complained of unreliable passage, as towpaths along the river were frequently damaged by floods (Laws of the State of New York 1825).

Further damage to sides of the canal was caused by crude rafts made of construction materials, such as boards and planks that were towed through the canal. “These rafts were frequently upwards of a thousand feet in length; and in drawing them along with a strong team their sides would frequently come in contact with the banks by which very considerable injuries were done to the canal” (Laws of the State of New York 1825). To discourage this activity, the state doubled the toll for these rafts; materials were eventually transported on individual boats. By 1823, boatmen using the canal complained that “the expense of transportation between Lake Champlain and Troy, during the season of 1823, had been greater on the short distance between Fort Edward and the Saratoga cut, than it had been upon the whole line of the canal, which embraces the residue of the distance” (Laws of the State of New York 1825). In response to this criticism, the state began to complete the missing portion of canal navigation and constructed a channel parallel to the river between Fort Edward and Northumberland (Williams 1995). By

1828 the portion of the Champlain Canal along the east bank of the river to Fort Miller opened (Figure 3-1; Johnson 1878).

3.1.2 FIRST CANAL EXPANSION (1858-1872)

The opening of the Champlain Canal was such a success that in 1835 an expansion plan was initiated. This program increased the size of both the canal prism and locks so that larger vessels could traverse the canal system (Figure 3-2). However, this expansion progressed slowly and was not completed until 1858. Meanwhile, in 1843 the Canadian Government completed the Chambly Canal, which bypassed rapids on the Richelieu River in southern Quebec and allowed access from Lake Champlain to the St. Lawrence River and the Canadian markets to the north. With the completion of this portion of the Champlain Waterway, an all-water route reaching from New York City to the St. Lawrence River had been realized.

3.1.3 SECOND CANAL EXPANSION (1872-1914)

The Champlain Canal's second enlargement began after a flurry of suggestions by politicians, boatmen, and shippers urged New York State to build the Champlain Canal to at least the dimensions of the Erie Canal (Figure 3-2). As trade and the local population continued to expand, the nature of industry in the Champlain Valley began to change. While extractive industries had been the focus of trade at the time of the canal opening, the manufacture of goods became an important business and these items became more important in the mid-nineteenth century. This trend continued into the second half of the century as the natural resources that the area had depended on earlier – particularly lumber – were exhausted. Industry continued to transition into the manufacture of completed goods, principally finished lumber which was now being imported in its raw form from Canada and processed in mills throughout the Champlain Valley.

The survival of this commercial waterway and canal boat freight came under increased competition throughout the end of the nineteenth century. The first threat was the great improvements in efficiency and power of the railroads; the second threat was the discovery of cheaper sources of forestry, mineral, and agricultural products in other regions of the country outside the Northeast. To contend with this competition, pressure mounted to drop the price of shipping on the Champlain Waterway by increasing the size and carrying capacity of the canals. This brought about the final expansion of the Champlain Canal into the New York State Barge Canal by 1916, which led to the adoption of steel barges and signaled the eventual end of the wooden canal boat era.

3.1.4 THE CHAMPLAIN BARGE CANAL (1915-1940)

The Champlain Barge Canal was opened in 1915 with concrete locks accommodating vessels 300-ft (91.5-m) long by 43.5-ft (13.25-m) wide drafting less than 12 ft (3.6 m) of water. Bridges and overhead power and telephone lines limited the vessels to a height of less than 15.5 ft (4.7 m) at normal water levels. With the opening of the Champlain Barge Canal, the old classes of canal boats were no longer economical. Soon, several new boat designs appeared that could use the larger locks more effectively. However, the old canal boats remained in use alongside these new vessels until the late 1930s.

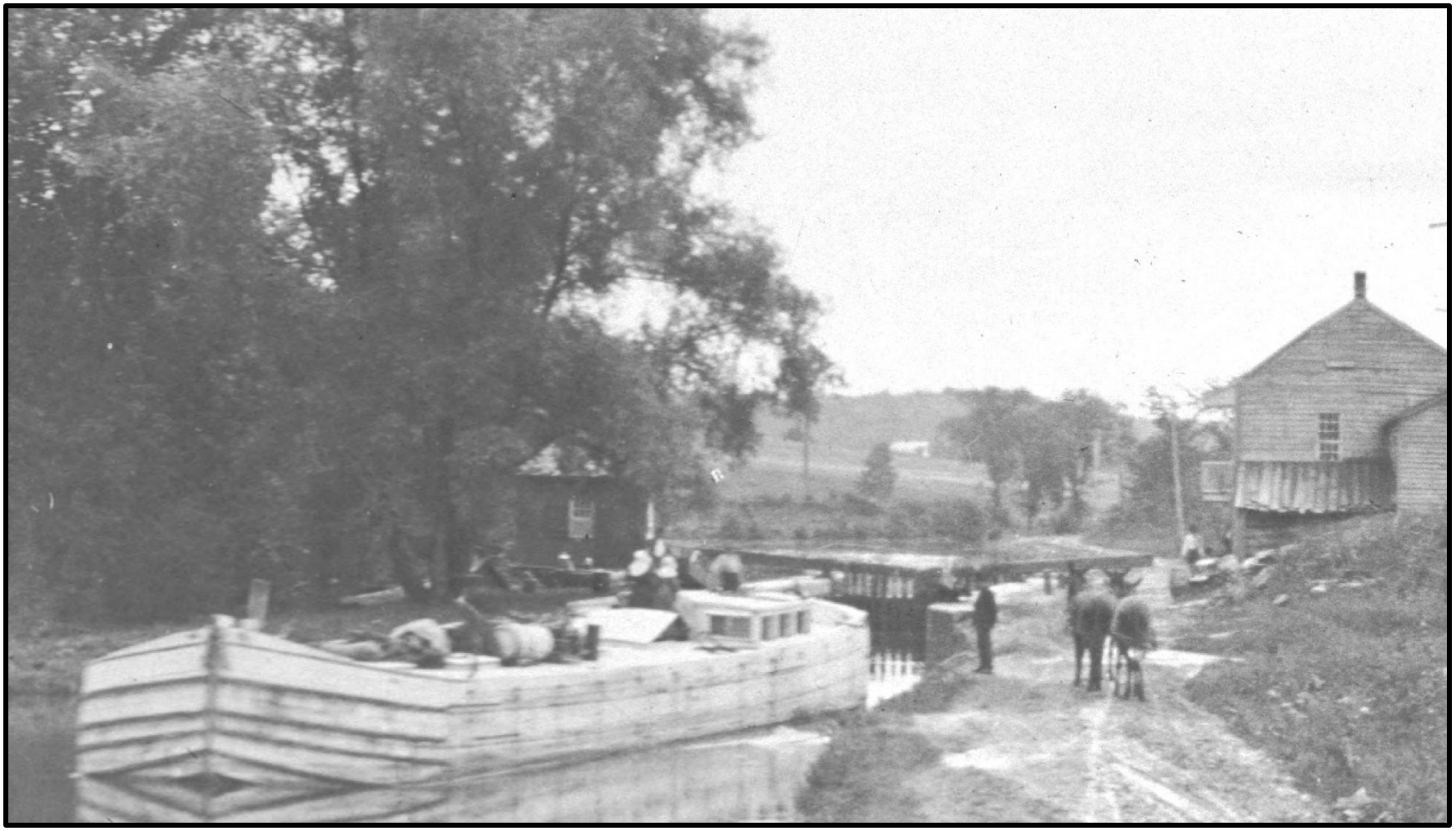

Figure 3-1. Canal Boat Being Towed by Mules Through the Champlain Canal (source: Howard Pyle, 1895).

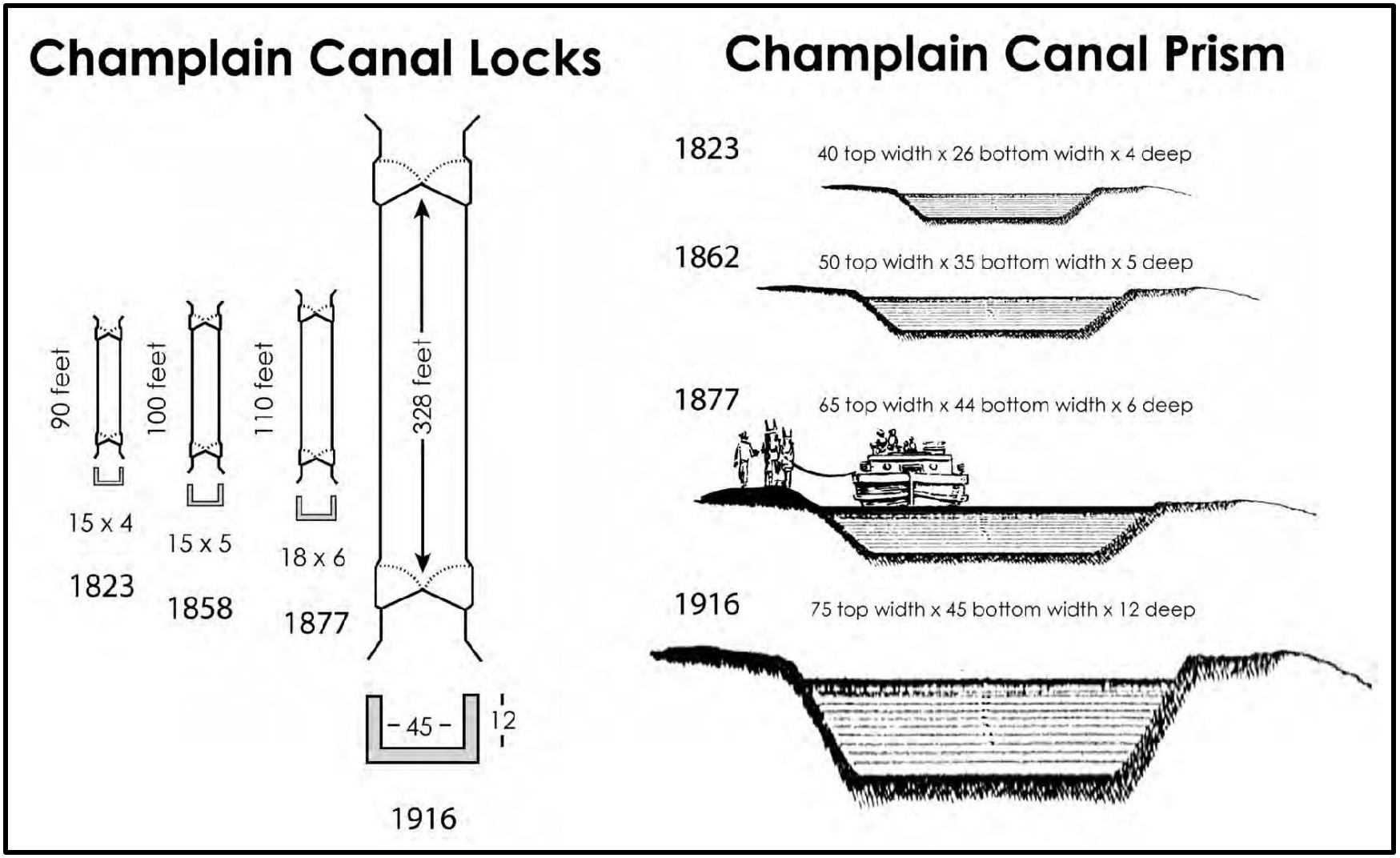

Figure 3-2. Champlain Canal Lock and Prism Sizes (prepared by LCMM).

3.2 CHAMPLAIN CANAL BOATS

Even before the opening of the full-length of the Champlain Canal, there appeared large numbers of long, narrow, shallow-draft boats constructed specifically for service on it. These canal boats were built loosely following European canal boat designs, but with unique North American shipbuilding elements. Two primary types of wooden canal boats were employed during the Champlain Valley's canal era (1819-1940): standard canal boats and sailing canal boats. All canal boats prior to 1915 were towed through the Champlain Canal by teams of horses or mules. When they entered open water, however, sailing canal boats had their own mode of propulsion, while standard unrigged canal boats were formed into tows, or rafts, of boats and towed by steam or tugboats to their destination. The freedom of movement gave the sailing canal boats an advantage for the first half of the canal period until the number of tow vessels available on the lake allowed standard canal boats to compete effectively. Once this occurred in the 1860s, the number of sailing canal boats dropped off dramatically, and many sailing vessels were simply dismasted and employed as standard towed boats (Figure 3-3).

The sailing canal vessel design appeared on Lake Champlain around 1823, at the very opening of the Champlain or Northern Canal. It was a new class of North American vessel, the design of which probably originated in Europe. The object of its construction was to create a vessel that was capable of sailing on the lake like traditional sailing craft, but could convert to a standard canal boat upon reaching the entrance to the canal. These newly designed vessels could load cargoes at distant lake ports, sail under their own power and on their own schedules to the canal, and continue their journeys without transshipping their cargo. Most vessels operating on Lake Champlain prior to this time were traditional sailing ships, whose design prevented them from fitting the beam dimensions of the newly constructed locks.

The sailing canal boat was equipped with a mast or masts, which stepped on the deck in a three-sided mast tabernacle that permitted easy lowering of the mast. The craft’s design was boxy and flat-bottomed to ensure that it would fit in the canal, and it generally relied on a retractable centerboard to provide stability when sailing. The centerboard was drawn up into a centerboard trunk when the vessel reached the canal. With masts down and centerboard up, a sailing canal boat could transit the canal just as standard canal boats did.

Sailing canal boats appeared simultaneously with the 1823 opening of the Champlain Canal. During the next five decades, commerce on the lake reached its height and sailing canal boats underwent a series of design changes and enlargements. By 1875, Lake Champlain provided a vibrant economic venue, but many new developments were underway. Railroads were changing the way goods and travelers moved within the region, and sailing canal boats became less economical and consequently less desirable.

The sailing canal boats that operated on the Champlain Canal were of two styles: sloops and schooners. Schooners had two gaff-rigged masts and their smaller sails made them easier to handle than the sloop-rigged vessels with their single large gaff-rigged sail. Both vessel types required the masts to be stepped into mast tabernacles and hinged with iron pins, which allowed the removal of the masts prior to travel through the Champlain Canal. Historical research has revealed that sloop-rigged sailing boats were the most popular during the Early Canal Period (1819-1857). However, it should be noted that *Gleaner*, the first vessel to pass through the Champlain Canal in 1823, was a schooner-rigged vessel and that this rig type increased in number as the size of canal boats increased.

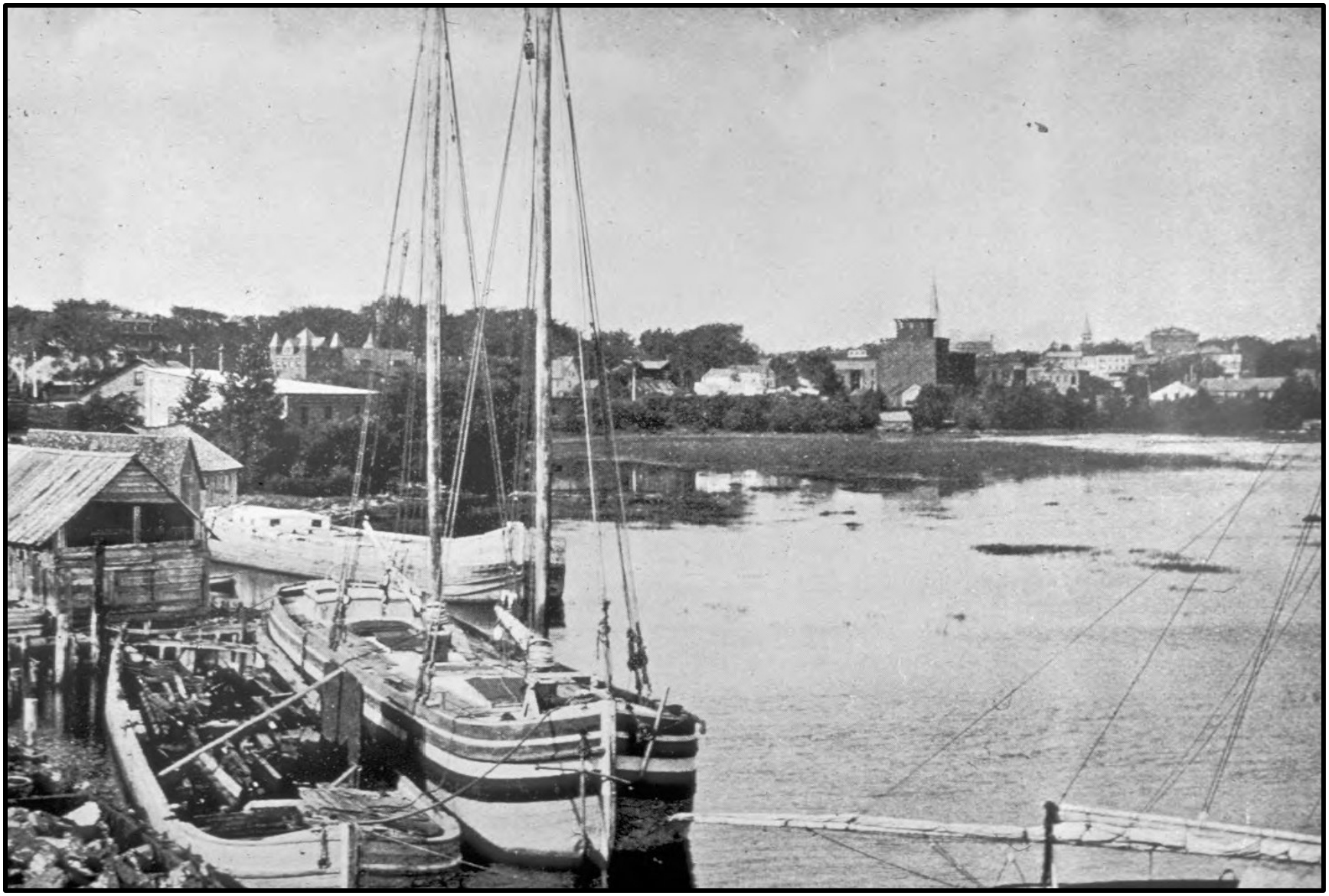

Figure 3-3. Standard and Sailing Canal Boats, Docked in Plattsburgh, New York (Source: Seneca Ray Stoddard, 1898).

The early 1870s saw most remaining sailing canal boats converted to standard, or unrigged, canal boats. At this time the number of tow vessels available on the lake had increased dramatically and the inconveniences of sailing had become more of a hindrance than an advantage (Figure 3-4). Centerboards and rigging took up valuable cargo space and it cost money to store the vessel's masts as it entered the canal. Therefore, the majority of sailing canal boat operators opted to join the ranks of the standard canal boats.

The design and construction of canal boats evolved over time in the shipyards along the Champlain Canal and Lake Champlain. The prolific growth of the shipbuilding industry that occurred immediately after the opening of the canal resulted in a variety of vessel designs and construction techniques. A typical canal boat took from three to six months to build depending on the skill and dedication of the shipbuilder and the availability of supplies. As with all vessel construction, builders had to find a compromise in design that could carry out the canal boats principal task of carrying cargo in a safe and efficient manner, within the constraints of the canal system itself.

A canal boat had to meet two basic requirements to function effectively. First, it had to be able to operate on the canals and on open water in all weather conditions. Secondly, it had to be able to move efficiently and in a controlled manner. Having a clear understanding of the design and construction of a canal boat is necessary for historians attempting to interpret how these requirements were satisfied and how they may have affected canaler behavior and lifestyle.

The principal limiting factor in the construction of canal boats was the dimensions of the locks in use at the time (Table 3-2). The original canal locks in 1823 limited vessel size to a maximum length of 81 ft (24.7 m), a beam of 13.5 ft (1.53 m), and depth of hold of 5.25 ft (1.6 m). The first canal expansion in 1858 allowed for an increase in vessel size to 87.75 ft (26.8 m) in length, 15 ft (4.6 m) in beam and 7.5-ft (2.3-m) depth of hold. This increase in size dramatically increased the carrying capacity of the vessels and quickly made the previous class of vessel obsolete. These vessels were in turn relegated to the scrap heap when the second canal expansion was completed in 1872. The 1872 lock system allowed for vessels 99 ft (30 m) in length, 18 ft (5.5 m) in beam, with a depth of hold of 8.5 ft (2.6 m). Vessels of this last class of wooden canal boats operated into the 1920s and 1930s despite the completion of the New York State Barge Canal and the capacity of the locks to accommodate 300-ft (91.5-m) long barges (Figure 3-5).

3.2.1 DAGGERBOARDS AND CENTERBOARDS

Sailing vessels were sometimes fitted with retractable boards that drop into the water; these boards increased the vessel's surface area beneath the waterline, countering the lateral force of a vessel's sails, which increases steerage. They could be retracted when not in use, giving the vessel a shallower draft (Fontenoy 1994). Depending on their design, they are known as leeboards, daggerboards, or centerboards (Figures 3-6 and 3-7).

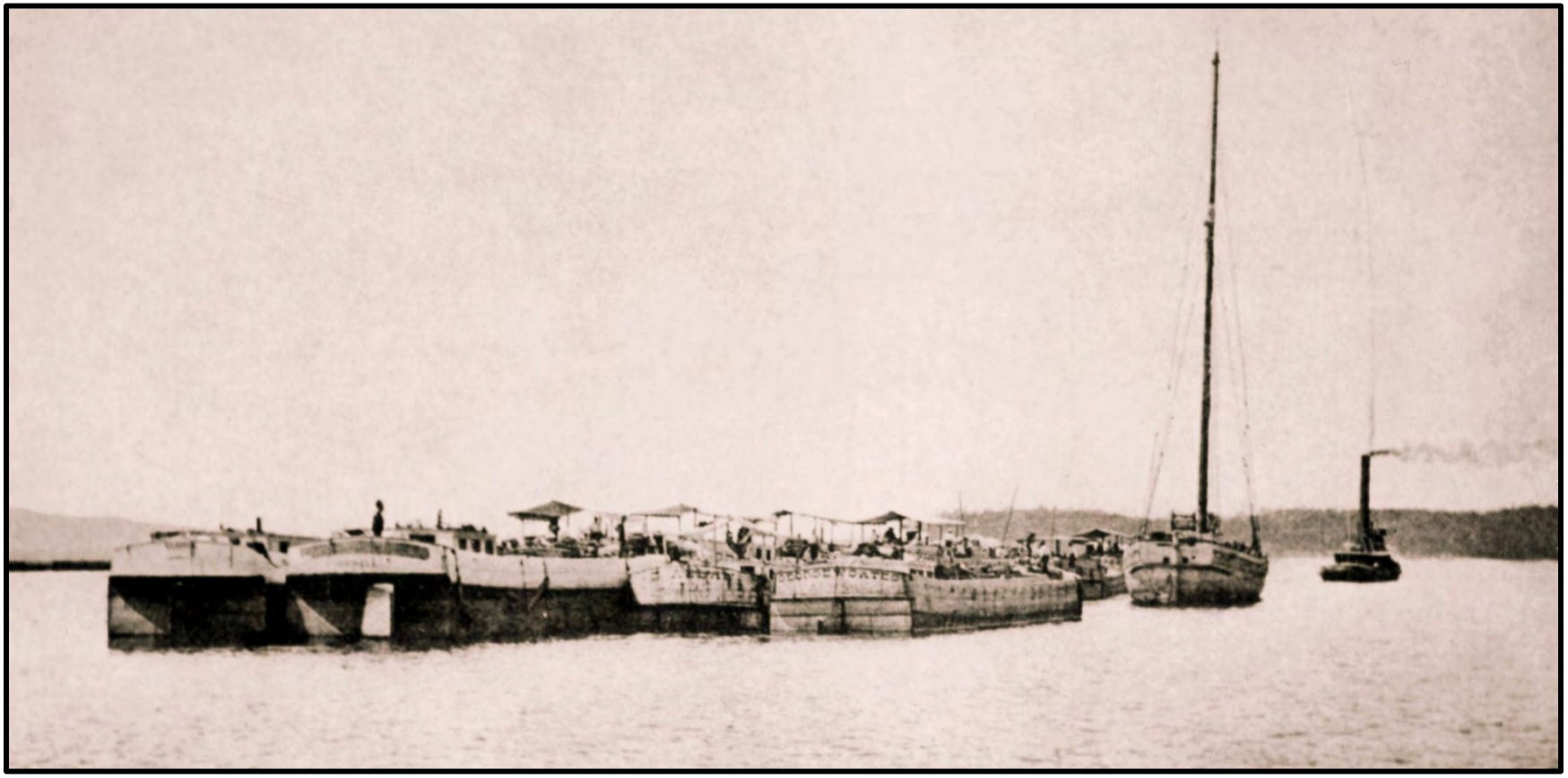

Figure 3-4. Canal Boat Tow on Lake Champlain (Source: Erie Canal Museum Collection, circa 1890).

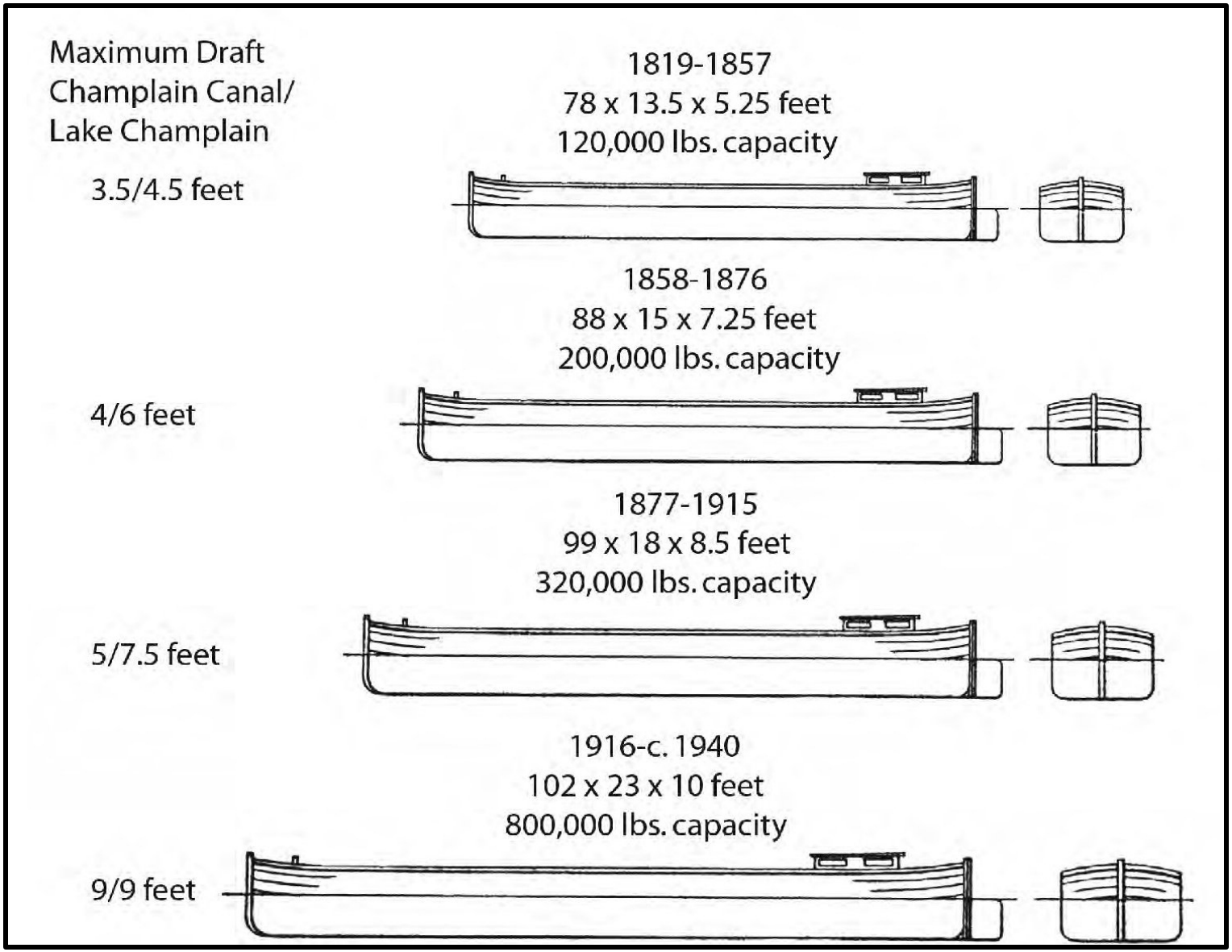

Figure 3-5. Northern Canal Boat Dimensions and Capacities (prepared by LCMM).

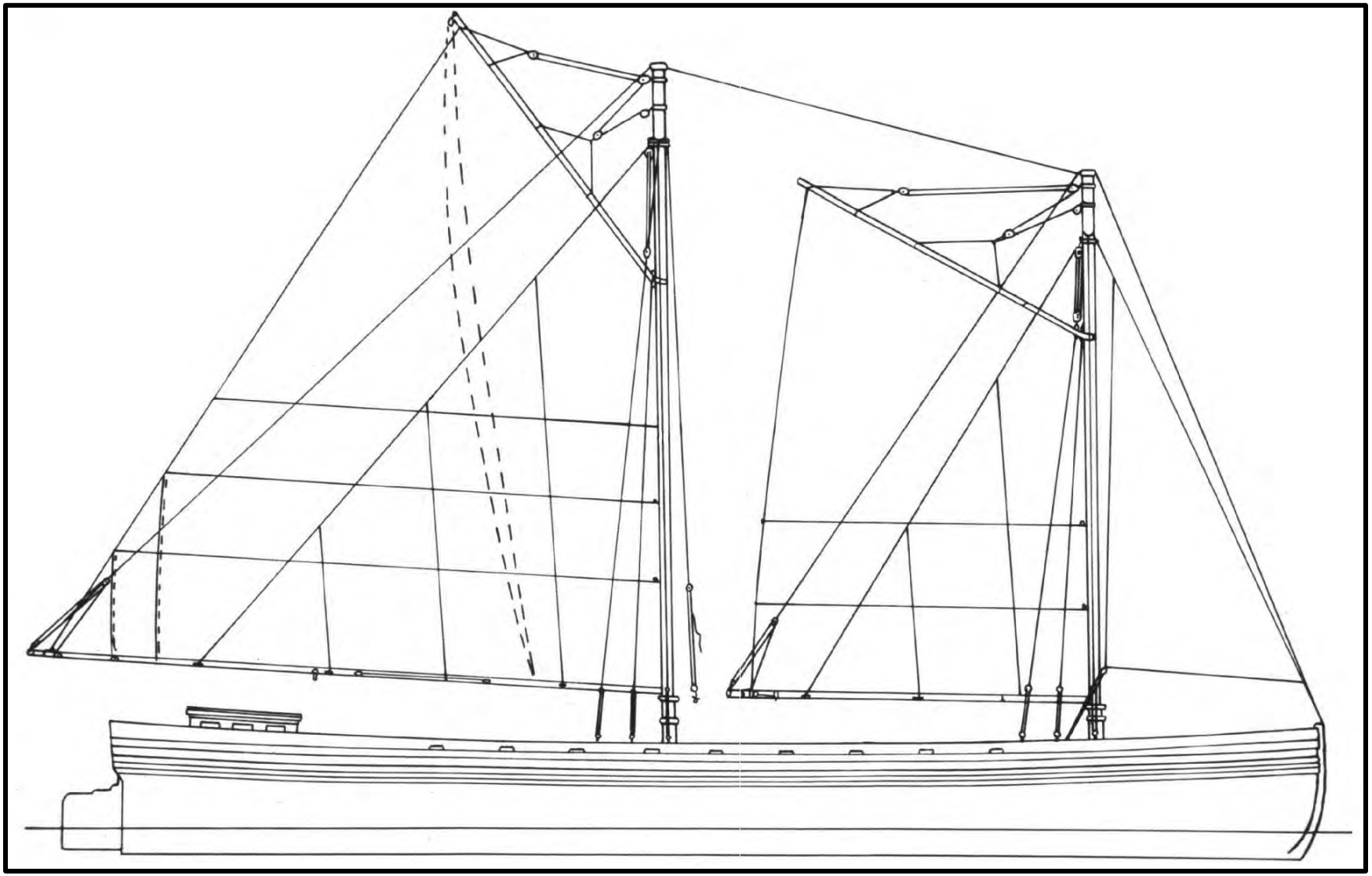

Figure 3-6. Parts of a Sailing Canal Boat, Profile (prepared by LCMM).

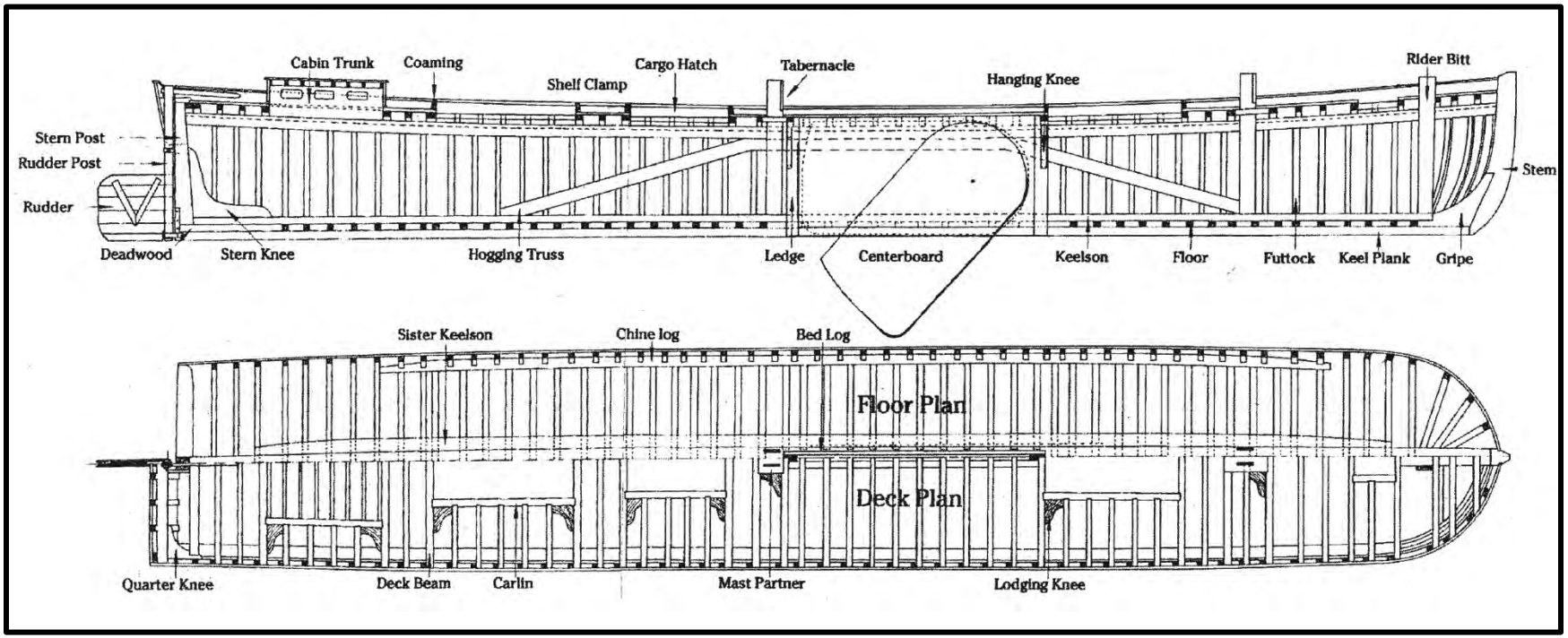

Figure 3-7. Parts of a Sailing Canal Boat, Profile and Plan View (prepared by LCMM).

Table 3-2. Dimensions and Construction Characteristics of Champlain Canal Boats

Period	Dimensions	Construction Characteristics
1819-1835	Length: 48.5 to 81 ft (14.8 to 24.7 m) Breadth: 13 to 13.5 ft (4 to 4.2 m) Height: 3.75 to 5 ft (1.1 to 1.5 m)	Plank on frame
1835-1857	Length: 73.5 to 81 ft (22.4 to 24.7 m) Breadth: 12.5 to 13.5 ft (3.8 to 4.1 m) Height: 3.25 to 5.25 ft (1 to 1.6 m)	Plank on frame, edge first fastening appears circa 1840
1858-1872	Length: 83 to 87.75 ft (25.3 to 26.7 m) Breadth: 13 to 15 ft (4 to 4.6 m) Height: 4.5 to 7. 5 ft (1.4 to 2.3 m)	Predominantly edge fastened
1872-1914	Length: 91.5 to 99 ft (27.9 to 30.2 m) Breadth: 15 to 18 ft (4.6 to 5.5 m) Height: 6 to 8.5 ft (1.8 to 2.6 m)	Edge fastened
1915-1940	Length:300 ft (91.5 m) Breadth: 43. 5 ft (13.3 m) Height: 12 ft (3.6 m)	Edge fastened wood and steel

A leeboard was located off-center, often secured outboard on one side. It was typically deployed on the "lee" side of the vessel under sail, providing surface area on the side of the vessel that was heeling over. Smaller vessels were often fitted with only a single leeboard, which needed to be moved to the lee side on each tack. Some vessels were fitted with two leeboards – one on each side – requiring that the leeboard not in use be pulled up rather than shifted to the opposite side. These are documented in North America as early as the seventeenth century, but were used by sixteenth century Dutch barges, and even as early as the eighth century in the Far East.

Unlike a leeboard which dropped off the side of a vessel, a centerboard dropped through the center of a vessel through a hole in its hull. Also known as a "sliding drop keel," a "shifting keel," or a "drop keel," a centerboard was placed within a trunk, or well, and dropped through the keel on a pivot, hanging down diagonally into the water. The *US Nautical Magazine* describes a centerboard as a strong plank that is bolted edgewise together, and hung on a bolt near its forward end (U.S. Nautical Magazine and Naval Journal 3 No. 2 1855). The centerboard was invented in 1775 by an officer of the Royal Navy (Crisman 2004). Not surprisingly, its use did not catch on right away, as many captains and shipwrights were wary of intentionally forming a hole in the bottom of their vessels.

A daggerboard differs from a centerboard in that although it too dropped through the center of a vessel, a daggerboard slid up and down in a casing rather than moving on a pivot.

Historically, "vertically sliding drop keels" were used on South American sailing rafts. Later, they were suggested for British naval use. Approximately twelve British vessels contained drop-

keels or centerboards, the largest of which were several gun-brigs and the ship-sloop *Cynthia* (Fontenoy 1994). Hudson River sloops began using centerboards after packet lines came into existence. Historian Arthur H. Clark states that the first centerboard sloop was *Advance* of 51 tons, built by Henry Gesnor at Nyack in 1816 (Clark 1904); alternatively, Cornelius Carman may have been the first builder with the 74-ton sloop *Freedom*, constructed at Low Point in 1816. The advantage of the centerboard to the Hudson River sloops was clear; it brought the normal draft of a large loaded sloop back to 6 ft (1.8 m), the draft which was prevalent at the end of the eighteenth century.

The placement of a centerboard affects many structural elements of the vessel. The centerboard on Hudson River sloops passed through the keel, necessitating the widening of the keel in the vicinity of the slot in order to maintain the vessel's structural integrity. This became known as a "moulded keel" (Fontenoy 1994). In many vessels, the board was so large that it protruded above the deck. The centerboard trunk often protruded above deck also.

The centerboard placement also affected the sail rig. If the board was placed at one side of the keel, the centerboard trunk did not interfere with position of the mainmast; otherwise the mast would need to be positioned a few feet farther aft to accommodate the centerboard (U.S. Nautical Magazine and Naval Journal 3 No. 2 1855). Therefore, if the vessel was a schooner, the fore boom was made longer and the main boom shorter.

The increased use of the centerboard provided several significant benefits. First, it allowed for a shoal draft which reduced the frequency of groundings. It also "substantially reduced wetted area," which promoted faster sailing; speed was important in the sloops' competition with steam (Fontenoy 1994). But perhaps the largest impact was that it permitted access to towns and villages on shallower creeks. This opened up new markets for the big sloops where steamboats could not follow. This increased trade affected the local economies as well, encouraging growth in areas that previously could not get their goods to market.

The first archaeological examples of centerboards on Lake Champlain shipwrecks are two mid-1820s sailing canal boats. Prior to the discovery of Resource U-2, all known archaeological examples of Lake Champlain sailing canal boats were believed to be equipped with centerboards.

3.3 SAILING CANAL BOAT CONSTRUCTION

3.3.1 1823 CLASS BOATS

3.3.1.1. Experimental Vessels (1819 to ca. 1835)

During the years leading up to the completion of the canal in 1823, and the decade or so immediately following, there was considerable variation in the design and construction of vessels for use in the canal system. This variation came about because many of these early craft were built by traditional shipbuilders attempting to adapt to the new limitations of the canal or they were constructed by carpenters who had not built sizable vessels before.

Few vessels from this time period have been located and none has been subjected to complete documentation; therefore, specific features that define vessels from this period cannot yet be fully codified. However, some generalizations can be made about the size of the canal boats from this first period of vessel construction based on historical documents. They were between 48.5 and 81 ft (14.8 and 24.7 m) long, had a beam of 13 to 13.5 ft (4 to 4.1m), and a maximum depth of hold between 3.75 and 5 ft (1.1 to 1.5 m). Actual designs and construction techniques

are expected to vary considerably between builders, if not between individual vessels. This class of vessel may more closely resemble the traditional sloops and schooners that operated on the lake since the end of the War of 1812. Later sailing canal boats were canal boats equipped with sails and a centerboard; however, the earliest sailing canal boats were more akin to traditional Lake Champlain sloops and schooner built to fit inside the canal locks. These characteristics would include variation in the shape of the hull, arrangement of the rigging of sailing canal boats, placement of hatches and companionways, and vessel equipment not seen on later classes of canal boat, such as a bowsprit.

3.3.1.2. Early Standardization Vessels (ca.1835 to 1857)

In the mid-1830s, the construction and design of canal boats began to become standardized. This occurred for a number of reasons, most prominently that several large merchant companies came to the fore of the canal trade and were able to construct fleets of vessels by the same shipwrights using a standard design. Many of the boat builders took full advantage of the size of the locks to maximize their carrying capacity, which led to standardized methods and designs that made canal boat construction more efficient.

The dimensions of vessels constructed during this period, however, varied with lengths of between 73.5 and 81 ft (22.4 and 24.7 m), beams of 12.5 to 13.5 ft (3.8 to 4.1m), and a depth of hold from 3.25 to 5.25 ft (1 to 1.6 m). It was during this period that the first edge-fastened canal boats began to appear. This method of construction was first employed during the 1840s and would later come to dominate canal boat construction because it was easier to assemble then traditional techniques and allowed for slightly more cargo to be carried in the hold of each vessel. With this class of vessels we also note a standardization in the shape, arrangement, and outfitting of the vessels. Hull shapes have typically done away with any unnecessary curves and show a preference for boxy shapes, which maximized cargo capacity. Companionways are located on the port side of the stern cabin, windlasses are typically found in the bow, and large iron or wooden cleats are spaced along either side of the vessel.

3.3.2 1858 CLASS BOATS

3.3.2.1. First Canal Expansion Vessels (1858 to 1872)

By 1835, the success of the canal system was apparent and an effort to expand the size of the canal and its locks was initiated. This improvement happened in a very piecemeal fashion with the expanded locks being complete in 1858 but the canal prism was not completely enlarged until 1862. With the completion of the lock expansion, canal boat builders began to design vessels to take advantage of the additional carrying capacity (Figure 3-8).

Vessels built after the completion of the first canal expansion in 1858 varied in dimension, measuring 83 to 87.75 ft (25.3 to 26.8 m) in length and 13 to 15 ft (4 to 4.6 m) in beam, and having a depth of hold of 4.5 to 7.5 ft (1.4 to 2.1m). Vessels of this class quickly replaced the smaller vessels, which were considered to be no longer commercially viable. The predominant canal boat construction technique during the period was the edge-fastened method, although plank-on-frame construction persisted, particularly in the construction of sailing canal boats. Size is the principal indicator of vessels from this period. The construction features present on this class of canal boat differ little from previous or later types; it is simply the size of the canal boats which had expanded to accommodate the new lock system at this time that defines this class of craft.

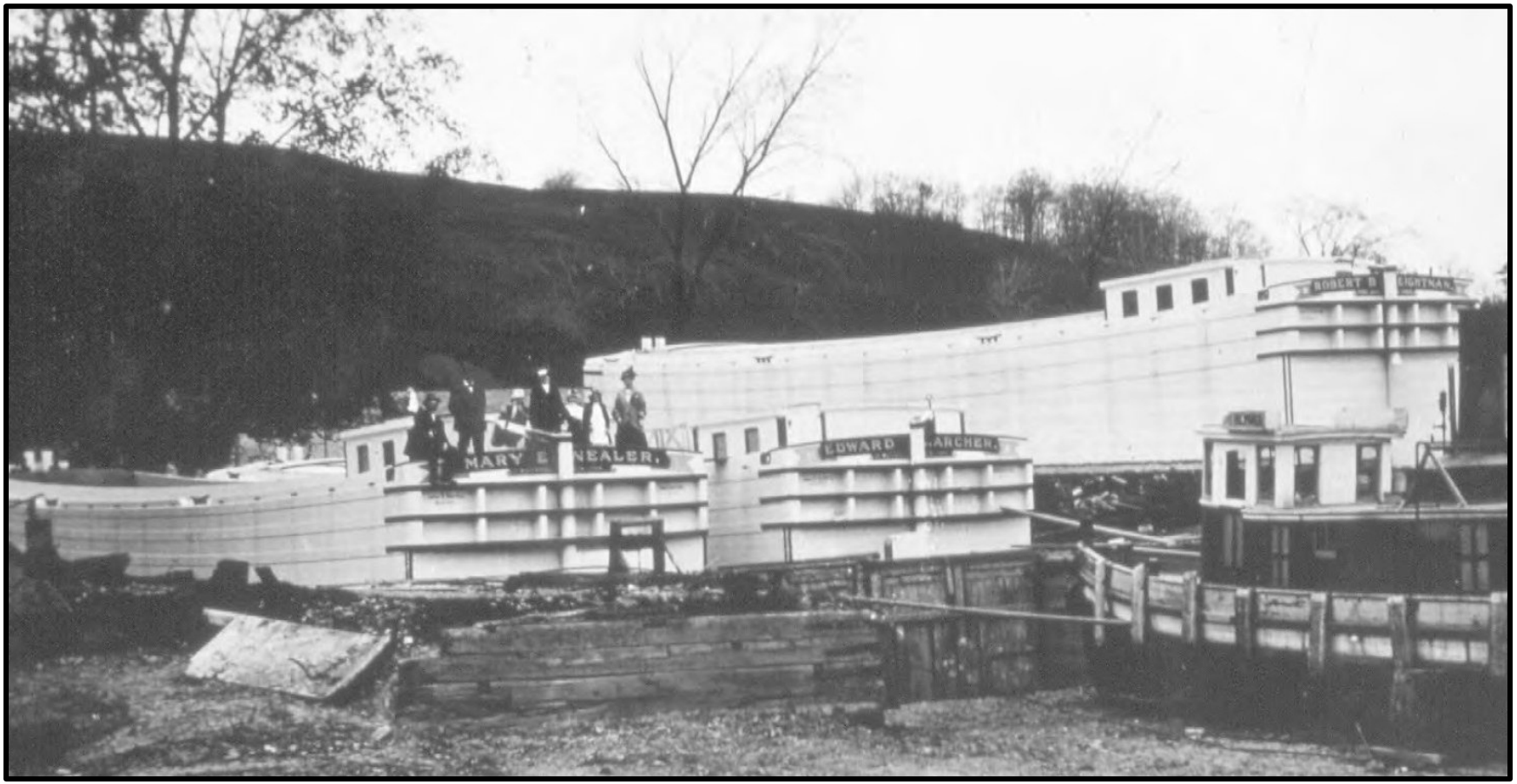

Figure 3-8. Canal Boats *Mary E Nealer, Edward Archer,* and *Robert W. Weightman* Under Construction in the John E. Matton Shipyard, Waterford, New York (Source: Canal Society of New York State, 1916).

3.3.3 1872 CLASS BOATS

3.3.3.1. Second Canal Expansion Vessels (1872 to 1914)

Almost immediately after the completion of the first canal expansion, a second expansion was begun in 1864. This expansion also progressed slowly and enlargement of the locks was not completed until 1872. Once again, shipbuilders constructed vessels that closely conformed to the enlarged lock dimensions with lengths of 91.5 to 99 ft (27.9 to 30.2 m), beams of 15 to 18 ft (4.6 to 5.5 m), and depth of hold of 6 to 8.5 ft (1.8 to 2.6 m; Figure 3-9). These larger vessels soon dominated the waterway, sidelining the older 1858 class canal boats. This new class of vessel continued to operate until the end of the wooden canal boat era. Many of these boats continued operating into the first half of the twentieth century, when they were eventually replaced with steel and wood barges. These vessels often had a single large hatch for ease of bulk cargo movement. Any plank-on-frame boats would be an exception rather than the rule during this period. It was also during this time period that canal boat operators adopted the technique of "double-heading," which means they operated two canal boats in conjunction with a single crew. Evidence of this technique includes the presence of a small windlass in the stern of the vessel for controlling the lines that attached the two vessels. It was also during this period that sailing canal boats fell out of favor with many operators. With a large number of tow vessels now present, the sailing capabilities of these vessels were no longer an advantage and many of them were converted to standard towed boats. Further evidence of these modifications is sure to be found on shipwrecks in the future.

3.3.4 1915 CLASS BOATS

3.3.4.1. New York State Barge Canal (1915 - ca.1940)

The Champlain Barge Canal was opened in 1915 with concrete locks that could accommodate vessels of 300 ft (91.5m) in length with a beam of 43.5 ft (13.3 m) that drafted under 12 ft (3.7 m) of water (Figure 3-10). The canal boats that operated on the Northern Waterway were limited in size by the locks on the Chambly Canal, which could accommodate a boat up to 198 ft (60.4 m) long, 22.5 ft (6.9 m) wide, and a draft of 6.5 ft (2 m).

Canal boats of the Chambly Canal lock dimensions were used alongside the previous class of vessels as well as large wooden and steel barges, which completely dominated the canal trade on the Northern Waterway by 1940. These wooden canal boats had one large hatch that ran the length of the vessel ending just forward of a crew cabin in the stern. Operation of the vessel was facilitated by a small walkway that ran around the hatch and the cabin. Photographic evidence suggests that these canal boats had flat transoms and lacked a rudder assembly altogether. This class of vessel has not yet been uncovered in the archaeological record.

Design, dimensions and carrying capacities changed through the different phases of canal boat development. Table 3-3 summarizes the changes in boat dimensions in conjunction with lock and prism dimensions.

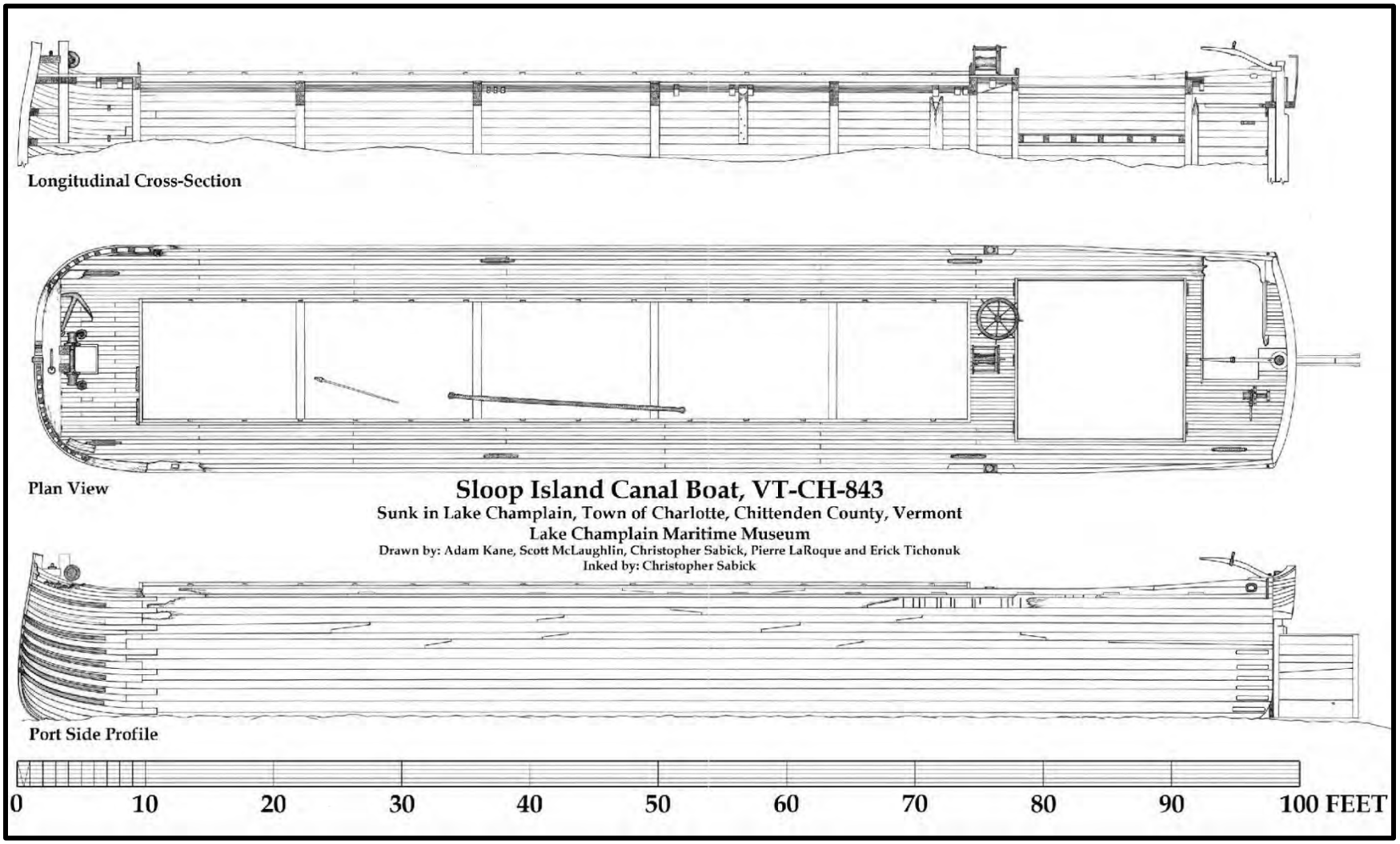

Figure 3-9. Archaeological Drawing of an 1872-Class Canal Boat (prepared by LCMM).

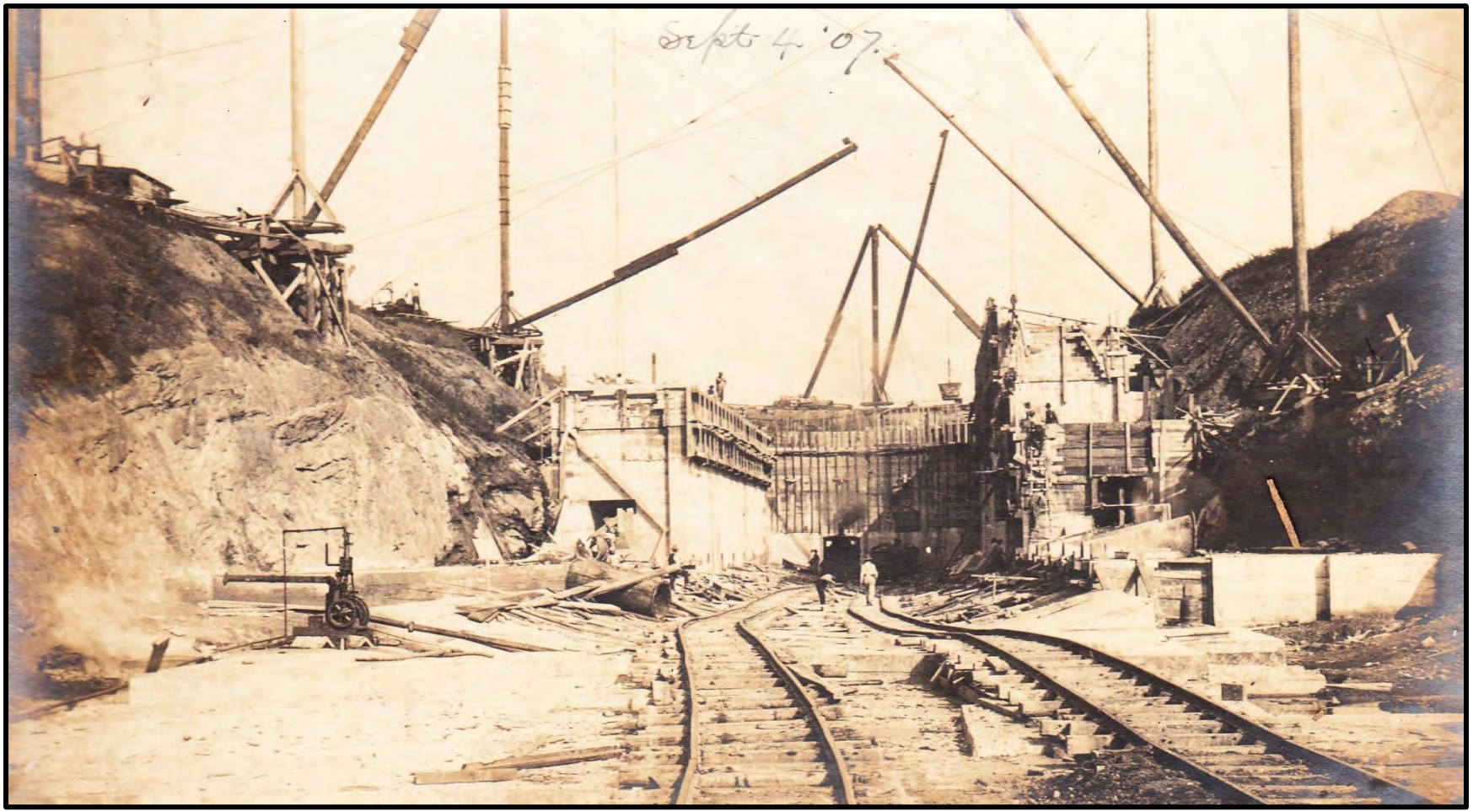

Figure 3-10. Construction of Champlain Canal Lock 3 (Source: LCMM Collection).

Table 3-3. Dimensions of the Champlain Canal and Northern Canal Boats

Year	Prism Dimensions	Lock Dimensions	Boat Dimensions	Boat Weight (Tons)	Maximum Carrying Capacity (Tons)
1823	Top Width: 40 ft (12.2 m) Bottom Width: 26 ft (7.9 m) Depth: 4 (1.2 m)	Length: 90 ft (27.4 m) Width: 15 ft (4.6 m) Depth: 4 ft (1.2 m)	Length: 81 ft (24.7 m) Width: 13.5 ft (4.1 m) Hold Depth: 5.25 ft (1.6 m)	25	60
1858	Top Width: 50 ft (15.2 m) Bottom Width: 35 ft (10.7 m) Depth: 5 ft (1.5 m)	Length: 100 ft (30.5 m) Width: 15 ft (4.6 m) Depth: 5 ft (1.5 m)	Length: 87.75 ft (26.7 m) Width: 15 ft (4.6 m) Hold Depth: 7.75 ft (2.4 m)	40	100
1872	Top Width: 65 ft (19.8 m) Bottom Width: 44 ft (13.4 m) Depth: 6 ft (1.8 m)	Length: 110 ft (33.5 m) Width: 18 ft (5.5 m) Depth: 6 ft (1.8 m)	Length: 99 ft (30.2 m) Width: 18 ft (5.5 m) Hold Depth: 8.5 ft (3.6 m)	60	180
1916	Top Width: 75 ft (22.8 m) Bottom Width: 45 ft (13.7 m) Depth: 12 ft (3.6 m)	Length: 328 ft (100 m) Width: 45 ft (13.7 m) Depth: 12 ft (3.6 m)	Length: 300 ft (91.4 m) Width: 40 ft (12.2 m) Hold Depth: 10 ft (3 m)	250	1000

3.4 ARCHAEOLOGICAL EVIDENCE: LAKE CHAMPLAIN SAILING CANAL BOATS

Wooden canal boat were employed on the Champlain Canal as soon as portions of the waterway were opened in 1819, and continued uninterrupted until the 1930s. During more than a century of operation, a large number of these vessels found their way to the bottom of the Champlain Canal, Hudson River, Richelieu River, and Lake Champlain through accidents, poor handling or

intentional scuttling. Beginning in the early 1980s, the LCMM in Vergennes, Vermont began studying the collection of canal boats still resting on the bottom of Lake Champlain. This research has led to the discovery of over 50 canal boats, of which 16 are sailing canal boats. A summary of 14 of those vessels is presented below.

3.4.1 1823 CLASS BOATS

3.4.1.1. Experimental Class Vessels

Troy **-** The canal schooner *Troy* disappeared on Lake Champlain with five crew members en route to Westport, New York in November of 1825 with a load of iron ore. The schooner was rediscovered 1999 during a sonar survey by the Lake Champlain Maritime Museum. The boat was found with its bow stuck fast in the lake bottom, while the transom projected approximately 30 ft (9.1m) above the lakebed. Apparently, the boat's cargo of iron ore rushed into the bow during its steep descent to the bottom, forever preserving evidence of its dramatic and tragic demise (Figure 3-11). Troy is a relatively small vessel approximately 60 ft (18.3 m) by 13 ft 6in (4.1m) by 3.5 to 4 ft (1.1 to 1.2 m).

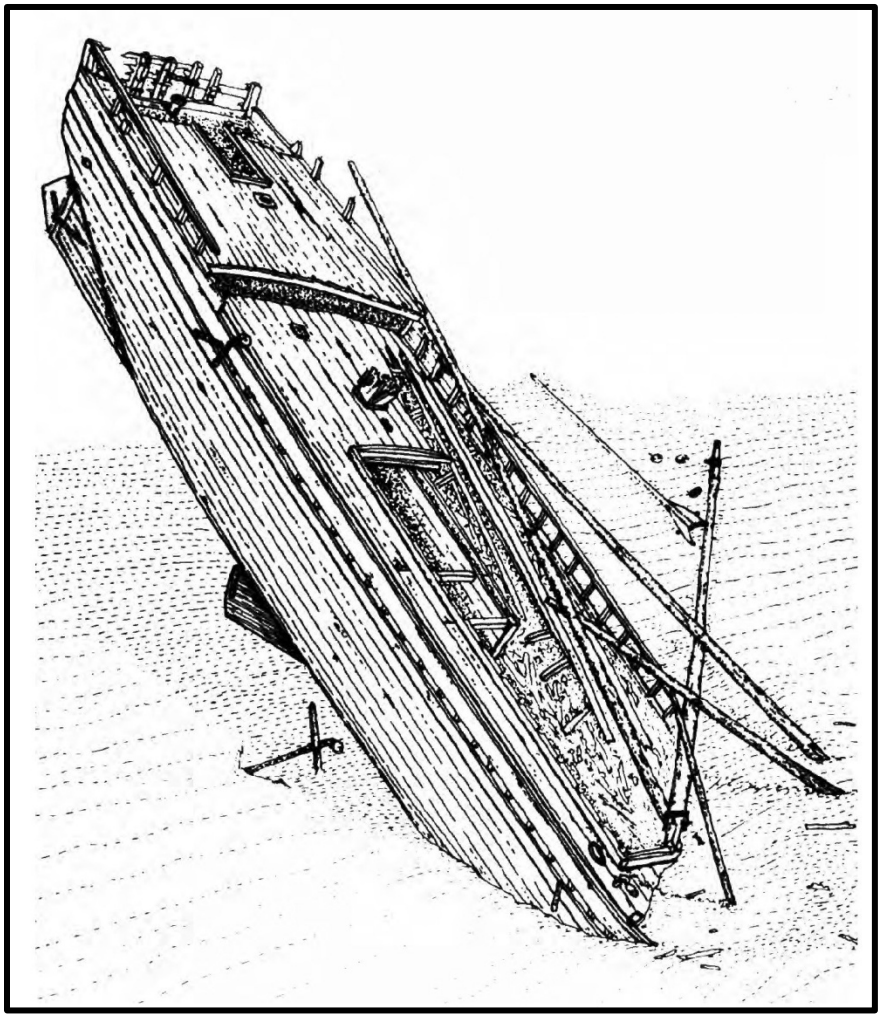

Figure 3-11. The Canal Schooner *Troy* (prepared by Kevin Crisman).

The boat's dimensions are estimated since its official registration has not been located and direct measurements of the site have not been recorded. The stern of the vessel contains a cockpit spanning the breadth of the hull. This space was used by the steersman to steer the vessel using a tiller attached to the rudder post. A companionway leads from the cockpit down into the stern cabin. The cabin roof is raised above the level of the rest of the deck to increase headroom in these living quarters. A low railing, approximately 10 in (25.4 cm) tall, surrounds the exterior portion of the hull in the stern. The main deck has a single large cargo hatch running between the foremast and the mainmast. *Troy* has two mast tabernacles that are three-sided boxes. The tabernacle allowed the mast to be raised when on the lake and lowered when being towed in the canal. The gaff rigging elements include the mainmast and foremast, gaffs and booms for each mast, numerous blocks, and deadeyes with chainplates adjacent to each mast. *Troy* is the only intact example of an early sailing-canal boat yet located. It is an extremely important link in the evolution of Lake Champlain commercial vessel design presenting a link between the design of pre-canal Lake Champlain sloops and schooners and later sailing canal boats (Kane and Sabick 2002).

Shoreham Sloop (VT-AD-1369) - Wreck H4, also known as the Shoreham Sloop, was discovered during the 2003 by LCMM. Archaeological study of the wreck took place in 2004-2006. The site is a ca. 1825 Lake Champlain canal sloop in fair condition. The hull is preserved up to the tops of the top timbers. However, the deck, deck beams, bowsprit, mainmast, cabin roof and cabin trunk are no longer extant (Figure 3-12). Approximately ¾ of the structure is present, although only a small portion of it is exposed above the bottom sediments.

The plank-on-frame hull is 64 ft 10 in (19.8 m) long measuring from the after face of the transom to the forward face of the stem. The vessel's overall length including the bowsprit knee is 67 ft 1 in (20.4 m). The original length accounting for the no longer present bowsprit was approximately 75 ft (22.9 m). The hull has a maximum beam of 14 ft 7 in (4.4 m), tapering to 12 ft 6 in (3.8 m) at the stern. The depth of hull measuring from the top of the keelson to the underside of the deck beams was approximately 4 ft (1.2 m).

The vessel's framing is very light with frames typically 3 in (7.6 cm) sided and moulded. Evidence of the vessel's deck structure is minimal, and consists of lodging knees and the partial remnants of deck beams. The hull contains the remains of a centerboard trunk, which was removed during the boat's use-life. Evidence of the vessel's rig was found both alongside and inside the hull and included two chainplates with deadeyes attached on each side of the hull. No other chainplates were found on the hull, leading researchers to believe that the wreck is a sloop.

Based on the archaeological data, the Shoreham Sloop is believed to be a sloop-rigged sailing canal boat built between 1823 and 1830. The most important data leading to this conclusion were the vessel's dimensions. The overall hull shape is also an important consideration in determining that the Shoreham Sloop is an early sailing canal boat. The canal locks limited vessel size; thus, canal boats were typically flat bottomed with parallel sides so that they filled the maximum volume of the canal locks. Traditional sailing vessels like lake sloops, however, were shapelier. In plan view their hulls had an oblong form with a fine entrance and a tapered stern. The Shoreham Sloop has elements of both vessel types with its parallel sides suggesting it is a canal boat, and the rounded hull setting it apart from later, more standardized flat-bottomed sailing canal boats. The rounded hull form is similar to the hull of the schooner *Troy*. All of the other, later archaeological examples of sailing canal boats are flat bottomed (Kane et al. 2010).

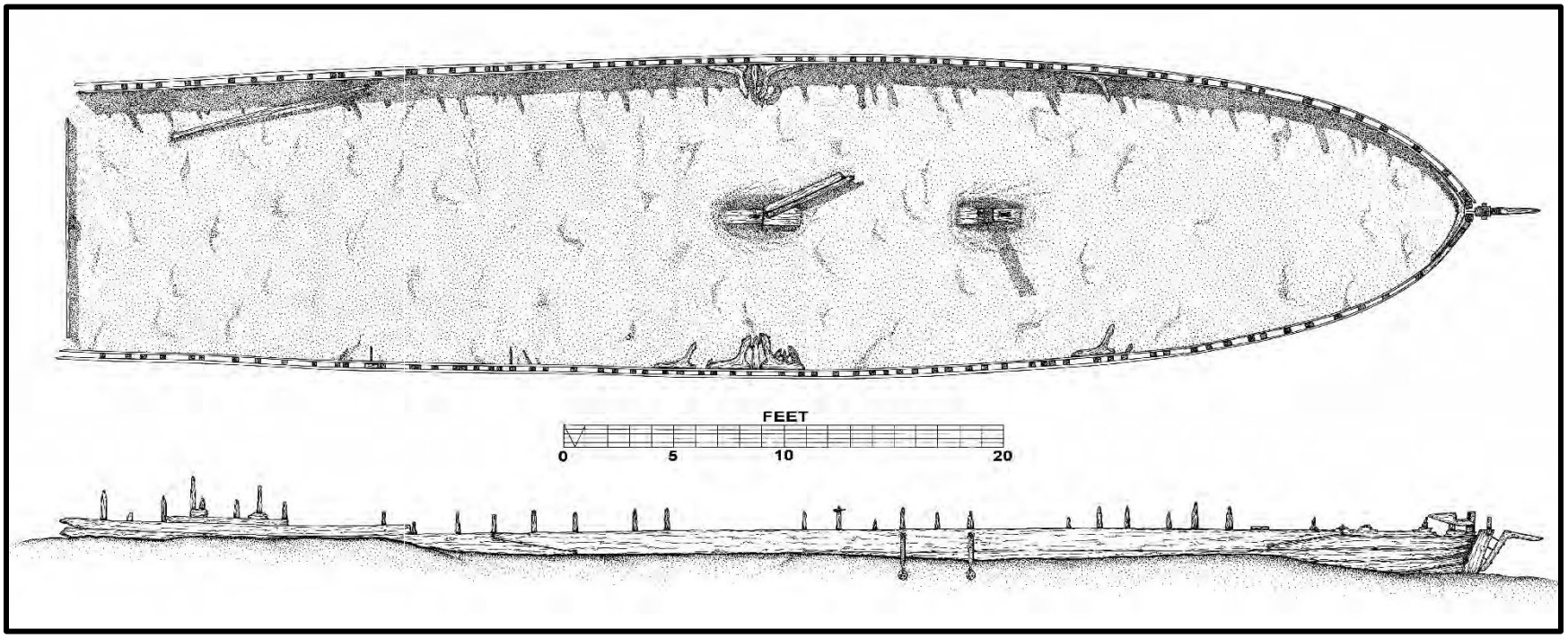

Figure 3-12. Plan and Profile Views of the Shoreham Sloop (prepared by LCMM).

3.4.1.2. Standardized Early Vessels

Isle La Motte Canal Sloop (VT-GI-24) - The *Isle La Motte* Canal Sloop (VT-GI-24) is a wooden-hulled vessel possessing an overall length of 79 ft 8 in (24.3 m), a maximum beam of roughly 13ft 6 in (4.1 m), and an approximate depth of hold of 4 ft (1.2 m). The sloop is largely intact with a cargo of stone. The boat's cargo and surrounding sediments prevented documentation of the wreck's interior construction.

Little of the sloop's framing could be seen during a survey in 1998, which concentrated on the hull's exterior and the most readily accessible internal members. The centerboard trunk runs roughly 12 ft 6 in (3.8 m) between two cargo hatches, with stanchions forming its forward and after structural members. Marble cargo and sediment prohibit examination of more than the trunk's upper section. The vessel's single mast was stepped on deck in a wooden tabernacle placed roughly one-quarter of the vessel's length aft of the stem. No remains of the mast itself survive on deck, but the iron bar on which it pivoted still runs through the tabernacle. The sloop was steered by a long wooden tiller set into the top of the rudder post above deck. An iron windlass is mounted to twin wooden bitts on deck in the eyes of the vessel. An iron folding-stocked anchor, which was apparently stored on deck, lies in the extreme bow of the hull amid the fragmented deck planking (Cohn et al. 2002).

Research by LCMM in 2000 may have uncovered the circumstances of the Isle La Motte canal boat's loss, although the vessel's name still remains a mystery. The September 2, 1846 edition of the Plattsburgh Republican reported:

> ***Accident*** – Mr. Daniel Hall, an industrious citizen of this town, who was employed in carrying stone on a small sloop from Gilman's quary (sic) to the new Fort at Rouse's Point, was drowned on the night of the 2d. inst. When within a few miles of Rouses's Point a sudden squall struck his vessel, which was heavily laden, and in endeavoring to throw the anchor over he was caught by the cable, the vessel partly capsized, filled and sunk – taking him down with it. His son and another man who were on board, saved themselves with much difficulty.
>
> (Plattsburgh Republican 5 September 1846)

The North Beach Wreck (VT-CH-607) - The North Beach Wreck was first discovered in 1987 by local sport divers, and subsequent investigations were carried out by the LCMM. The wreck does not retain any of its cargo and the hull is broken up, with both the port and starboard sides resting flat on the lake bottom, leaving the vessel bottom exposed. It measures 79 ft 6 in (24.2 m) in length, 13 ft 6 in (4.1 m) in breadth, and 4 ft 3 in (1.3 m) deep in the hold. The edge-fastening construction and size of the canal boat suggest a building date between 1840 and 1858.

The boat's hull was edge fastened. In this construction technique, the wooden planks that made up the sides of the boat were fastened together with iron drift pins, which were driven into holes that had been bored vertically through each of the planks (Cozzi 2000). The bow and stern of the vessel, however, were constructed in a traditional plank on frame technique.

Closer examination of the starboard bow revealed information concerning the transition from edge-fastening to moulded construction techniques. Although there is not an exact date for the sinking of this vessel, excavation of lake sediments covering the wreck revealed stratigraphic deposits of sawdust overlaying layers of sand. This band of sawdust is assumed to most likely be

related to Burlington Bay lumbering activities prior to 1870. The position of this sawdust within the stratigraphic column of sediments that buried the ship remnants suggest that this vessel sank at North Beach and broke apart sometime prior to 1870 when Canadian lumber shipments to Burlington were at their peak and the Burlington waterfront was covered with piles of lumber and lumber processing mills (Cozzi 2000).

Wreck PP: Snake Den Harbor Wreck - Archaeological investigations revealed the Snake Den Wreck is an early to mid-nineteenth century sailing canal boat. The vessel had transversely planked bottom, vertical sides and a centerboard keel. The maximum preserved length of the vessel was 63 ft 4 in (19.3 m); however, neither the bow nor stern were intact. The breadth of the Snake Den Harbor Wreck, 13 ft 6 in (4.1 m), indicates it was built before the 1858 Champlain Canal expansion. In situ components of the vessel included the keel, planking, ceiling, centerboard trunk, chine log, bilge stringers, and edge fastened side strakes. The Snake Den Harbor Wreck's shallow depth was the most significant influence on the current condition of the vessel. Over the years since its abandonment, ice has severely impacted the hull. Repeated freezing and thawing tore most of the hull apart, thereby spreading timbers from the vessel across a large area.

Similar to most of the nineteenth century sailing canal boats on Lake Champlain, the Snake Den Harbor Wreck had a centerboard housed in a centerboard trunk. The centerboard was no longer present, but the bottom of the trunk remained. The base of the trunk, moulded 7 in (17.8 cm) and sided 11 in (28 cm), was the largest timber in the preserved portion of the hull. The timber was 25-ft 10-in (7.9-m) long, and had a 14-ft 9-in (4.5-m) longitudinal opening through its center. The centerboard was raised and lowered through this opening.

Both ends of the base of the centerboard trunk were scarfed into the keelson. The keelson, moulded 4 in (10.2 cm) and sided 8 in, (20.3 cm) did not run the entire length of the hull, but was interrupted in its center by the base of the centerboard trunk. The Snake Den Harbor Wreck lacked a keel; therefore the keelson ran on top of the planking. One bilge stringer was documented on the better preserved side of the hull. This timber was moulded and sided 3 in (7.6 cm). The longitudinal extent of this timber is unknown.

Most of the canal boats archaeologically documented in Lake Champlain have a single chine log joining the side of the hull to the bottom. The Snake Den Harbor wreck, however, has a chine log assembly made up of three timbers. The lowermost of these timbers is moulded 5 in (12.7 cm) and sided 8 in (20.3 cm). The lowest side strake is rabbeted into this timber. Positioned above the lowest timber in the chine log assembly are two other longitudinally oriented timbers. These timbers, which were moulded 7 in (17.8 cm) and sided 3 in (7.6 cm) and 7 in (17.8 cm), added additional strength to this juncture. Planking on the bottom of the hull is oriented transversely. The thickness of the planks is 2 in (5.1cm), and the widths range from 8 to 13 in (20.3 to 33cm). The sides of the Snake Den Harbor wreck are edge fastened (Kane et al. 2002).

Wreck UUU (VT-CH-920) - Wreck UUU is a sailing canal schooner. The remains of Wreck UUU are poorly preserved, perhaps representing 15 percent of the entire hull. However, these remains contain important information about combining edge-fastening and plank-on-frame construction. Although this technique is not well understood, the exposed nature of this wreck's hull remains makes it ideal for learning how the techniques were meshed together. The wreck measures 39 ft (11.9 m) long, and the vessel's beam is 12 ft 10 in (3.9 m). This beam was consistent with the earliest canal boats on the Champlain Canal, built between 1823 and 1858.

The extant remains include: a chine log, planking, centerboard trunk, floors, first futtocks, keelson, sister keelsons, and bilge stringers (Figure 3-13). The sides of the hull are edge fastened. Edge fastened construction changes the way the rest of the hull was built relative to the more traditional plank-on-frame method. The bottom planking for the run of the hull was oriented transversely, and was supported inside the hull by longitudinally oriented bilge stringers. Although this technique was well suited to building the rectangular mid-section of the hull, it was not used for the moulded bow. The forward 12 ft (3.7 m) of the hull was built in the plank-on-frame tradition. Bottom planking in the bow was oriented longitudinally, and the side strakes were not edge fastened.

One of the hull's most interesting features was the base of the centerboard trunk, which differs from other examples recorded on Lake Champlain's sailing canal boats. At the forward end of the trunk, the same piece of wood served as the beginning of the trunk and the keelson. This was accomplished by using a curved piece of compass wood. Only one plank from the trunk is still present, but this plank has drift bolts protruding from its upper face, indicating that the sides of the trunk were edge fastened (Kane et al. 2003).

***Wreck WWW (NYSM 11413)* -** In 2001, LCMM archaeologists relocated and completed preliminary documentation of a wreck near Plattsburgh, New York initially located in 1970. Based on the accounts of local divers, the wreck's location was fairly well known, and over the years a number of artifacts were collected. LCMM's examination revealed the vessel to be a mid-nineteenth century sailing canal boat. The remains of the vessel are 75 ft 3 in (22.9 m) long and 12 ft 3 in (3.7 m) in beam (Figure 3-14). The site consists of just the bottom of the hull. The vessel's bow and stern were poorly preserved. Based on the dimensions of the wreck, the vessel was built sometime between 1823 and the 1858 enlargement of the canal locks; however, standardized hull construction suggests a build date between 1835 and 1858. Additionally, excavations in the 1970s discovered an 1837 Canadian coin indicating the vessel was deposited on the lake bed sometime after 1837 (Mize 1970).

The wreck had many features common to other documented sailing canal boats, but there were other previously undocumented construction aspects. The extant hull components include: chine logs, floors, standing knees, futtocks, futtock and floor wedges, planking, sternpost, stem, cant frames, centerboard trunk, and ceiling. The canal boat was built using the plank-on-frame method. The framing pattern was simple and efficient. The flat floors were consistently spaced at 2 ft (0.6 m) intervals on centers, with room-and-space averaging 1 ft 6 in (0.5 m). The outboard end of each floor was mortised into the chine log and held in place with a wedge. At the outboard end of each floor there was a corresponding standing knee attaching the floor to the side of the hull. On the upper face of the chine log in between the floors there were mortises for the vertically oriented futtocks. Only the bases of a few of the futtocks survive, held in place with a wedge.

The hull's central feature is the base of the centerboard trunk. The centerboard opening is 14-ft 4 -in (4.4-m) long and 7-in (17.8-cm) wide. The total length and width of the trunk is 16 ft 9 in (5.1 m) and 1 ft 4 in (0.4m), respectively. The keelson ran the length of the hull with the exception of the area where the centerboard trunk was located. Two "S" scarfs were apparent on the keelson, one in the bow and one just aft of the trunk.

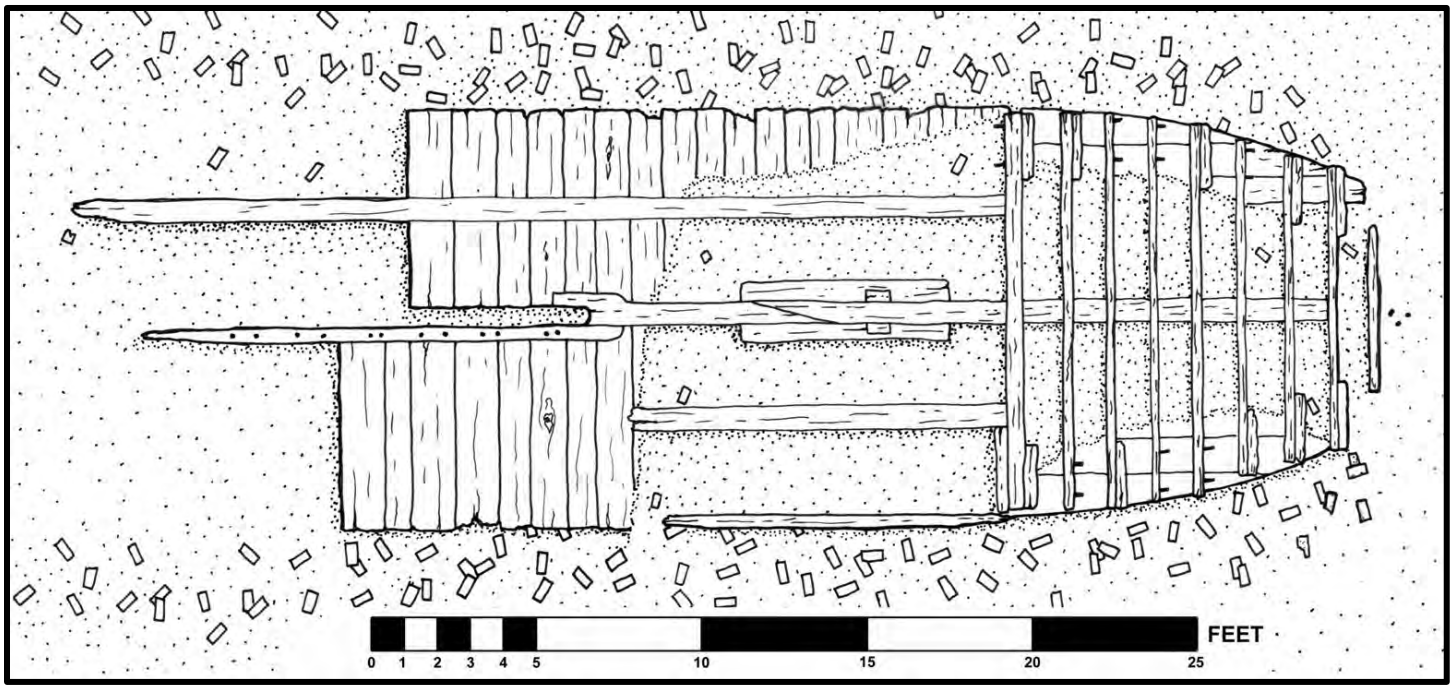

Figure 3-13. Plan View of Shipwreck UUU (prepared by LCMM).

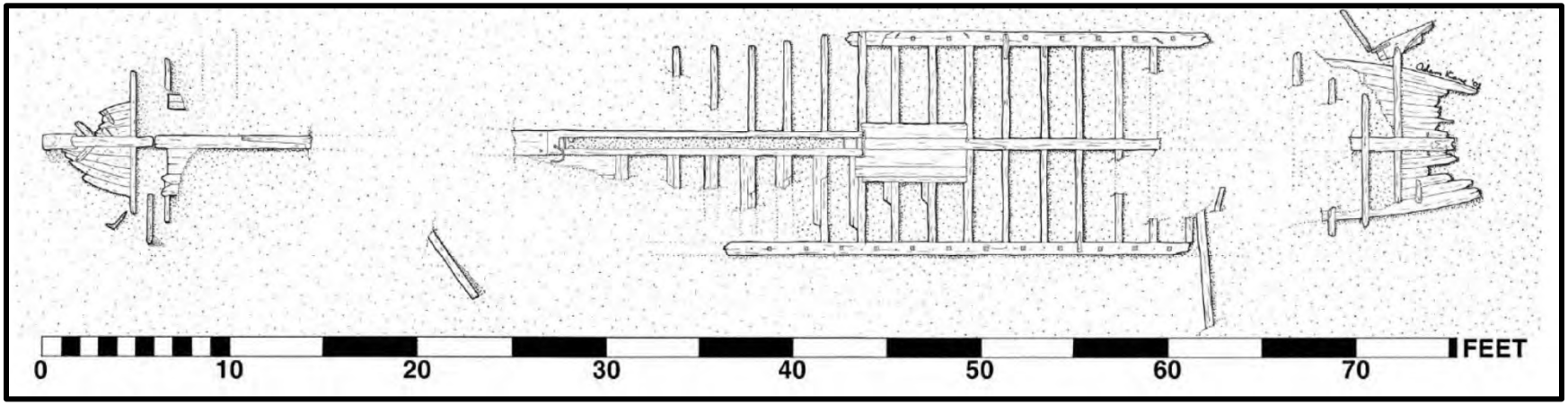

Figure 3-14. Preliminary Plan View of Shipwreck WWW (prepared by LCMM).

The disposition of the vessel's ceiling was one of the Wreck WWW's most perplexing features. In the bow there is evidence that the ceiling was still extant on both the port and starboard sides. However, from the trunk aft there only appears to be one small section of ceiling. This small section is 3-ft (0.91-m) wide and 6-ft (1.8-m) long. The dearth of ceiling in the hull is unusual, given that this vessel would have carried much of its cargo in the hold. It seems unlikely that the ceiling was removed from the entire hull during the decay of the hull. Moreover, the purposefully cut ends of the small section of ceiling just aft of the trunk indicate it was intentionally placed in an area that otherwise did not have any ceiling (Mize 1970).

A wrought-iron pintle for attaching the rudder to the sternpost is still attached to the sternpost. A pintle is typically a vertical pin on the forward end of the rudder, which fits into the gudgeon mounted on the sternpost. The gudgeon/pintle arrangement allowed the rudder to swing freely on the sternpost. The pintle is normally constructed of two iron bands, one on each side of the rudder. At the forward face of the rudder the bands meet and form a downward facing pin, which fits into the gudgeon. The pintle discovered next to Wreck WWW differs from a typical pintle: it consists of a flat iron bar with a pin. The pintle was mounted on the bottom of the keel with the pin facing upward. The corresponding gudgeon was mounted on the rudder. An arrangement similar to this was also recorded on *General Butler* (Cohn et al. 1996).

***Missisquoi Bay Sailing Canal Boat* -** In 2008, a scatter of timbers in the shallow waters of Missisquoi Bay was reported to the Lake Champlain Maritime Museum by local fisherman Gil Gagne. The timbers turned out to be a sailing canal boat built between 1835 and 1858. Its size indicates that it is of the first generation of canal boats to transit the Champlain Canal and the hull is typical of boats when they became more standardized a few decades after the opening of the canal in 1823. The disarticulated hull consists of the bottom, parts of both sides and the centerboard. Ice damage has torn the vessel apart and spread bits and pieces all over the lake bottom. The boat's location and lack of cargo suggest that it was abandoned at the end of a long career. The wreck still contains a surprising number of artifacts such as a ship's wheel, cleats, a bilge pump, and anchor and windlass parts. This wreck has not yet been thoroughly documented.

3.4.2 1858 CLASS BOATS

Wreck TTT (VT-CH-921) - Wreck TTT is a poorly preserved sailing canal schooner, with only the very bottom of the hull surviving. A preliminary documentation of the vessel took place in 2001 during one dive by LCMM archaeologists (Figure 3-15). Significant portions of the extant remains are buried below the sandy bottom sediments.

The overall length of the remaining hull is 60 ft 2 in (18.3 m), and the beam is 14 ft 2 in (4.3 m). The beam measurement indicates that the vessel was built sometime after 1858, based on the maximum allowable breadth of canal boats in the Champlain Canal. The length of this vessel would have been approximately 88 ft (26.8 m). No features associated with a bow or stern were observed. The visible hull parts include: the chine logs, floors, keelson, centerboard trunk, bilge stringers, and futtocks. Other features such as the keel and planking are presumed to be extant; however, they are not exposed above the sediments.

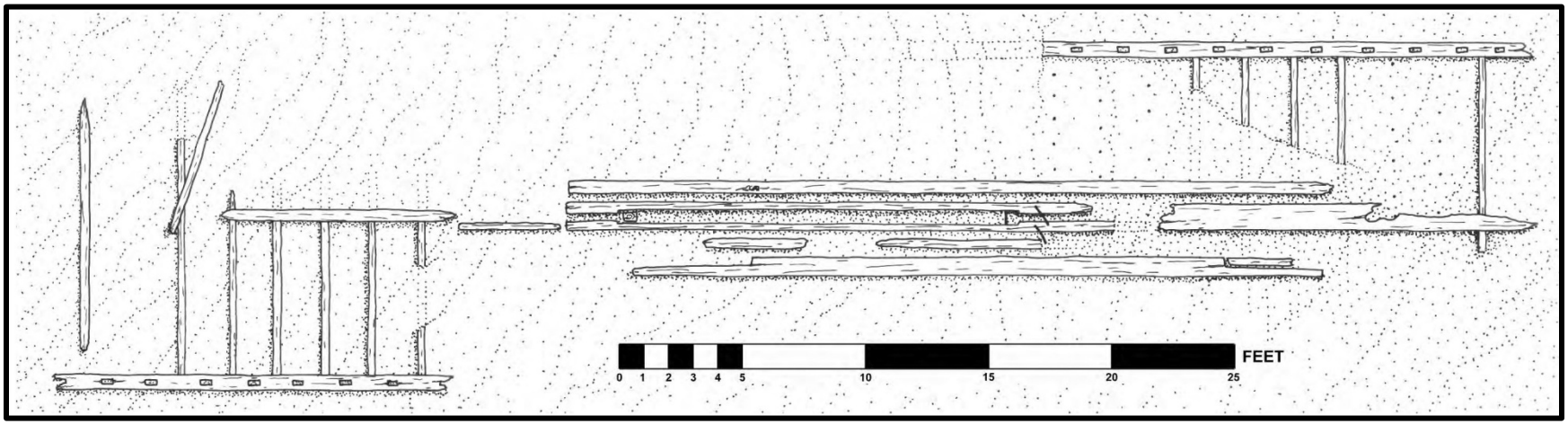

Figure 3-15. Plan View of Shipwreck TTT (prepared by LCMM).

Overall, the hull was built using the plank-on-frame method. The framing pattern consisted of flat floors and vertical futtocks. The floors and futtocks were connected via a longitudinally oriented chine log. The floors and futtocks were arranged in an alternating pattern, with futtocks mortised into the chine log between the floors. In typical ship construction, all of the components of a frame (floor[s] and futtock[s]) would be situated along the same transverse line. However, in this case, the use of a chine log as a central part of the framing warranted a different construction pattern. If the futtock and floor of Wreck TTT had been in the same transverse line, two adjacent mortises would have been cut into the chine log, thereby weakening the chine log. The alternating framing pattern avoids this weakness.

The central feature of the hull is the centerboard trunk. Small sections of the keelson are preserved along the length of the hull. The lack of any visible cargo or artifacts indicates that the vessel's placement may have been intentional. It could have sunk while tied to the Clay Point Dock, and the proprietors saw no need to move the hulk. Another possibility is that the vessel was placed there as an extension of the dock (Kane et al. 2003).

***Wreck C: Canal Sloop* -** Wreck C was located in 1996 during a side scan sonar survey and studied in detail in 1997. The cause of the vessel's sinking is not known, although evidence from the site indicates that the vessel was intentionally scuttled. Many hull timbers show excessive wear, suggesting that the vessel had a long, active life on the lake. No cargo elements were found, and there is little evidence of artifacts that might represent the crew's possessions or the ship's equipment. These combined factors point to the conclusion that the vessel was deliberately sunk after its useful life as a canal boat on Lake Champlain had ended.

The hull of the Wreck C is in poor condition; the bow and stern are relatively intact, but both sides of the vessel have collapsed. However, the hull's decayed state allowed a more detailed investigation of the interior construction details of this vessel. The hull has a maximum length of 89 ft (27.15 m) and a maximum beam of 14 ft 6 in (4.42 m). These dimensions place Wreck C in the 1858 class of sailing canal boats.

Wreck C's bow is in better condition than any other section of the hull, although it is separated from the rest of the wreck. The bluff bow was built with pre-erected frames, a design feature that appears to have been quite common in this time period. The windlass, which is supported by two bits, is interesting for a number of reasons. First, it is the largest windlass so far found on a Lake Champlain canal boat. Second, its placement in the bow is somewhat unusual. Typically, windlasses were attached to bits in the very bow of the vessel, which were in turn supported by a breasthook that joined the sides of the vessel together. In the case of Wreck C, the windlass was set back several feet from both bits and breasthook. This arrangement is unique among canal boats examined to date.

The central region of the hull was edge-fastened with more traditional plank-on-frame ends attached to the sides. Unfortunately, the collapsed port side allowed only limited access to the structural timbers of the vessel's bottom. Wreck C's keelson is 64 ft 2 in (19.5 m) in length, and three sister keelsons on either side of the principal timber provided additional longitudinal strength.

The stern is in fair condition and indicates that the vessel was steered by means of a tiller mortised into the top of the rudderpost, which is 9.5 in (24.1 cm) in diameter. The rudderpost protrudes through an opening between two transverse timbers. Wreck C has a single mast tabernacle, which now lies upside down along the centerline approximately 30 ft (9.14 m) aft of

the bow. While the overall condition of this wreck is poor, the substantial bow and stern remains yielded important information regarding this class of sailing canal boats.

***Canal Schooner General Butler (VT-CH-590)* -** The 1862 sailing canal schooner General Butler was discovered in 1980 by the Champlain Maritime Society just west of the Burlington breakwater. An 1876 newspaper account of its sinking helped to identify this wreck (Cohn et al. 1996a). The schooner was built in Essex, New York, at the Hoskins & Ross Shipyard. It was named after General Benjamin Franklin Butler of the Union Army, who had risen to notoriety after the battle for and occupation of New Orleans during the Civil War. In the decade after its construction, the schooner carried cargoes for three different owners, the last of whom was Captain William Montgomery. It was under Montgomery's command that the vessel met its fate.

General Butler measures 88-ft (26.8-m) long and 14-ft (4.3-m) wide. The depth of hold of the vessel is 6 ft 2 in (1.9 m) with an estimated draft of 6 ft (1.8 m; Figure 3-16). The wreck is located approximately 75 yards (68.5 m) west of the southern end of the Burlington Breakwater. It rests on its keel that measures approximately 10-in (25-cm) moulded and sided, with the bow facing the Breakwater submerged in about 40 ft (12 m) of water (Cohn et al. 1996a). The wreck still has its windlass, deadeyes, and the marble cargo it was hauling when it sank (Cohn et al. 1996a).

This sailing vessel had two gaff-rigged masts, stepped into mast tabernacles and hinged with iron pins, which allowed the removal of the masts prior to travel through the Champlain Canal. General Butler was constructed with a flat bottom and a centerboard, which could be lowered and raised dependent upon if the boat was under sail or under tow in the shallow canal system (Cohn et al. 1996a).

The deck has five hatches which provide access to below deck habitation compartments and the large cargo hold. The forward-most hatch is a small companionway to the forecastle. Three larger hatches amidships allow access the cargo hold. The aftmost hatch is an entry way to the stern cabin (Cohn et al. 1996a).

The wreck *General Butler* is now open to public access (scuba diving as well as remotely operated vehicle access) as part of the Lake Champlain Underwater Historic Preserve System.

***Canal Schooner O. J. Walker (VT-CH-594)* -** The sailing canal schooner *O. J. Walker* (1862) was built in what is now South Burlington, Vermont. The vessel had a remarkably long working life of 34 years and was owned by a number of different citizens throughout its career. It sank during a gale in 1895 as it was entering Burlington Bay. The Champlain Maritime Society located the hull of O. J. Walker during a 1984 side scan survey of Burlington harbor. the wreck rests, virtually intact, in 65 ft (19.8 m) of water (Cohn et al. 1996b).

The *O.J. Walker* was built by well-known shipbuilder Orson Saxon Spear. On May 11, 1895, *O. J. Walker* was carrying a load of bricks and tile to a construction site near Burlington. Unfortunately, hoping to speed the vessel's unloading in Burlington, the crew of *O. J. Walker* had decided to stack the load of bricks and tile on the deck of the canal boat instead of stowing them in the hold. As the schooner approached Burlington it encountered a strong storm. The aged schooner could not withstand the strain of the cargo and sprang a catastrophic leak (Cohn et al. 1996b).

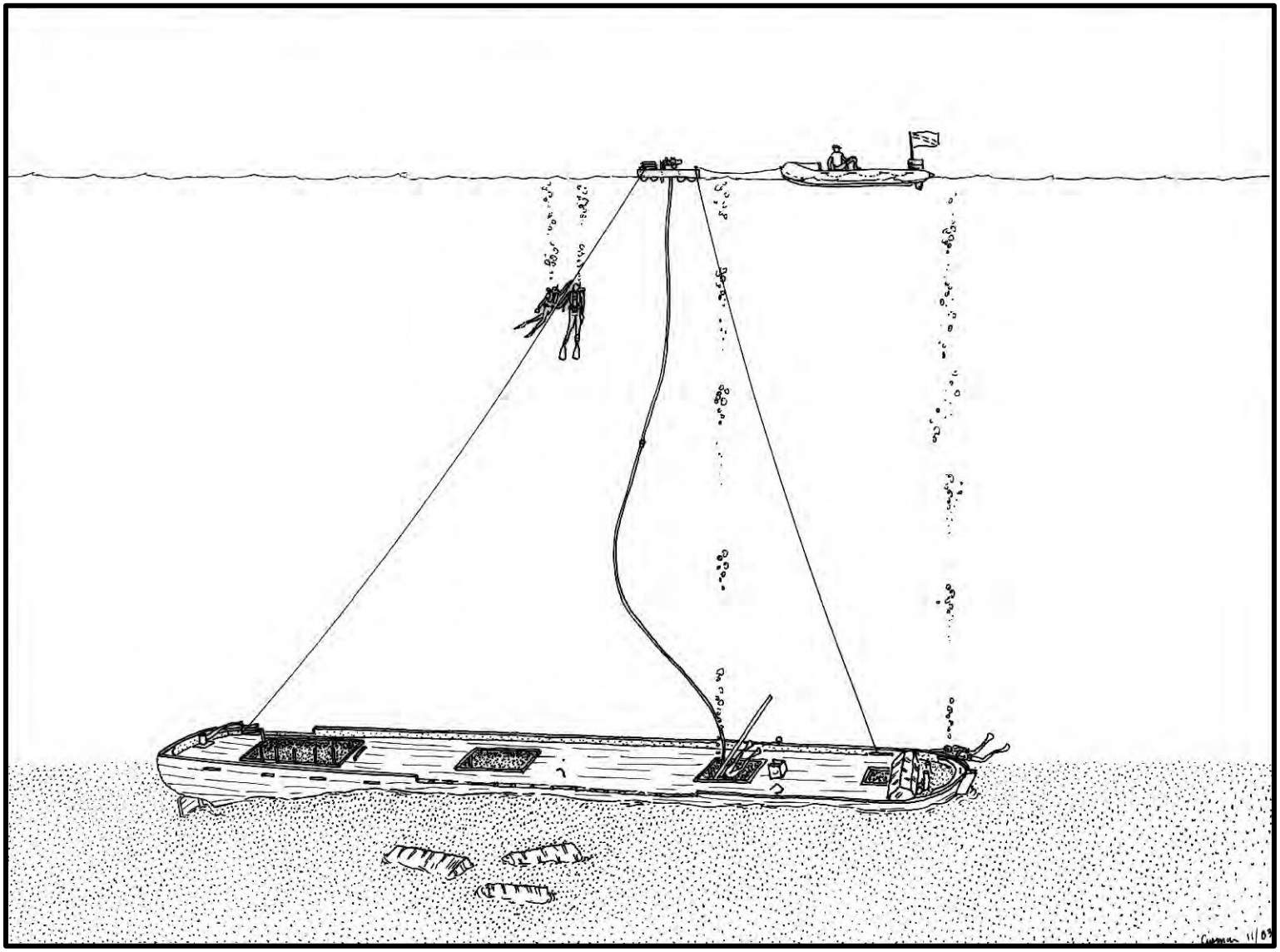

Figure 3-16. Perspective Drawing of *General Butler* (prepared by Kevin Crisman).

The schooner measures 86 ft 6 in (26.4 m) in length, with a beam of 14 ft 8 in (4.5 m) and a depth of 6 ft 6 in (2 m) (Figure 3-17). The vessel has straight sides and moulded bow and stern sections. It carried two fore-and-aft rigged masts that maximized performance on the lake and minimized the crew necessary to man the vessel. These masts were stepped in pivoted mast tabernacles that allowed them to be lowered when the vessel entered the canal system. *O. J. Walker* was also fitted with a retractable centerboard, which would have greatly improved its sailing characteristics on the lake (Cohn et al. 1996b).

The wreck of the *O. J. Walker* is now open to public access (scuba diving as well as remotely operated vehicle access) as part of the Lake Champlain Underwater Historic Preserve System.

***Wreck F (VT-GI-31)* -** Wreck F was discovered in 1996 using sonar and dive verified, which revealed that the vessel is a sailing canal sloop in pristine condition. It sits upright and completely intact on the bottom and almost certainly sank in unplanned and extreme circumstances. All elements that made it a working watercraft are still present. The mast lies in situ in the mast tabernacle; the wood and paint are in an excellent state of preservation; the boom is present with its leather coated jaws; the anchor still hangs off the hawse pipe in the bow of the vessel; and the windlass is intact on the bow.

The rear cabin of Wreck F still houses a wood stove, plates, dishes, cups and water pitchers. The sloop clearly went down in distress and its archaeological potential is very high. Further research may yet identify the vessel, although those same artifacts that may aid identification efforts are currently exposed and vulnerable to theft and zebra and quagga mussel infestation (McLaughlin and Lessmann 1996).

***Sailing Canal Sloop Cornelia (Wreck K) (VT-CH-595)* -** Sailing Canal Sloop Cornelia (Wreck K) was first located in 1984 and the deep site was relocated during a survey in 1996 and documented by remotely operated vehicle in 1997. The vessel is extremely well preserved, a fact that may be best demonstrated by its paint scheme, which is still clearly visible. The lower hull has a coat of white paint, and its upper portions are painted blue-green. The vessel itself is virtually intact, with its toppled single mast and elements of the rigging draped over the port rail. The bow of the canal boat is buried quite deeply into the bottom of the lake, and the vessel's stern stands clear of the bottom by several feet. Wreck K's angle of repose indicates that the vessel's cargo of coal shifted to the forward half of the vessel as it descended from the surface.

Built in 1878, *Cornelia* (Wreck K) was the last sailing canal boat built at Essex, New York, and may also have been the last representative of this class built on Lake Champlain. Essex historian Morris Glenn has located *Cornelia's* enrollment papers, which report that the vessel's registration number was 126049 and it was enrolled at 55 tons. Its dimensions were 77.4 ft (23.6 m) in length, 18.9 ft (5.8 m) in beam, and 5 ft (1.5 m) in depth of hold. *Cornelia's* papers state that the vessel had a "moulded head" and a "scow stern."

The fact that *Cornelia* (Wreck K) was rigged as a sloop is somewhat surprising. The vessel was built after the canal expansion completed in 1862, at which time most sailing canal boats were rigged as schooners. The sloop rig was used on numerous canal boats during the early years of the Champlain Canal, but as vessels grew in accordance with increases in lock size, most owners shifted to a schooner rig for ease of handling. As is apparent from the remains of Wreck K, a single gaff-rigged sail would have been quite large and very cumbersome (Mclaughlin and Lessmann 1996).

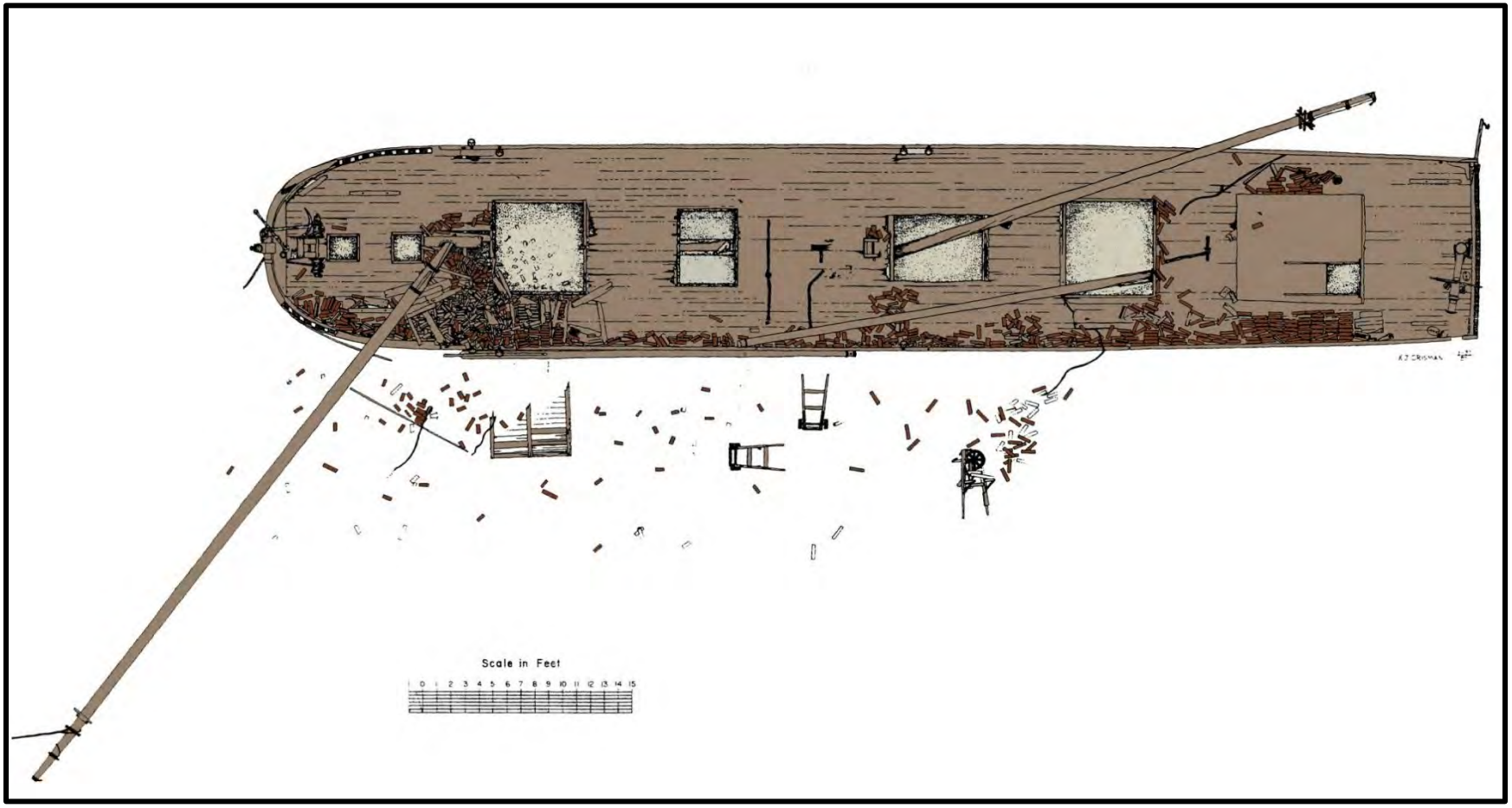

Figure 3-17. Preliminary Plan of Canal Schooner *O.J. Walker* (prepared by Kevin Crisman).

***US Coast Guard Wreck (VT-CH-575)* -** Canal Boat VT-CH-575 lies upright in approximately 14 ft (4.2 m) of water parallel to a north-south running portion of an abandoned timber crib (VT-CH-577) from the original US Coast Guard Station breakwater in Burlington Harbor. It was initially noted to be similar in construction and size to the 1862 class canal boat *General Butler*, located nearby (Cohn 1984a). However, VT-CH-575 is both longer and wider than *General Butler*, suggesting that the boat was likely built later, when the Champlain and Chambly Canals were enlarged in 1873. Sediment and crib debris cover much of the wreck and the forward 45 ft (13.7 m) of the starboard side of the vessel is completely buried by crib fragments.

The vessel has an 18-ft 7-in (5.7-m) beam, and measures 95 ft (28.9 m) from the forward edge of the stem post to the forward edge of the stern post. Documentation involved probing the areas of the vessel buried by lake sediments. Probes along the width and centerline of the wreck indicated that the vessel appears to be relatively intact in the hold and hull. The aft cabin roof was collapsed, yet partially visible. Much of the diagnostic elements of this vessel are buried beneath lake sediments and debris, and features such as the mast and centerboard could not be discerned. This wreck does not retain any cargo, rigging or artifacts, and as it rests only 14 ft (4.2m) of water, these items may have been purposefully removed after the vessel sank (Cohn 1984a). Study of this vessel, which likely represents one of the 1873 models of sailing canal boat, could potentially yield important information pertaining to the ways canal boats were adapted and modified to make use of the maximum dimensions the canals could permit (Cohn 1984b).

4.0 PREVIOUS INVESTIGATIONS

Previous investigations in the vicinity of U-2 include archaeological and architectural history surveys. Due to the nature of U-2, only historic sites will be listed and discussed below. Special attention will be focused on previous studies on the Hudson River, particularly those that identified and evaluated U-2.

4.1 ARCHAEOLOGICAL INVESTIGATIONS

Twenty-six archaeological projects have been conducted within 2 mi (3.2 Km) of the Fort Edward project area in which U-2 was found, 16 of which were Phase IA or Phase IB surveys (Table 4-1). Surveys were conducted for various civil projects, including five road and bridge construction actions, two utility line excavations, and the review of the proposed footprints of a topsoil mine, a health center, and a facilities building. There were also seven Phase II evaluations, including four road construction sites, a sewer line placement, and the proposed footprints of an industrial park and topsoil mine. The three Phase III data recoveries were conducted to mitigate damage done by the construction of an industrial park and waste water treatment facility. The final Phase III was an academic excavation of various aspects of Fort Edward by David Starbuck.

Seven of the 26 projects were conducted as part of evaluations at the Hudson River PCBs Superfund Site. These included five surveys and two Phase II evaluations. Approximately 20 years ago, Collamer and Associates, Inc. undertook a Stage IA and IB survey of access roads and borrow pits to be used to remove and cover PCB laden sediments (Collamer 1990). More recently, URS prepared an *Archaeological Resources Assessment Report for the Phase 1 Dredge Areas* in April 2005 (Cassedy 2005a). That report summarized information gathered from background research and from GE's Sediment Sampling and Analysis Program (SSAP) to evaluate the archaeological sensitivity of the Phase 1 project area. The report contained a proposal for additional field efforts to further evaluate areas of high archaeological potential on the upper Hudson River and its shoreline that are subject to, or could be affected by, Phase 1 of the dredging program. These efforts included a survey to identify and assess potential resources on the riverbank and in the river itself.

Archaeologists again began collecting supplemental field data in July 2005. Reconnaissance by boat and foot of the shoreline adjacent to the Phase 1 dredge areas in the Northern Thompson Island Pool (NTIP) and the Eastern Griffin Island Area (EGIA) was completed. This was followed by a systematic terrestrial archaeological survey of archaeologically sensitive riverbank sections that abut delineated Phase 1 dredge areas in August 2005. Findings were presented in a report titled *Terrestrial Archaeological Survey Report: Addendum I to Archaeological Resources Assessment Report for Phase 1 Dredge Areas*, which was submitted to EPA in October 2005 (Cassedy 2005b). Additional fieldwork was then conducted on several sites, and a revised report titled *Terrestrial Archaeological Survey and Testing Report: Addendum I to Archaeological Resources Assessment Report for Phase 1 Dredge Areas* was submitted to EPA in February 2006 (Cassedy 2006).

Table 4-1. Archaeological Projects within 1.6-km (1-mi) of the U-2 Project Area

Sites Identified/Evaluated	Company Name	Type of Study	Report Date
None	Cultural Resources Management Services (Gimigliano et al. 1979)	Stage IB survey	1979
None	Environmental Archaeology, Inc. (Ivey and McCarty 1982)	Stage II evaluation	1982
Unidentified prehistoric site	Collamer and Associates, Inc. (Collamer 1990)	Stage IA and IB survey	1990
A011542.000007	Joel Grossman (Grossman 1990)	Stage III data recovery	1990
A09113.000029 (Prehistoric site)	Telemarc, Inc. (Hartgen 1991)	Stage IB survey	1991
A09113.000029 (Prehistoric site)	Collamer and Associates, Inc. (Collamer 1991)	Stage II investigation	1991
None	New York State Museum (Pickands 1995)	Stage IB survey	1995
A11542.000003	David Starbuck (Starbuck 1995, 2010)	Stage III data recovery	1995-2010
A11506.000615 A11506.000616	Columbia Heritage, Ltd. (Oberon and Majot 2001)	Stage IA and IB survey	2001
A09113.00029 A09113.00050 (Prehistoric Sites)	Edward V. Curtin (Curtin 2001)	Stage III data recovery	2001
A11506.000618 A11506.000619 A11506.000620	ARCH TECH (Majot 2004)	Stage IA and IB survey	2004
None	ARCH TECH (Majot 2005)	Stage IA and IB survey	2005
None	URS Corp (Cassedy 2005)	Stage IA survey	2005
A11542.000329 A11542.000330 A11542.000331 A11542.000332 A11542.000333 A11542.000334 A11542.000336 A09113.000070	URS Corp (Cassedy and Cox 2006a and 2006b)	Stage IB survey	2006

Sites Identified/Evaluated	Company Name	Type of Study	Report Date
A11506.000623 A11506.000624 A11542.000003	URS Corp (Cassedy 2006)	Stage IB survey	2006
A11542.000353 A11542.000354	New York State Museum (Davis and LoRusso 2006)	Stage IB survey	2006
A11542.000330 A11542.000331 A11542.000332 A11542.000333 A11542.000334 A11542.000336 A09113.000070	URS Corporation (Cassedy and Cox 2006a and 2006b)	Stage II evaluation	2006
A11542.000330 A11542.000331 A11542.000332 A11542.000333 A11542.000334 A11542.000336 A09113.000070	Lake Champlain Maritime Museum (Kane et al. 2007)	Stage IA and IB surveys and Stage II evaluation	2007
None	New York State Museum (Mazeau and LoRusso 2007)	Stage IA and IB surveys	2007
A11542.000353 A11542.000354 (Prehistoric sites)	New York State Museum (Dale 2007)	Stage II evaluation	2007
None	Birchwood Archaeological Services (Moyer and Moyer 2007a)	Stage IB survey	2007
2 Unidentified historic sites	Columbia Heritage (Oberon 2008)	Stage II evaluation	2008
None	Hudson Mohawk Archaeological Consultants, LLC (Clark and Fenton 2008)	Stage IA and IB surveys	2008
A11542.000362 (Prehistoric site)	Birchwood Archaeological Services (Moyer and Moyer 2007b)	Stage IA and IB surveys	2007

Sites Identified/Evaluated	Company Name	Type of Study	Report Date
2 Unidentified sites	Curtin Archaeological Consulting, Inc. (Roberts et al 2009)	Stage IA and IB surveys	2009
2 Unidentified sites	Curtin Archaeological Consulting, Inc. (Roberts et al. 2009)	Stage II evaluation	2009

Initial underwater archaeological studies in the Phase 1 dredge areas were completed in September 2005. Field studies were directed by J. Lee Cox, Jr., who was with URS subcontractor Dolan Research, Inc. A report was prepared by URS Principal Investigator Daniel Cassedy in association with Dolan Research to document the results of the underwater survey, and that report was submitted to EPA in January 2006. It was titled *Underwater Archaeological Survey Report: Addendum II to Archaeological Resources Assessment Report for Phase 1 Dredge Areas* (Cassedy and Cox 2006a). Eleven underwater resources at ten different locales were described in the January 2006 report (U-1 through U-10). The 2005 underwater archaeological survey work provided some information to determine the resources' eligibility for the NRHP. However, for most of those resources, a conclusive determination of their eligibility could not be made based on the data available at that time. Additional underwater archaeological studies were therefore completed in July 2006 by Dolan Research, and a report titled *Underwater Archaeological Resource Documentation Report for Phase 1 Dredge Areas* was prepared by Dolan and URS and submitted to the EPA in September 2006 (Cassedy and Cox 2006b).

EPA determined that it needed additional information concerning the NRHP eligibility of three of the underwater resources, so in October and November of 2006, EPA contracted with LCMM to conduct testing studies at U-1, U-2, and U-10 and surveys at several other locations. LCMM submitted a report called *Additional Cultural Resource Investigations for Phase 1 Dredge Areas, Hudson River PCBs Superfund Site* to EPA in January 2007 (Kane et al. 2007).

EPA determined that U-2 was eligible for the NRHP, and since it was located within the NTIP02B dredge area, an impact mitigation plan was developed and implemented in 2009. U-2 was a fragmentary vessel that appears to have been previously dredged up, broken, and re-deposited upside down in its current location. The fragmentary nature and relatively fragile condition of the vessel remains did not lend itself well to removal, and this condition also limited its utility for public display. The agreed-upon remedy was to document the remains of the vessel by sponsoring an underwater archaeological data recovery excavation prior to its removal as dredge debris. Since contaminated sediments were on and around the wreck, the archaeological project had to be coordinated with the overall remedial dredging program.

4.2 HISTORIC SITES

Twenty terrestrial historic sites have been identified within 2 mi (3.2 km) of U-2 (Table 4-2). Of these, three have been determined eligible for listing on the NRHP (A11542.000069, A11542.000074) and the entirety of Rogers Island (A11542.000069) has already been listed based on the historic record. Thirteen of the historic sites are 18th through mid-20th century artifact scatters or middens likely associated with historic Fort Edward and associated town.

Three sites are directly associated with standing structures or ruins of Fort Edward, including two blockhouses and the fort itself. The other sites are a historic boat launch, a farmhouse foundation, the Champlain Canal, and the aforementioned Rogers Island. Ten underwater sites, including U-2, were identified in 2005 during the underwater survey of the Hudson River (Cassedy and Cox 2006a; Table 4-3). These sites include a possible submerged landing (U-1), the canal boat described in this report (U-2), shipway remnants (U-3), two wooden barges (U-4), a wooden barge fragment (U-5), a canal boat (U-6), a timber bulkhead (U-7), a wooden barge (U-8), a wooden canal boat (U-9), and a wooden barge (U-10).

Table 4-2. Historic Sites Located within 2-mi (3.2-km) of U-2

Site Number	Site Type	Time Period	Eligibility (NRHP)
A11506.000615	Historic scatter	19th century	Not evaluated
A11506.000616	Historic scatter	19th century	Not evaluated
A11506.000618	Historic scatter	Early 20th century	Not evaluated
A11506.000619	Historic scatter	Early 20th century	Not evaluated
A11506.000620	Historic scatter	19th and 20th centuries	Not evaluated
A11506.000623	Historic scatter	Unknown	Not evaluated
A11506.000624	Historic scatter	18th and 20th centuries	Not evaluated
A11542.000003	Fort Edward	18th century	Eligible
A11542.000008	Historic scatter	Unknown	Not evaluated
A11542.000067	Fort Edward Blockhouse	18th century	Not evaluated
A11542.000068	Blockhouse remnants	18th century	Not evaluated
A11542.000069	Rogers Island	18th century	Listed
A11542.000074	Historic scatter	18th century	Eligible
A11542.000329	Historic underwater launch	19th century	Not evaluated
A11542.000338	Historic scatter and foundation	19th century	Not evaluated
A11542.000339	Historic scatter	19th and early 20th centuries	Not evaluated
A11542.000342	Champlain Canal	19th and early 20th centuries	Eligible
A11542.000353	Historic scatter	19th and early 20th centuries	Not evaluated
A11542.000342	Historic scatter	18th through early 20th centuries	Not evaluated
A09113.000072	Historic scatter	19th and early 20th centuries	Not evaluated

Table 4-3. Underwater Sites Located within 2-mi (3.2-km) of U-2

Site Number	Site Type	Time Period	Eligibility (NRHP)
A11542.000329	possible landing (U-1) (later determined non-cultural)	19th century	Not eligible
A11542.000330	Historic canal boat (U-2)	19th century	Eligible
A11542.000331	Historic slipway (U-3)	Unknown	Not eligible
A11542.000332	Two historic barges (U-4)	Unknown	Not eligible
A11542.000333	Historic barge fragment (U-5)	19th century	Not eligible
A11542.000334	Historic canal boat (U-6)	19th century	Not eligible
A11542.000336	Two historic barges (U-8and U-10) and a historic 1858-class canal boat (U-9)	19th and early 20th centuries	Eligible
A09113.000070	Historic bulkhead (U-7)	Unknown	Not eligible

4.3 ARCHITECTURAL INVESTIGATIONS

Fort Edward was first settled during the late eighteenth century around the site of one of four military forts established by the English on the Hudson River. The town did not truly prosper until after the Champlain Canal was opened all the way to Troy in 1823. The heyday of the town was between 1840 and 1900, when the canal was the main economic artery in the region. Despite this, the majority of standing structures in Fort Edward date from the late 19th to mid twentieth centuries. There are only five structures within a 2-mi (3.2-Km) radius of the project area listed on the NRHP. These are summarized in Table 4-4, and include St. James Episcopal Church, a U.S. Post Office Building, the Old Fort House, the Old Champlain Canal Aqueduct, and the Wing-Northup House.

Table 4-4. NRHP Structures within 2-mi (3.2-km) of U-2

Name	Construction Date	Location	NHRP Number
St. James Episcopal Church	1849	112 Broadway	96NR1031
U.S. Post Office Building	1925	126 Broadway	96NR0988
Old Fort House	1825	29 Broadway	90NR2757
Old Champlain Canal Aqueduct	1800	Fort Edward	90NR2762
Wing-Northup House	1820	167-169 Broadway	96NR0937

4.4 SUMMARY

Information from previous investigations has established that the U-2 wreck was situated in a locale that was a nexus of regional riverine transportation routes beginning in the prehistoric period and extending well into the 20th century. Fort Edward became a key node in the Champlain Canal system starting in 1819 when this portion of the canal was completed between there and Lake Champlain. The original outlet of the canal was built at the mouth of Little Wood Creek at the south end of the village of Fort Edward, 1,100-ft (335-m) upstream from the U-2 site (Figure 4.1), and from there, southbound boats continued downstream within the Hudson River to Fort Miller before entering another separate canal channel. By 1828, an overland channel had been completed along the east side of the river from Fort Miller to Fort Edward, so the original outlet became a local connector off the main canal. The last canal expansion in 1916 established a new outlet to the Hudson River about 1,400-ft (427-m) downstream from the U-2 wreck site (the current Barge Canal Lock 7).

Other canal-related sites and features have been identified in the area around Rogers Island near the U-2 site. These include two canal boats (both likely post-dating 1858) and a shipyard that produced both wooden and concrete barges in the first two decades of the 20th century. In addition to the two canal boat wrecks, the remains of at least six wooden barges have been identified nearby. Most of these deteriorated vessels are partially embedded in the river bank, and they appear to have been either abandoned along the river's edge or scuttled in these locations to help stabilize the shoreline. Of this group of local vessels, U-2 is currently the only wreck site situated out in the channel away from the shoreline, and as discussed elsewhere, it appears to have been redeposited at this location.

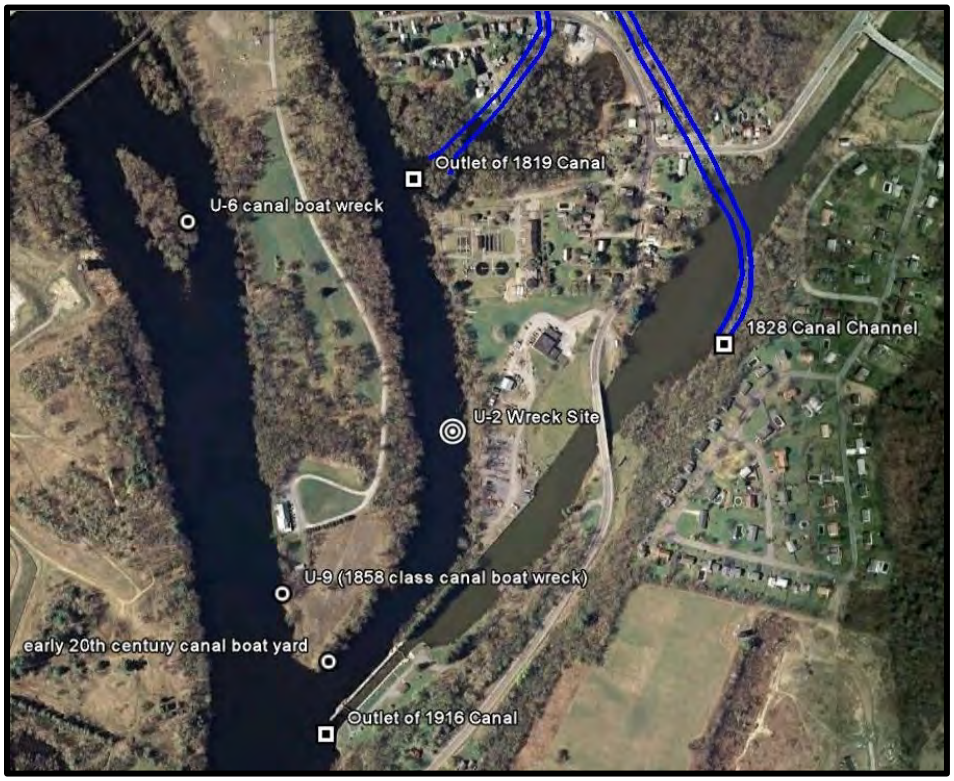

Figure 4-1. Location of U-2 Wreck Site in Relation to Nearby Canal-related Sites and Features (no scale).

5.0 METHODS

The main goal of the Phase III data recovery investigations for U-2 was to mitigate adverse effects to the site through retrieval and analysis of the maximum amount of data possible prior to removal of the resource, so as to address research topics regarding the construction, function, and use life of U-2. This study was a multi-disciplinary effort that included safety and decontamination protocols associated with PCB contamination, a strict scientific diving plan, sediment dredging and artifact recovery, shipwreck documentation, and laboratory analysis of artifacts and wood samples.

5.1 RESEARCH METHODS

In conjunction with LCMM, URS conducted documentary research to uncover the history of the Champlain Canal, Fort Edward, and canal boats. LCMM provided an overall description of the history and archaeology of sailing canal boats based on their prior research in the Lake Champlain region, and URS conducted a detailed review of the available reports and scholarship on the archaeology of Champlain Canal and Lake Champlain canal boats. Sources also included shipwreck lists and reports of previous archaeological and architectural investigations within Fort Edward. These resources were accessed at LCMM and among the New York State Site Files located at the Bureau of Historic Sites in Waterford, New York.

5.2 FIELD METHODS

5.2.1 SAFETY AND DECONTAMINATION PROTOCOLS

In order to safely document the U-2 shipwreck, archeological divers and support staff had to be protected from PCB contaminants found in sediments, on artifacts, and onboard the support barge and associated vessels. This was achieved through a process of isolation and decontamination. All divers were encapsulated is non-permeable SCUBA diving gear, and all non-diving staff in the proper level of personal protective equipment (PPE). Exclusion and support zones were also established on the support barge to ensure that contaminated materials were isolated and properly removed and disposed of without cross contamination. This program was developed in compliance with established URS and Hudson River Remedial Action Health and Safety protocols.

5.2.1.1. Support Barge Layout

The support barge was provided by Cashman Equipment Corp. and measured 30-ft (9.1-m) wide by 60-ft (18.2-m) long, with the sediment containment barge attached to the starboard side. As part of the isolation protocol, the support barge was divided into two sections that were called the exclusion zone and the support zone. The portside of the barge faced the underwater work area

The exclusion zone was located on the forward half of the barge, and was separated from the support zone with snow and silt fence. This zone measured 20 ft (6.1 m) by 30 ft (9.1 m), but large portions of deck space were taken up by crane or excavator pads, crane weights, fuel tanks and hydraulic power units. These obstacles reduced the exclusion zone to two 10-ft (3-m) by 15-ft (4.5 m) areas, from which diving and pumping operations were conducted. The exclusion zone was the area where activities that might result in PCB contamination took place. The first ten foot section of this zone, on the port side of the barge, was dedicated to the Scientific Diver and Primary Dive Tender (Figure 5-1). All divers entered and exited the water from this portion of the exclusion zone. The tool drop was also located in this area. The Support Archaeologist

accessed the sediment containment barge from the fore starboard corner of the exclusion zone. The rear portion of the exclusion zone on the port side served three purposes. Decontamination tools and liquids were stored there, along with the artifact storage tubs and SCUBA air tanks. The contaminated refuse bin (used for PPE disposal) was also located in this area. The safety diver and safety diver tender were stationed in the exclusion zone between the pump station and dive station. The entry from the exclusion zone to the support zone was through an enclosed changing room that isolated contamination (Figure 5-2).

The support zone was located behind the exclusion zone, and measured approximately 40 ft (12.2 m) by 30 ft (9.1 m). All uncontaminated activities took place in the safe zone. The majority of space was taken up by a Conex storage box, an office trailer and an electric generator (Figure 5-3).

The Dive Supervisor/Communications Operator (DSC) was positioned inside the clean zone on a 26-foot (7.9-m) pontoon boat moored along the port side of the barge, behind the exclusion zone (Figure 5-4). This location permitted an unobstructed view of the diving area and provided cover for the communication station beneath the vessel's canopy. Access to the barge was via the pontoon boat that held the DSC.

5.2.1.2. Decontamination Procedure

Upon dive completion, the Scientific Diver contacted the DSC to prepare the support staff for the decontamination procedure. Divers were led to a small wading pool with a seat after stepping onto the support barge. This pool was used to capture spent cleaning solution and rinse water. This waste was pumped into a holding barrel after completing decontamination.

The decontamination procedure was comprised of three cycles of Alconox surfactant and sterile water rinses (Figures 5-5 and 5-6). Soft brushes were used to scrub the diver during the Alconox applications. Special care was taken to clean latex wrist and face seals. Divers exited the exclusion zone and removed their dry suit and scuba apparatus after decontamination.

5.2.1.3. Personal Protection Equipment (PPE)

Staff who entered into the exclusion zone donned PPE, which consisted of a full chemical resistant, hooded Tyvek suit, latex gloves, Tyvek booties, and a face shield if working in the splash zone (Figure 5-7). This configuration is referred to as a modified Level D, as defined by the US Department of Labor's Occupational Safety and Health Administration (OSHA). Divers were protected by the previously mentioned dry suits and full face masks. Hands were protected from PCB contamination with two sets of latex gloves. The first (inner) set was fixed under the latex wrist seal of the dry suit, and a second (outer) pair was taped to the exterior of the wrist seals.

Figure 5-1. Scientific Diver and Primary Dive Tender in Exclusion Zone.

Figure 5-2. Exclusion Zone Changing Room, Waste Water Storage, and Decontamination Station.

Figure 5-3. Clean Zone (Left of Silt Fencing).

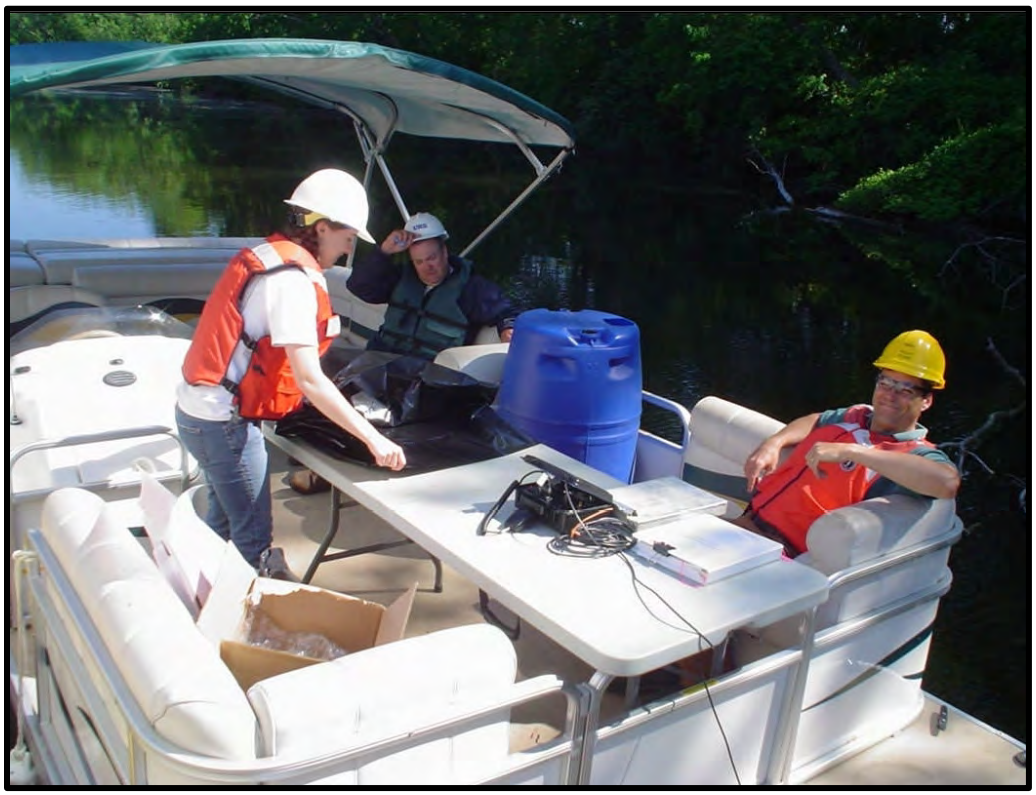

Figure 5-4. Communications Station and Pontoon Boat.

Figure 5-5. Primary Dive Tender Preparing the Decontamination Station.

Figure 5-6. Decontamination in Process.

Figure 5-7. Primary Dive Tender in Modified Level D PPE.

5.3 SCIENTIFIC DIVING REGIMEN

The URS scientific dive team consisted of six archaeologists, five of whom were certified divers trained in nautical archeology, and one who provided archaeological (non-diving) and logistical support. Dive team roles included: the DSC, Primary Archaeologist/Scientific Diver, Primary Dive Tender, Safety Diver, Safety Diver Tender, and Support Archaeologist. These roles are described below, followed by a review of dive equipment.

5.3.1 SCIENTIFIC DIVER

The responsibilities of the Scientific Diver on the U-2 project were three fold. The first was to establish a clear path to the site and to attach a marker buoy to the wreck. The buoy served as the descent line for the initial dive and was later replaced with a travel line from the base of the entry ladder to the wreck site. The second was to operate the Keene underwater dredging system and remove sediment that had buried U-2. This matrix, which was comprised of well sorted sands, wood mill refuse, mussels, and organic debris, ranged in depth from a few inches to over three feet. The third responsibility was to document U-2 using standard underwater archaeological techniques. Documentation included the creation of a comprehensive site plan, scale drawing of representative construction features, a scantling list, and photo and video documentation. The primary goal of all scientific dives was to efficiently execute the dive plan while maintaining safety standards established in the URS Scientific Dive Safety Manual (Figures 5-8 and 5-9).

5.3.2 PRIMARY DIVE TENDER

The role of the Primary Dive Tender (PDT) was to monitor and assist the Scientific Diver throughout the planned dive (Figure 5-10 and 5-11). The PDT had three responsibility phases, which included pre-dive responsibilities, active dive responsibilities, and post-dive responsibilities. The pre-dive responsibilities of the PDT were to assist the diver with gear inspection. This included inspection of the air bottle/supply, gauges, first stage, buoyancy compensator device, weight system, dry suit and gloves, and full face mask and communication system. The PDT then helped the diver dress in the dry suit and gloves while ensuring that all seals were intact and functional. The tender then helped the diver don the dive gear and gather all tools to be used during that dive.

The active dive responsibilities of the PDT began after assisting the diver into the water. These tasks often included attaching a tether to the support barge and diver and transferring tool bags. The PDT then maintained contact with the diver through the dive tether (if needed) or by watching the diver's bubbles to assess the diver's workload and air consumption rate. The PDT could communicate directly with the diver through a series of scripted tugs or "pull signals" on the dive tether, or by relay through the DSC.

The post-dive responsibilities of the PDT began they assisted the diver aboard the support barge. The tender was responsible for the decontamination of the Scientific Diver as well as helping the diver out of dry suit and gear.

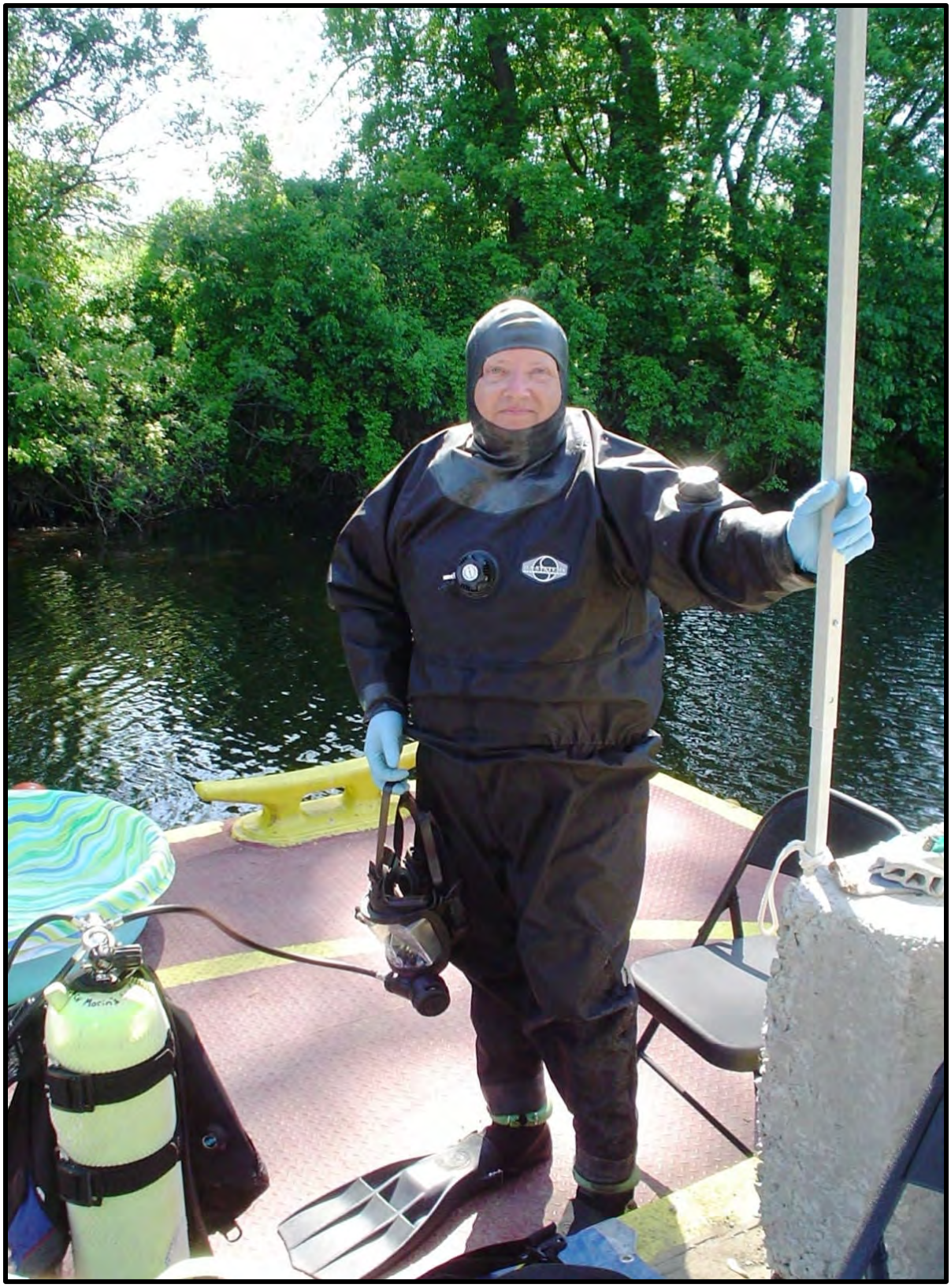

Figure 5-8. Scientific Diver Preparing to Enter the Water.

Figure 5-9. Scientific Diver Entering Water.

Figure 5-10. Primary Dive Tender and Scientific Diver.

Figure 5-11. Divers Dressing In.

Figure 5-12. Safety Diver (Seated) Observes Scientific Diver and Primary Dive Tender.

5.3.3 SAFETY DIVER

The role of Safety Diver was to ensure the safety of the Scientific Diver while submerged. The Safety Diver monitored the progress of the planned dive while outfitted in complete dive gear, and was ready to enter the water immediately if a dive problem had been reported. Once submerged, the Safety Diver was prepared to address the dive problem (s), including assisting the Scientific Diver to the surface. The Safety Diver sat in the exclusion zone during the planned dive and could enter the water via the entry ladder and then follow the tether to the diver. The Safety Diver would also exit the water through the exclusion zone, and followed the same decontamination procedure as the scientific diver.

5.3.4 SAFETY DIVER TENDER

The role and responsibilities of the Safety Diver Tender (SDT) are the same as those for the PDT. The SDT would attend to the Safety Diver, and would quickly assist the diver into the water. The SDT was dressed in the same PPE as the PDT, and followed the same decontamination procedure for the safety diver as described for the scientific diver.

5.3.5 DIVE SUPERVISOR/COMMUNICATIONS OPERATOR

The role of DSC was to oversee each planned dive. The DSC was responsible communicating with the Scientific Diver, for relaying and potentially recording archaeological data, and for logging all dive related data. The dive data recorded by the DSC included diver name, dive time, date, general dive objectives, current weather and water conditions. These dive records were curated as project data. The DSC sat outside of the exclusion zone on a pontoon boat. This was done to reduce the risk of accidental exposure and also allowed the DSC to immediately assist the tenders/divers within the exclusion zone in an emergency.

5.3.6 SUPPORT ARCHAEOLOGIST

The primary role of the Support Archaeologist was to monitor the artifact screens located on the work platform of the sediment containment barge, and to constantly agitate the sediments beneath the screens so the transfer pump could move it into the containment barge. The Support Archaeologist also removed organic debris from the screen and searched for artifacts associated with the shipwreck. Secondary responsibilities included keeping the pumps in service and assisting in clearing dredge pipes clogs. Support Archaeologists working with the pumps and removing material captured in the screens were dressed in personal protective equipment consisting of a full Tyvek suit with hood, latex gloves, and a face shield.

5.3.7 DIVING EQUIPMENT

Divers were outfitted with SCUBA and an O.S. Systems Dolphin Dry suit. The dry suit was constructed of a chemical resistant, 210 HC nylon outer shell with a waterproof polyurethane inner layer. The hood, neck, and wrist seals were constructed of .030-in (.08-cm) latex rubber to prevent water seepage. The integrated latex hood provided a waterproof seal with the full face mask, which completely isolated the diver from contaminated water and sediments. The full face mask was an OTS Guardian with a wireless underwater communications module.

5.4 SEDIMENT DREDGING AND ARTIFACT RECOVERY

Documentation and analysis of the U-2 shipwreck required the removal of sediments overlaying portions of the wreck. It was determined that removal and screening of these sediments could be

accomplished using an underwater, handheld dredge to remove the sediments, pump them to the surface, and pass the them through quarter-inch mesh screens in order to recover any artifacts associated with the wreck.

Sediments in the immediate vicinity of U-2 were composed of sorted riverine soils, wood mill waste, natural detritus, and trash, and had previously been determined to contain measureable amounts of PCBs (Figures 5-13 and 5-14). Due to the presence of PCBs, it was determined that any material removed from the river bottom needed to be pumped into a materials barge for further processing and disposal.

The dredge pump used to remove sediments from the U-2 wreck and river bottom was a Honda brand high volume, low pressure pump capable of pumping 300 gallons of water per minute (Figure 5-15). The dredge apparatus consisted of a hand held brass tube connected to a length of 2.5-in diameter plastic hose. This was connected to the dredge pump/engine which floated on two pontoons adjacent to the work barge. Two additional plastic tubes were attached to the rig in order to pump water through the dredge to create suction. A 2.5-in diameter plastic discharge hose extended from the pump/engine and was secured to screens overlaying a large metal tank used for temporary storage of water and sediments.

The temporary storage tank into which water and sediments from the wreck were pumped was secured to a pontoon boat attached to the work barge (Figure 5-16). This tank measured approximately 9-ft (2.7–m) long and 3-ft (.9-m) deep, and held up to 500 gallons of water. Two wooden box screens with quarter inch mesh were placed in the center of the tank. Water and sediments removed from the river bottom were pumped to the surface by the dredge pump and passed through the screen by attaching the dredge pump discharge hose to the screen surface. Water and sediments passed through the screen, while larger material such as rocks, freshwater mussels, and artifacts were trapped in the screens. This material was removed by the dredge pump operator (Figures 5- 17 and 5-18).

A 4-in trash pump capable of pumping 600 gallons per minute was used to pump water and sediments out of the temporary storage tank and into the materials storage barge attached to the work barge (Figure 5-19). A hose extending from the trash pump was attached to the interior wall of the temporary storage tank on the pontoon boat. Sediments that accumulated on the bottom of the temporary storage tank were pushed towards the trash pump hose using a broom or shovel in order to move this material and prevent it from filling the temporary storage tank and weighing down the pontoon boat. The hose attached to the storage tank lead directly to the trash pump, which was positioned on the work barge. All water and sediments were pumped through the trash pump discharge hose into the 195-ft (59.4-m) by 30-ft (9.1-m) sediment catchment barge attached to the work barge (Figures 5-20 and 5-21).

Artifacts were retained in plastic bags, while rocks, wood fragments, and other non-cultural materials were placed in buckets and eventually deposited in the materials barge. No specific provenience data was recorded for finds, because it was assumed that U-2 had been moved from its original location. All artifacts were assigned to the site's general collection.

Figure 5-13. Video Image of Sediment Package and Debris that Covered U-2, Facing East.

Figure 5-14. Video Image of Mill Waste on the River Bottom, Facing East.

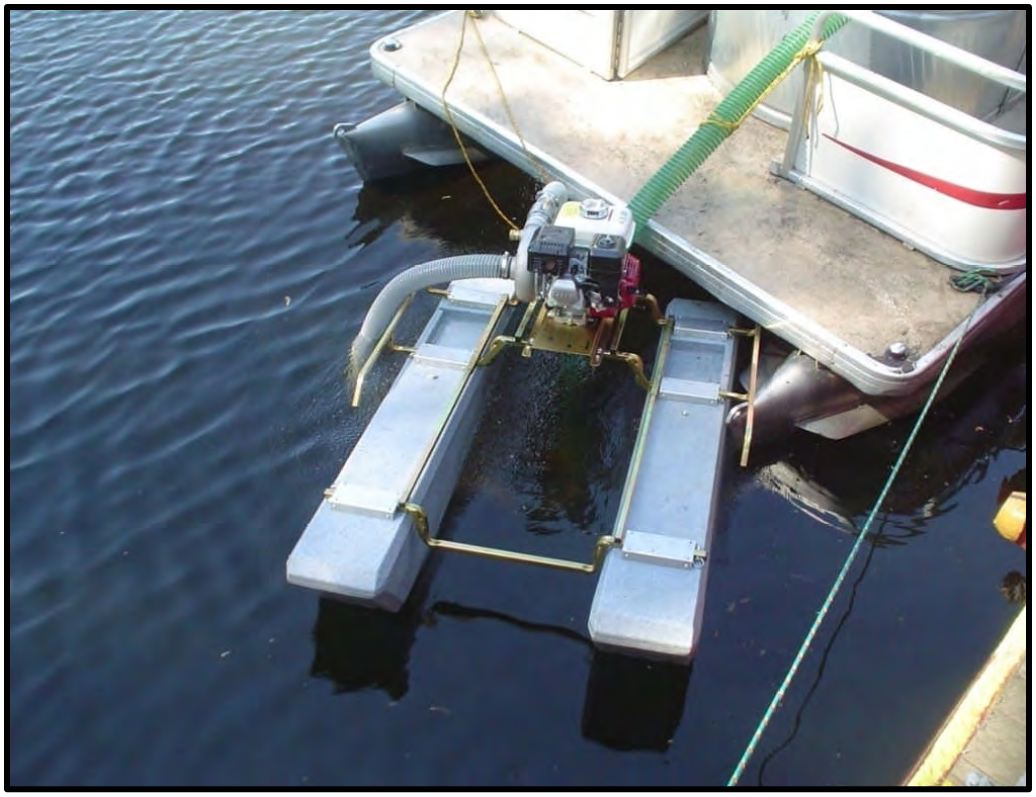

Figure 5-15. Dredge Pump Used to Expose Wreck U-2.

Figure 5-16. Storage Tank and Pontoon Boat.

Figure 5-17. Screening Dredged Sediments.

Figure 5-18. Dredge Waste Removed during Screening.

Figure 5-19. Intermediate Sediment Pump between Screen and Catchment Barge.

Figure 5-20. Exterior of Catchment Barge, Facing North.

Figure 5-21. Interior of Catchment Barge, Facing North.

5.5 SHIPWRECK DOCUMENTATION

The main focus of the data recovery was to document the ship remains. U-2 was a badly fragmented vessel that appears to have been moved from its original wreck site, broken, and re-deposited upside down in its current location. The fragile vessel remains could not be moved without greatly diminishing the research potential of the site. The documentation of U-2 was a multi-step process that included underwater photography and video, the creation of detailed site plans and profiles, the scale drawing of diagnostic construction elements, and wood sample collection.

The recordation of the exposed portion of U-2 began with the establishment of a baseline along the longitudinal axis of the shipwreck. The baseline was composed of a fiberglass reel tape delineated in tenths of feet which was fixed to the wreck with green tabbed roofing nails (Figures 5-22 and 5-23). The baseline extended along this axis for 35 ft (10.67 m). Construction elements were then documented sequentially by recording perpendicular offsets from this baseline. Offset measurements were taken using folding rulers delineated in tenths of feet, and were recorded in pencil on frosted 0.10-millimeter (mm) Mylar sheets data taped to plastic clipboards. Hull planking was documented first, followed by the internal framing, the daggerboard trunk, fastening patterns, and other construction elements such as limber holes and tool markings. Data recorded during each dive was immediately transferred upon surfacing to the plan view drawing. No additional raw data were obtained until the site plan had been thoroughly updated. Artifacts were not included on the site plan because it was assumed that the shipwreck had been re-deposited.

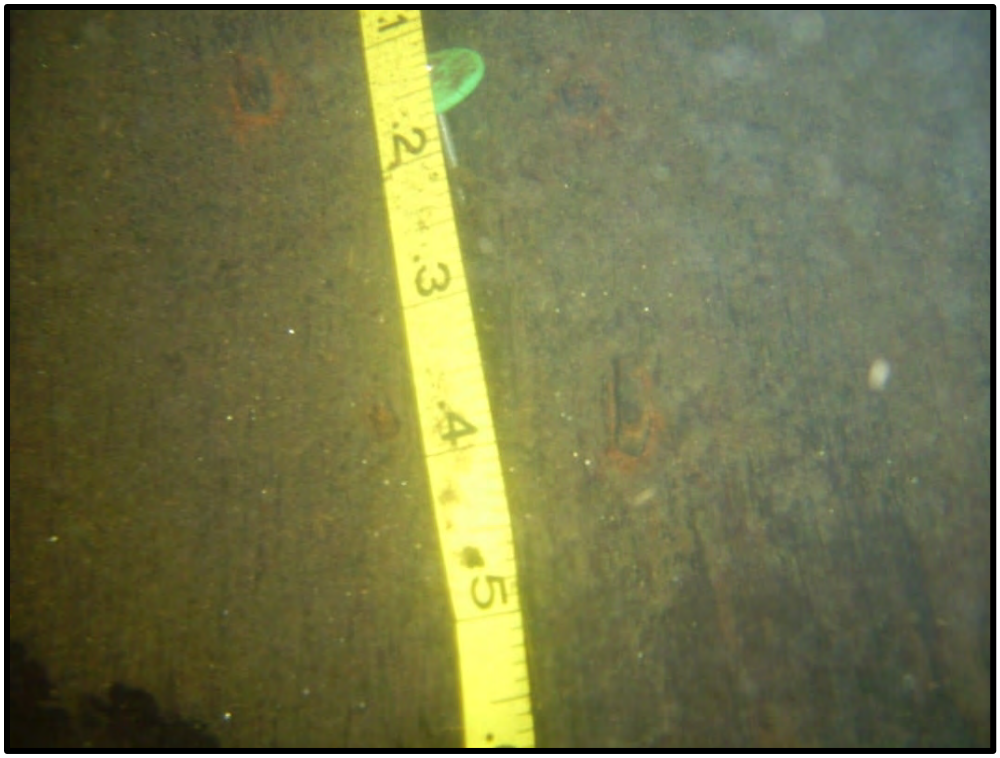

Figure 5-22. Underwater Photograph of Baseline, Facing South.

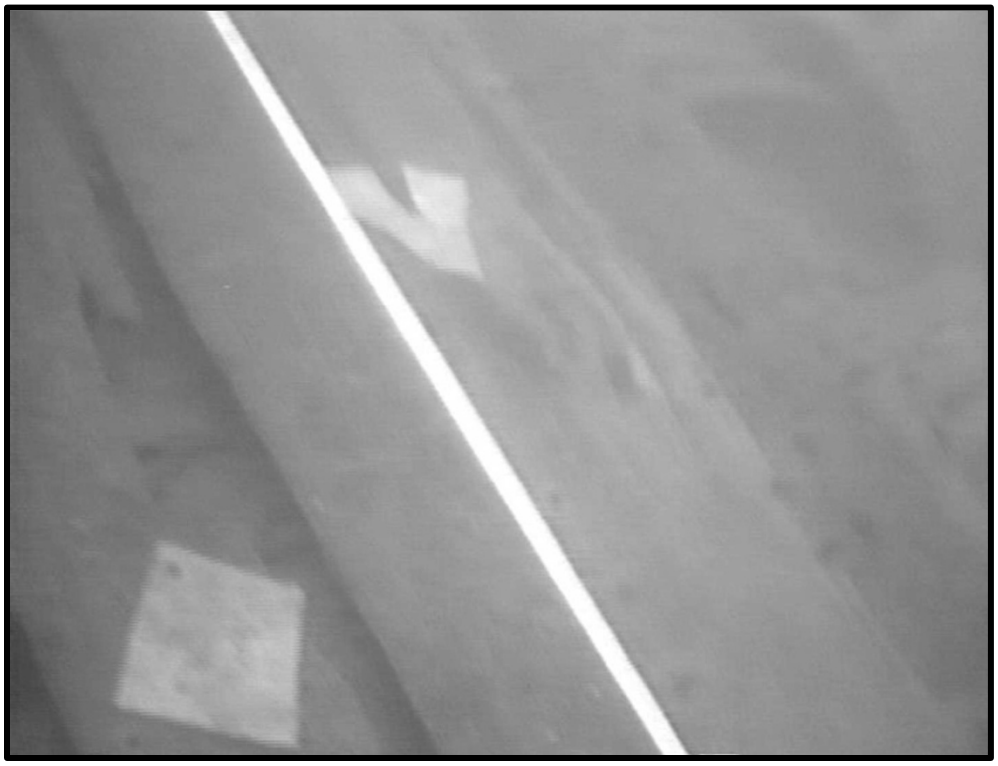

Figure 5-23. Video Image of Baseline and Mylar Marking Tags, Facing Southwest.

Diagnostic elements of the vessel were documented separately, including select frames and the daggerboard assembly. Construction elements, including floors and futtocks from Frame 11, were removed from the river and documented aboard the support barge. Documentation included scale drawing of at least two faces and digital photography (Figures 5-24 to 5-27). The daggerboard was documented by establishing a secondary baseline along the longitudinal axis of the trunk. Offset measurements were then taken from this datum and a second schematic was created at a larger scale. The daggerboard box was then cut free from the shipwreck, raised from the sediment and documented in a similar manner. It was then added to the scale drawing of the trunk.

Digital photography and video were also taken of U-2. These included an overview of the entire wreck after dredging was completed, and a review of diagnostic elements. Water turbidity prevented clear photography and video in most cases. Photograph and video logs were created to catalog the imagery.

A total of 18 wood samples were removed from diagnostic elements of the shipwreck using a three pound mallet and wood chisel. Each wood sample was placed in a zip lock bag labeled with the sample site. Samples were taken to the URS archaeological laboratory in Gaithersburg, Maryland for identification by archaeobotanist Kathleen Furgerson.

Figure 5-24. Timbers to be Documented.

Figure 5-25. Documentation in Progress.

Figure 5-26. Creating Scale Drawings of Diagnostic Construction Features.

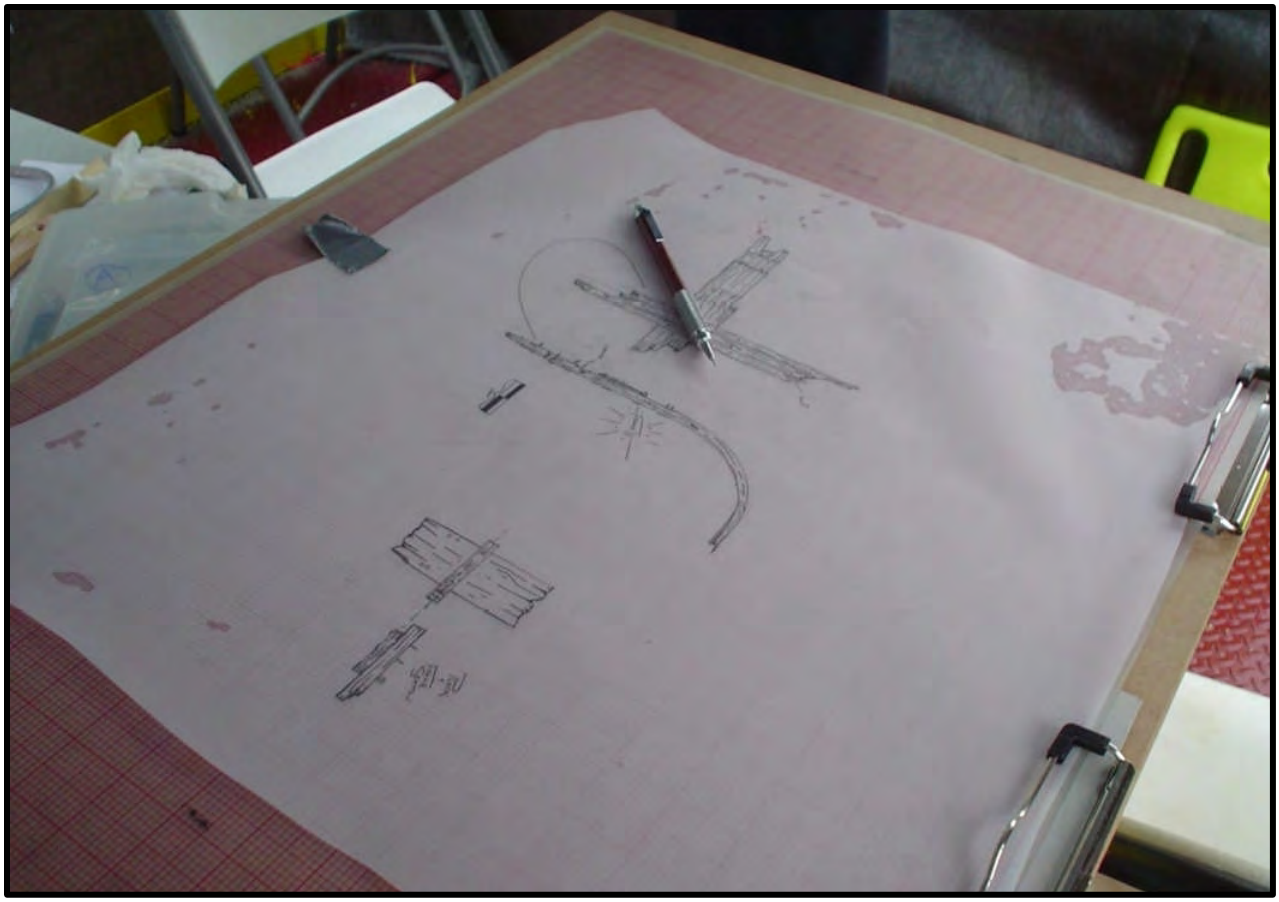

Figure 5-27. Partially Completed Drawing.

5.6 LABORATORY METHODS

Artifacts from the U-2 investigation were transported to the URS archaeological laboratory in Burlington, New Jersey. They were processed according to the Secretary of the Interior's *Standards and Guidelines for Curation* (36 CFR 79). The objectives of laboratory processing and analysis were to determine, to the extent possible, the date and potential function of U-2.

Each artifact was first assigned a provenience-based binomial log/catalog number. The number prefix 02 indicates that the artifact were a component of the general collection from the site. The sequential number in the binomial represents the artifact number. Artifacts were then gently washed using plain water and a soft toothbrush.

All objects were cataloged according to functional group, material, and type based roughly on South (1977), and information was entered into an Access database (Appendix D). South's artifact groups consist of:

- Kitchen – items used primarily in the kitchen, such as glass, ceramics, stove parts, and food remains;
- Faunal/Bone – items consumed by site occupants;

- Architecture – construction material and decoratively functional (e.g., doorknobs or moldings) elements used in a building;
- Clothing – any part of clothing, from a whole garment to a fragment of cloth, a single bead, or a button, as well as sewing items such as a needle or thimble;
- Furniture – furniture hardware and other furniture parts;
- Personal – small items belonging to one person, such as coins, hygiene products, and jewelry;
- Arms – gun parts and ammunition;
- Tobacco – items used to smoke tobacco; and
- Activities – items used to perform an act, such as hardware, toys, transportation, construction, and recreation.

Artifacts were handled with nitrile gloves during washing and cataloging to prevent PCB contamination. They were not labeled or conserved due to PCB contamination and were discarded after analysis and documentation.

5.6.1 Wood Identification Methods

A total of 18 wood samples were submitted for analysis from seven different structural elements of the vessel. Samples were received dry in 2-mm thick plastic Ziploc bags with provenience tags. Due to PCB contamination, strict safety protocols were followed during analysis. PPE used during analysis included a long-sleeved white lab coat, a Tyvek apron and nitrile gloves. If a glove was torn or punctured, it was removed, discarded, and replaced. All PPE was disposed of upon completion of the analysis.

Initial examination was completed while samples were still in plastic bags; this was done to assess the samples' condition and minimize exposure. The samples were received dry, which obscured vital microscopic detail on the ends of the samples. Hydration inside a fume hood was therefore necessary to soften the wood. Each sample was soaked for 20 minutes in a labeled metal pan filled with tap water. Thin sections were then removed from the transverse end of the sample using a single-edge razor blade. Sections were then placed into labeled plastic bags and taken to the microscope station; larger wood samples were allowed to dry under the fume hood.

Taxonomic identification was completed using a trinocular, stereo-zoom microscope at 10 – 40x magnification illuminated with an adjustable fiber-optic lamp. Wood thin sections were handled with disposable plastic forceps to reduce contact. All taxa were identified to the lowest taxonomic level possible (i.e., family, genus, or species level). Taxa that could not be identified to genus or species with 100 percent confidence were preceded with "cf." following Pearsall (1989:149). A modern reference collection, reference texts (Core et al. 1979; Hoadley 1990, 2000; Panshin and de Zeeuw 1970), and online databases (e.g., USDA, NRCS 2010) were used to identify taxa. All nomenclature follows USDA, NRCS (2010) conventions.

6.0 RESULTS OF ARCHAEOLOGICAL INVESTIGATIONS

Resource U-2 was tentatively identified as an early 19th century sailing vessel with a flat bottom and centerboard during the previous Phase I and Phase II studies. The focus of the data recovery was to expose and document more of the shipwreck in order to identify and more thoroughly comprehend the morphological nuances of the vessel. It was anticipated that these insights would permit a more definitive identification of general vessel type and form, which would, in part, place U-2 within a better defined historical context.

6.1 SITE OVERVIEW

U-2 was discovered upside down in a severely fragmented condition (Cassedy and Cox 2006a). This indicates that the vessel likely sank in, or near, the river channel in an upright position, and was later moved and re-deposited upside down near the eastern bank line. This was done, in all probability, because the wreckage was deemed a hazard to navigation (Kane et al. 2007). Deterioration on several frame ends found buried in river sediment supports the supposition that the vessel was at one point lying on the keel, or right side up, and was either not completely buried or periodically exposed above the waterline (Figure 6-1).

The wreck, as encountered, lay almost flat to the river bottom in between 7 ft (2.1 m) and 10 ft (3 m) of water. The daggerboard assembly was situated closest to the river channel (facing northwest), and the intact portion of the turn of the bilge toward the southeastern bank line. The portion of the wreck that lay closest to the channel was scoured clean and exposed; the remainder of the vessel was buried by 3 to 4 ft (0.9 and 1.2 m) of sediment and debris.

The wreck location, sediment removal, and documentation were accomplished in 26 dives with a cumulative bottom time of 1,213 minutes. Site conditions were fair with water temperatures ranging between 49 and 55 degrees Fahrenheit, underwater visibility between 3 to 6 ft (.9 to 1.8 m), and currents between 0.5 and 1 knot. The structural remains of U-2 measured approximately 13 ft (4 m) in width and 33 ft (10.1 m) in length. They were composed of portions of the vessel bottom (including hull planking and framing), a daggerboard assembly, and a small portion above the turn of the bilge for a span of 13 frames (Figures 6-2 to 6-4). Twenty-eight artifacts (Appendix B) were recovered during the excavation, and 18 wood samples were taken from representative structural members.

Figure 6-1. The Deteriorated Terminus of Frame 7.

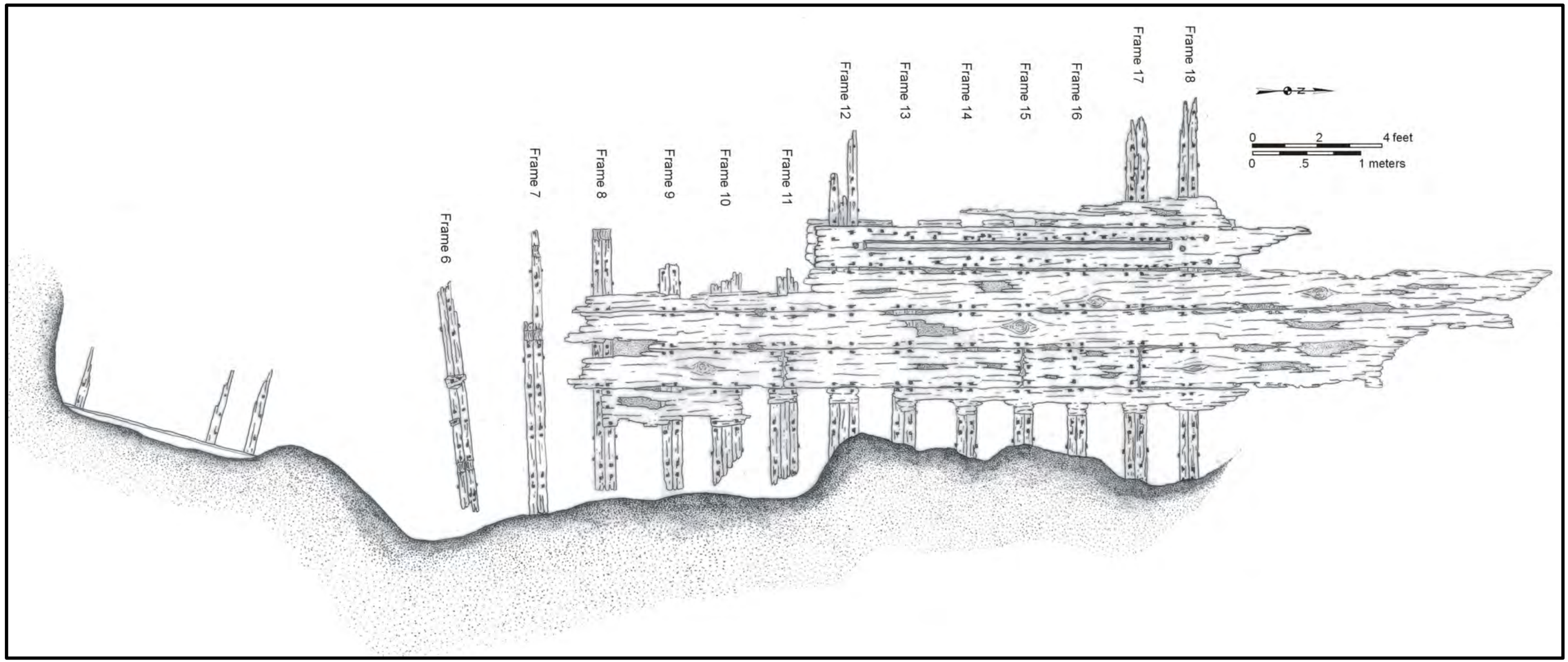

Figure 6-2. Overall Site Plan of U-2, as of May 2009

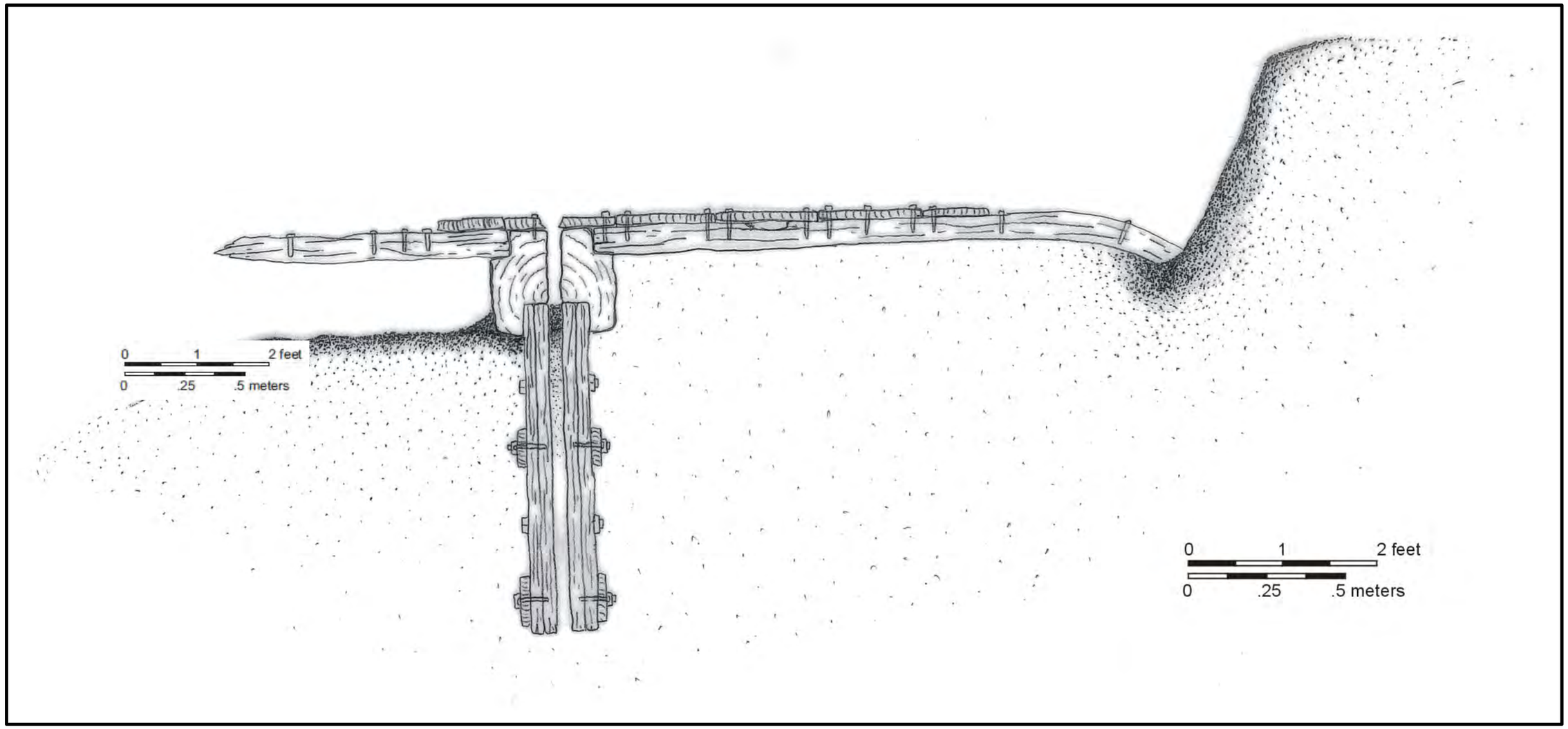

Figure 6-3. U-2 Site Profile, Facing North.

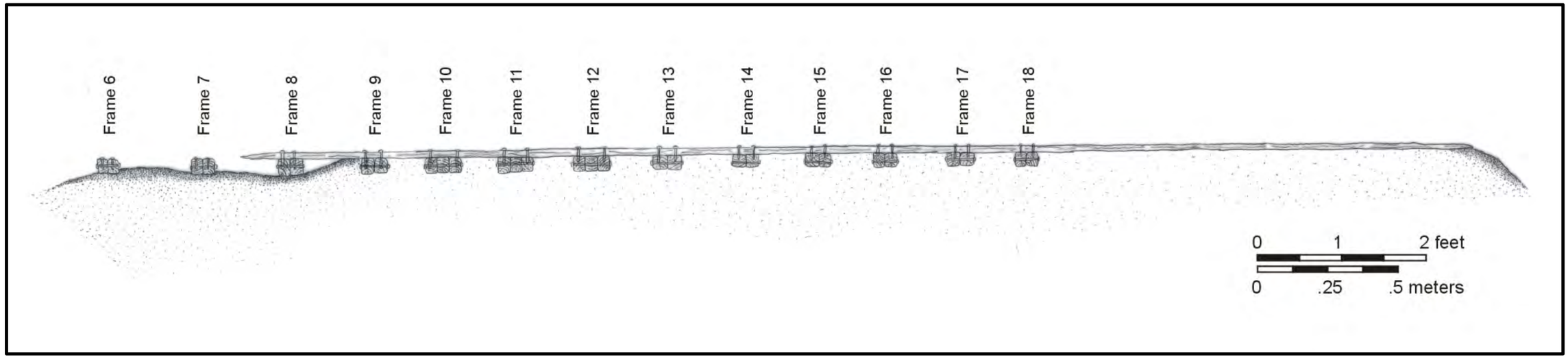

Figure 6-4. Profile of U-2 Showing Framing Pattern, One foot East of Daggerboard Trunk, Facing West.

6.2 LABORATORY ANALYSIS RESULTS

Thirty-four historic artifacts were recovered from dredging efforts during the data recovery; and eight additional artifacts, all fasteners, were removed from wreck elements as examples (Table 6-1). Four functional groups were represented in this assemblage, including the architectural group (n=9, 26.5 percent), the kitchen group (n=19, 55.9 percent), the tobacco group (n=5, 14.7 percent), and the miscellaneous group (n=1, 2.9 percent). Artifacts ranged in date from the mid-eighteenth century to the present. The architectural artifacts included four iron cut nails, one iron nut, one iron washer, one iron bolt, one iron rod fragment, and one copper alloy hinge (Figure 6-5 to 6-7). The cut nails were originally used to attach planks to frames. The bolt, washer, nut and hinge were recovered during dredging and are likely not associated with U-2.

Table 6-1. Artifact Groups Recovered during Dredging

Group	Count	Percent
Architectural	9	26.5
Kitchen	19	55.9
Miscellaneous	2	5.8
Tobacco	4	11.8
Total	**34**	**100.00**

Kitchen group artifacts include seven glass fragments and 12 ceramic fragments (Table 6-2; Figures 6-8 and 6-9). The glass assemblage was comprised of five bottle fragments and two milk glass dish fragments. The ceramic assemblage includes three white granite, two whiteware, one redware, one creamware, one porcelain, and four stoneware fragments.

Table 6-2. Kitchen Artifacts

Artifact	Date Range	Count
Creamware	1765-1820	1
White granite	1842-1930	3
Albany slip stoneware	1805-1940	1
Grey salt glazed stoneware	17th century-present	1
Blue stamped Westerwald stoneware	1700-1775	1
White salt glazed stoneware	1744-1775	1
Whiteware	1820-present	2
Chinese porcelain	17th century-present	1
Redware	17th century-present	1
Aqua glass (hand blown)	1800-present	2
Milk glass	1850-present	2
Non-leaded clear glass (hand blown)	1750-1920	3
	Total	**19**

The remaining artifacts include two kaolin tobacco pipe bowl fragments, two kaolin tobacco pipe stem fragments ($^{5}/_{64}$-in bore diameter) from the tobacco group (Figure 6-10). The miscellaneous group includes a single kaolin kiln stilt and a terra cotta sewer pipe fragment.

Figure 6-5. Sample of Cut Nails Removed from Planks and Frames.

Figure 6-6. Nut, Washer, and Bolt Fragment Recovered During Dredging.

Figure 6-7. Hinge Recovered During Dredging.

Figure 6-8. Glass Recovered During Dredging.

Figure 6-9. Ceramics Recovered During Dredging.

Figure 6-10. Kaolin Tobacco Pipe Fragments Recovered During Dredging.

Thirty of the 34 artifacts were recovered from overburden during dredging, and are likely not associated with U-2. They do not appear to have any demonstrable functional or chronological association with the shipwreck. They are, in all likelihood, associated with 250 years of historic trash disposal activity on that section of the Hudson River, beginning with the early development of Fort Edward. In contrast, the four cut nails recovered from the site were removed from frames and planks of the wreck as a fastener sample.

6.3 WOOD IDENTIFICATION RESULTS

Three wood taxa were identified from the 18 wood samples taken from U-2. These include the white oak group (*Quercus* spp., Leucobalanus group), eastern white pine (*Pinus strobus*), eastern redcedar (*Juniperus virginiana*), and tamarack (*Larix laricina*). Of the 18 samples, 16 were from the white oak group, with the remaining two identified as noted. A description of each taxon follows with a summary of its historic uses; Table 6-3 includes a summary of the wood samples with their wood identifications.

Table 6-3. Wood Types from U-2

Provenience	Common Name	Latin Name
Plank fragment, Frame 11	White oak group	*Quercus* sp. Leucobalanus group
Plank sample	White oak group	*Quercus* sp. Leucobalanus group
Plank repair	White oak group	*Quercus* sp. Leucobalanus group
Plank on exposed futtocks	White oak group	*Quercus* sp. Leucobalanus group
Plank, daggerboard trunk	White oak group	*Quercus* sp. Leucobalanus group
Floor-Frame 10	White oak group	*Quercus* sp. Leucobalanus group
Floor-Frame 11	White oak group	*Quercus* sp. Leucobalanus group
Floor, Frame 17	White oak group	*Quercus* sp. Leucobalanus group
Floor, Frame 9	White oak group	*Quercus* sp. Leucobalanus group
Futtock, exposed	White oak group	*Quercus* sp. Leucobalanus group
Futtock 2 Frame 11	White oak group	*Quercus* sp. Leucobalanus group
Futtock 1 Frame 11	White oak group	*Quercus* sp. Leucobalanus group
Futtock 1, Frame 9	White oak group	*Quercus* sp. Leucobalanus group
Daggerboard trunk	Eastern redcedar	*Juniperus virginiana*
Daggerboard box stanchion	White oak group	*Quercus* sp. Leucobalanus group
Daggerboard box stringer-bottom	White oak group	*Quercus* sp. Leucobalanus group
Daggerboard box stringer-top	White oak group	*Quercus* sp. Leucobalanus group
Daggerboard box lining	Tamarack	*Larix laricina*

6.3.1 TAMARACK (LARIX LARICINA)

Tamarack, or American larch, (*L. laricina*) is a native species that grows to 100 ft (30.5 m) in height and 3 ft (.9 m) in diameter (Britton and Brown 1970; USDA, NRCS 2010). Tamarack thrives in swampy woods and around lake margins; the wood has water resistant properties (Britton and Brown 1970). This species is durable and was used in construction and shipbuilding (Bailey 1909; Henderson 1890). Kellogg (1914) lists many uses of larches, including manufacture of floors, keels, knees, and stringers of ships.

6.3.2 EASTERN REDCEDAR (JUNIPERUS VIRGINIANA)

Eastern redcedar belongs to the family Cupressaceae; it is a native, slow-growing tree that grows east of the Rocky Mountains (USDA, NRCS 2010). This species can reach a maximum height of 100 ft (30.5 m) and trunk diameter of 5 ft (1.5 m; Britton and Brown 1970). While found in a variety of habitats, eastern redcedar prefers dry soils (USDA, NRCS 2010). Eastern redcedar is durable, easily workable, and resists moisture and decay. It is no surprise it was a favorite wood for many uses, especially fence posts, shingles, and boatbuilding (Kellogg 1914; Porcher 1869).

6.3.3 WHITE OAK GROUP (QUERCUS SPP., LEUCOBALANUS)

Oaks are shrubs or trees in the beech family (Fagaceae); there are over 400 species worldwide (Britton and Brown 1970; eFloras.org 2010), including over 187 oak species in North America (183 native and four introduced; USDA, NRCS 2010). Native oak trees can grow to over 200 ft (61 m) in height and over 8 ft (2.3 m) in trunk diameter and grow in a variety of habitats (Britton and Brown 1970). Oaks are split into three main groups based on their microanatomy: live oaks, red oaks (Erythrobalanus), and white oaks (Leucobalanus). Of the eastern oaks, the white oak group includes white oak (*Q. alba*), swamp white oak (*Q. bicolor*), overcup oak (*Q. lyrata*), bur oak (*Q. macrocarpa*), chinkapin oak (*Q. muehlenbergii*), chestnut oak (*Q. prinus*), and post oak (*Q. stellata*).

Oak is strong, tough, hard, and heavy, making it desirable for a variety of purposes. White oaks were generally viewed as more durable than red oaks and were used for shipbuilding (Griffith 1847; Kellogg 1914; Porcher 1869; Von Mueller 1888). Von Mueller (1888:353) notes that *Q. alba* and *Q. stellata* were both used in ship building, and that *Q. stellata* was "particularly prized for ship-building." Both species grow in the Northeast.

6.3.4 DISCUSSION

Oak samples were noted to have very little late wood in the growth rings, which indicates slow growth (Hoadley 1990; Panshin and de Zeeuw 1970). Slow growth can result from a number of factors, including moisture stress (i.e., lack of adequate moisture during the growing season). The early nineteenth century date of the U-2 vessel places it within the Little Ice Age, which may partially account for this.

The Little Ice Age occurred between ca. AD 1200 and 1900, and it was defined by cooler temperatures and glacial advances in many parts of the world (Grove 1990). Goudie (1992) noted that complex cooling and warming patterns existed during the Little Ice Age, which created periods of climatic instability. Historic records provide detailed accounts of deteriorating climatic conditions in Canada and the northern United States (Bradley and Jones 1995; Goudie 1992; Grove 1990; Wilson et al. 2000). The Little Ice Age would have been characterized not only by erratic temperature fluctuations, but also by periods of drought that could last decades

(e.g., Brush and Hilgartner 2000; Mann et al. 1998; Mayewski et al. 2002; National Climatic Data Center 2005; Osborn and Briffa 2006). Cooler temperatures and less moisture would stress tree populations and would slow individual tree growth. It appears that the oak used on the U-2 vessel suffered such environmental stress.

The other species of wood (tamarack, and redcedar) were not noted to have the same patterns of slow growth as the oak. Redcedar and tamarack are slow-growing species, and it is possible they would not exhibit stress in the same way. It is also possible that the thin sections removed from this sample and the tamarack and redcedar were not sufficient to determine unusual growth ring patterns.

Regardless of any climatic stresses on the woods, all three taxa were chosen for their water- and decay-resistant properties, durability, and strength. These are species that were well-known historically, and were chosen for the qualities that made them valuable for construction of watercraft.

The majority of U-2 construction elements were fashioned from white oak (planks, floors, and frames; Table 6-3). The daggerboard stanchions and posts were also white oak, but the trunk was comprised of red cedar and the daggerboard box lining of larch.

6.4 HULL ANALYSIS

The most complex artifact analyzed during nautical archaeological efforts is the hull, or structure, of the vessel. Approximately 10 percent of the hull of U-2 was available to be documented during the data recovery. These remains were comprised of hull planking, a series of 13 frames, and a daggerboard assembly. Each of these structural features is described in detail below, followed by the presentation of four reconstructed cross sections.

6.4.1 HULL PLANKING

The frames and daggerboard trunk were sheathed in four runs of white oak hull planking that measured between 9-in and 11.5-in (22.9-cm and 29.2-cm) wide and 1.25-in and 1.5-in (3.2-cm and 3.8-cm) thick (Figures 6-2, 6-3, and 6-11). The planking was fastened to frames with 2-in to 3-in (5-cm to 7.5-cm) long square shanked, hand wrought iron fasteners that measured approximately 0.25-in (0.6-cm) thick at the 0.4-in (1-cm) head. The shank of each fastener tapered abruptly to a point. The fastening pattern was standard throughout the vessel, with two fasteners pinning the plank to each frame 0.8 to 1.2 in (2 to 3 cm) from the plank edge. A single plank repair was observed between frames 15 and 17, on the third plank run east of the daggerboard trunk. The repair was fastened heavily (Figure 6-1) and is fashioned from white oak. Other plank butt seams were visible, and these were heavily fastened like the plank repair.

6.4.2 FRAMING

A total of 13 frames were documented during the U-2 excavations (Figures 6-1 through 6-3). Frame 5, which was documented in the 2007 LCMM report was not present, and was likely carried away from the site during a period of heavy current (some exposed planking was also damaged between the Phase II and Phase III excavations). Frames identified during the Phase III excavation were assigned numbers established originally by LCMM during dive operations in November and December of 2006. No complete frames were documented during the data recovery.

The frames of U-2 were flat bottomed with an abrupt turn of the bilge that quickly formed straight, parallel sides (Figures 6-12 to 6-15). They were lightly constructed of white oak and were composed of doubled or tripled floors and futtocks. Both floors and futtocks were curved at the turn of the bilge. Basic wood grain analysis indicates that the vast majority of curved framing elements were compass timbers, but some curved frame components were further shaped to match the shape of mated pieces.

Figure 6-11. Planking Sample with Attached Floor.

Figure 6-12. Video Image of Frames 9, 10, and 11 Curving into the Sediment, Facing North.

Figure 6-13. Video Image of the Eastern Extreme of Frame 10, Facing East.

Figure 6-14. Example of a Doubled Floor from Frame 17.

Figure 6-15. Example of a Tripled Floor, Frame 11.

Floors were joined to futtocks with a diagonal scarf (Figure 6-16); these scarfs were staggered so as to not significantly reduce the lateral stiffness and strength of the frames. All frames had matching sets of limber holes to either side of the centerline. The holes were 1-in (2.5-cm) moulded and 2.5-in (6.4-cm) sided, and tool markings indicate that limbers were cut with a small adze (Figures 6-17 and 6-18). Limber runs were located approximately 2.5 ft (0.8 m) from the centerline of the daggerboard trunk.

Frame sets 12 through 18 were located along the daggerboard trunk. Frames 13 through 17 were half frames married to the daggerboard trunk via 2.5-in to 3-in (6.3-cm to 9.8-cm) deep notches cut into the base of the trunk itself. Frames 12 and 18 were whole frames that were set in a flat mortise that extended the width of the daggerboard trunk. Frames 12 through 18 were spaced between 9 in and 10.5 in (22.9 cm and 26.7 cm). Frames 13 through 18 were doubled, with each member measuring 2.5-in (6.4-cm) sided and 2-in (5-cm) moulded for a total dimension of 5-in (12.7-cm) sided and 2-in (5-cm) moulded. Frame 12 was tripled, with each member measuring 2-in (5-cm) sided by 2-in (5-cm) moulded, for a total dimension of 6-in (15-cm) sided and 2-in (5-cm) moulded.

Frames 6 through 11 were whole frames that extended the entire breadth of the vessel. Frames 6 through 9 were doubled, with each member measuring 2.5-in (6.3-cm) sided and 2-in (5-cm) moulded, for a total dimension of 5-in (12.7-cm) sided and 2-in (5-cm) moulded. Frames 10 and 11 were tripled, with each member measuring 2-in (5-cm) sided by 2-in (5-cm) moulded, for a total dimension of 6-in (15-cm) sided and 2-in (5-cm) moulded. Frame 11, which was recovered intact beyond the turn of the bilge, maintained sides that were straight after the turn of the bilge and formed a 90 degree angle with the associated floor timbers. Spacing was 1 ft (30.5 cm) between each of frames 6, 7, and 8, but varied between 9 in and 10 in (22.9 cm and 25.4 cm) between frames 9, 10, and 11.

Two types of fasteners were used to construct frames. Floors were fastened to futtocks with a series of hand wrought, square-shanked iron spikes that measured 0.4 in (1 cm) in diameter with a 0.5-in (1.25-cm) head. The shanks were between 3 in and 6.5 in (7.6 cm and 16.5 cm) in length and tapered to a sharp point. Doubled and tripled futtock and floor members were fastened with slightly larger, hand wrought, square-shanked iron spikes that measured 0.5 in (1.25 cm) in diameter with a 0.6-in to 0.7-in (1.5-cm to 1.8-cm) head. They were between 4 in and 6.5 in (10.2 cm and 16.5 cm) in length and also tapered to a sharp point. There was no apparent fastening pattern noted on frames.

6.4.3 DAGGERBOARD ASSEMBLY

The most diagnostic feature of U-2 is the daggerboard trunk and box assembly (Figure 6-19). A daggerboard, or slip keel, served as a keel that could be raised and lowered through a watertight housing, or box. The board was lowered when sailing in water deep enough to contain it, and was gradually raised as waters became shallower. The daggerboard provided sailors with the flexibility to traverse shoal waters, and also reduce lateral drift when sailing in a more open environment. Boats with this design feature could access shallow ports and pass over dangerous rock outcrops, and could also more efficiently transport goods and people in deeper waters due to less lateral drift. These shallow and deeper water ports are common to the upper Hudson River and Lake Champlain waters in which U-2 operated.

Figure 6-16. Example of a Diagonal Scarf on a Floor Timber.

Figure 6-17. Video Image of a Limber Hole in Plan View, Frame 11, Facing East.

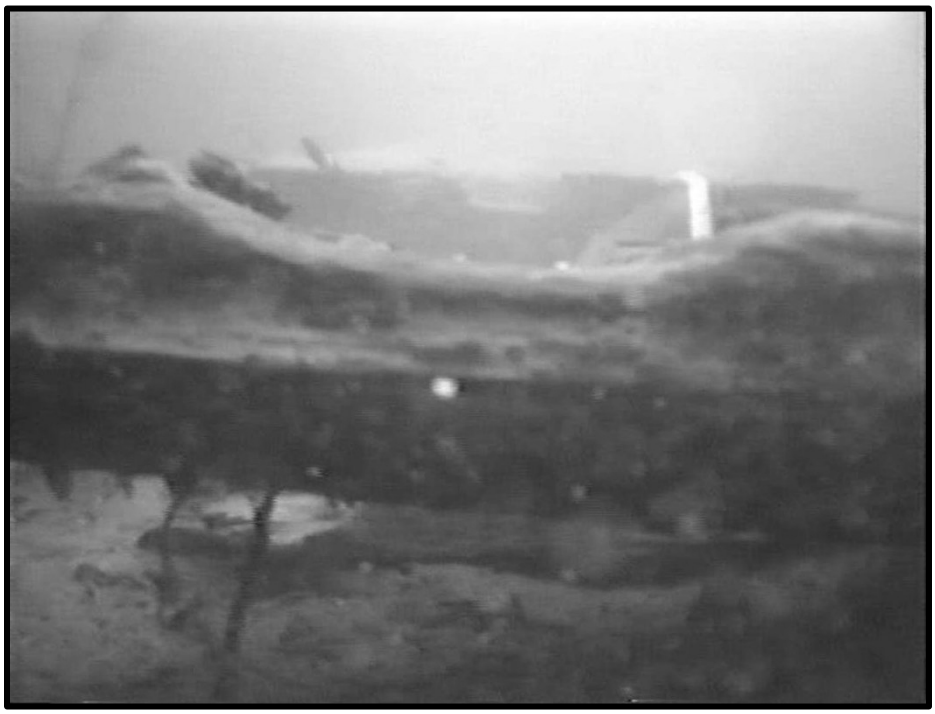

Figure 6-18. Video Image of Limber Holes in Profile, Frames 11 and 12, Facing North.

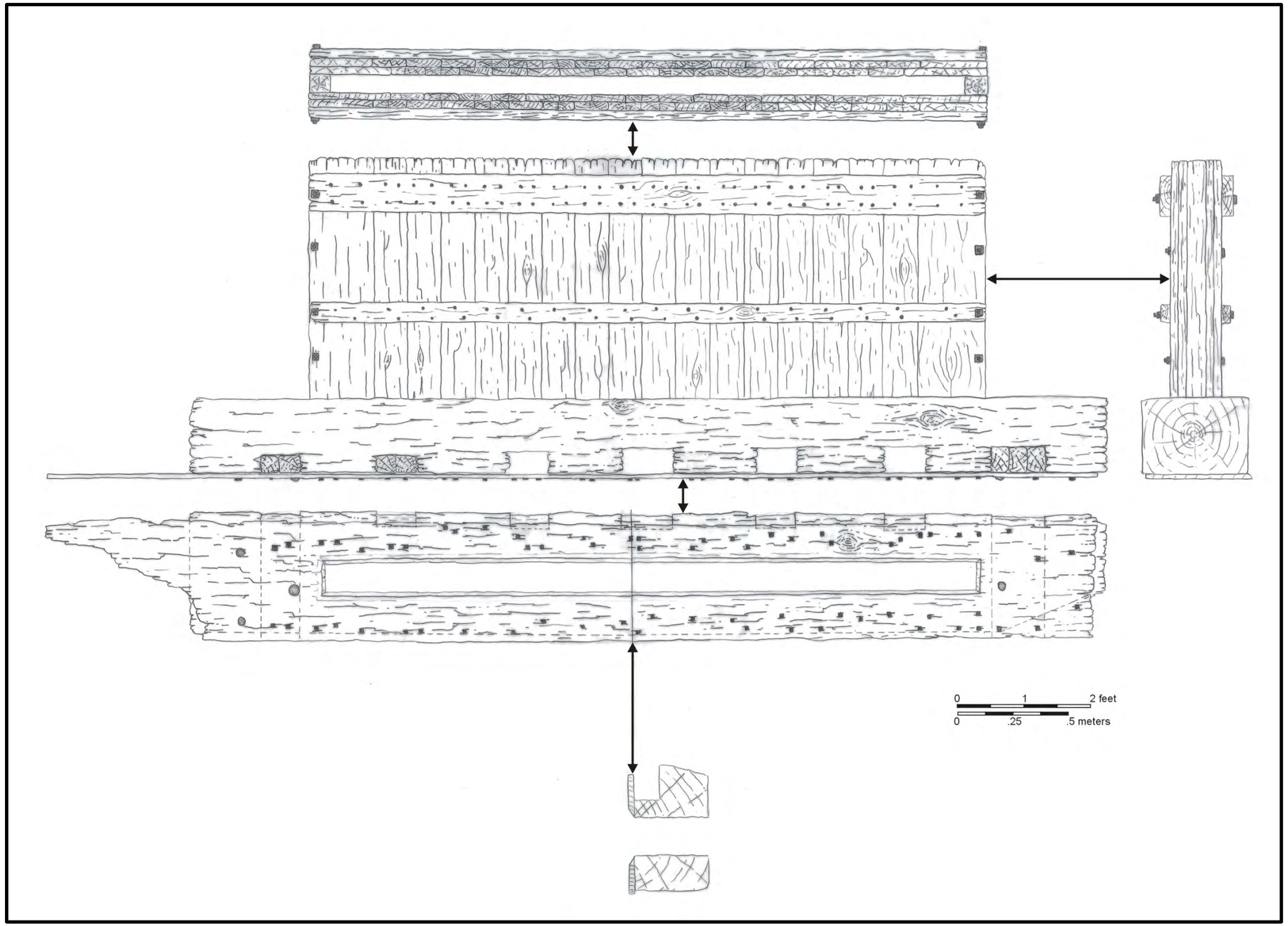

Figure 6-19. Schematic Drawing of Daggerboard Assembly.

It is clear that the trunk and box assembly of U-2 was designed for housing a daggerboard (and not a centerboard) because of its small size and light construction compared with known centerboards. It also did not maintain a large centerboard pin that would have served as the pivot point for raising and lowering a centerboard. The daggerboard trunk and the daggerboard box will be described separately below.

The daggerboard trunk was fashioned from half of a single eastern red cedar log that measured 9 ft 3 in (2.8 m) in length, is 9.5-in (24.1-cm) sided and 13.5-in (34.3-cm) moulded (Figure 6-19). The slit for the daggerboard measures 6-ft 6-in (2-m) long and is 4-in (10-cm) wide (Figure 6-20). This slit abruptly tapered to 2.5 in (6.3 cm) in width. The log had been split lengthwise to aid the fashioning of the daggerboard slit. The trunk was mortised through to house frames 12 and 18 (Figure 6-19). Frames 13 through 17 were half frames married to the daggerboard trunk via notches cut into the base of the trunk itself (Figure 6-21). The base of the daggerboard trunk was covered with a 13.5-in (34.3-cm) wide, 1.25-in (3.2-cm) thick plank that was cut and beveled to allow passage of the daggerboard (Figure 6-19). This plank was heavily fastened to the daggerboard trunk with square shanked, hand wrought iron fasteners that measured 0.25 in (0.64 cm) in diameter. The interior lining of the daggerboard slit appeared reddish in color (Figure 6-20). This coloring does not appear to be pigment or paint; rather, it likely represents oxidation from internal iron fasteners.

The daggerboard box, which houses the daggerboard while in the raised position, was 2-ft 4.5-in (72.4-cm) high and 6.5-in (16.5-cm) wide (Figure 6-19). The extremities of the box were fashioned from two 2-ft 5-in to 2-ft 7-in (73.7-cm to 78.7-cm) long white oak posts that measured 2.5-in (6.4-cm) sided and 2.5-in (6.4-cm) moulded. These posts were set into a recessed notch of undetermined depth cut into the top of the daggerboard trunk. They were fixed in position by a 0.5-in (1.25-cm) hand wrought iron spike of undetermined length. Two layers of 1-in (2.5-cm) thick, vertical overlapping larch planking formed each side of the box, with 2-in, 8-in, and 10-in (5-cm, 20.3-cm, and 25.4-cm) planks attached to each side of both posts, followed by runs of 16 (exterior) and 15 (interior) overlapping 4-in (10-cm) wide planks. The vertical planking was fastened to two horizontal white oak cross members that measured 2-in and 3.5-in (5-cm and 8.9-cm) wide respectively, and 1-in (2.5-cm) thick. Each end plank was fastened to these cross members with two rows of square-shanked, hand-wrought iron fasteners that measured 0.25 in (0.64 cm) in diameter and between 2.5 in and 3 in (6.4 cm and 7.6 cm) in length. These sides were fashioned before being inserted into the recessed top of the daggerboard trunk as evidenced by that fact that all fastener head were located on the interior of the dagger board box. Cross members were fastened to both posts with 0.5-in (1.25-cm) round-shanked, square headed carriage bolts secured with a 1-in (2.5-cm) thick, 1-in (2.5-cm) wide square iron nut.

The daggerboard itself was not found, but the general size and shape of this element can be surmised from the length and width of the daggerboard slit. The slit itself measured 6-ft 6-in (2-m) long and 2.5-in (6.3-cm) wide. The daggerboard itself was slightly smaller, and was likely 2 in (5-cm) wide and 6 ft 4 in (1.9-m) long. The top of the dagger board would have been flat, and likely terminated in a wider wooden rail, that would have been 4-in to 5-in (10.2-cm to 12.7-cm) wide and 6-ft 8-in to 6-ft 10-in (2.03-m to 2.08-m) long. This rail would have prevented the daggerboard from slipping through the box if unsecured. The bottom would have been rounded and angled up toward the bow, which would allow the daggerboard to rise if it collided with an obstruction while moving forward.

The daggerboard assembly was not set directly into the keelson of U-2, as was typical of other archaeological examples. It was instead mounted into a trunk, which was composed of the aforementioned cedar log. There was no visible means by which the keelson was married to the trunk, aside from a single diagonal half scarf at one extremity of the trunk (Figure 6-19). One plausible scenario for how the daggerboard trunk was married to the keelson is that, based on the assumption that the keelson was of similar dimension to the cedar log, it simply butted against both ends of the trunk. The trunk could have been secured in place by sister-like timbers fixed to the port and starboard edges of the keelson. Overall, the daggerboard assembly gives the impression that it was fashioned separately from the rest of the vessel, and was simply plugged into the viscera of U-2. It may have replaced an earlier daggerboard assembly that had been damaged or torn from the bottom.

6.5 CROSS SECTION RECONSTRUCTION

Based on discussions between LCMM and URS, it was decided to focus reconstruction efforts on the midsection of the vessel. Sufficient fragments of the hull adjacent to the daggerboard assembly survived to allow reconstruction of two sets of cross sections of this area. These cross sections can provide additional data that will better define the form and function of the vessel.

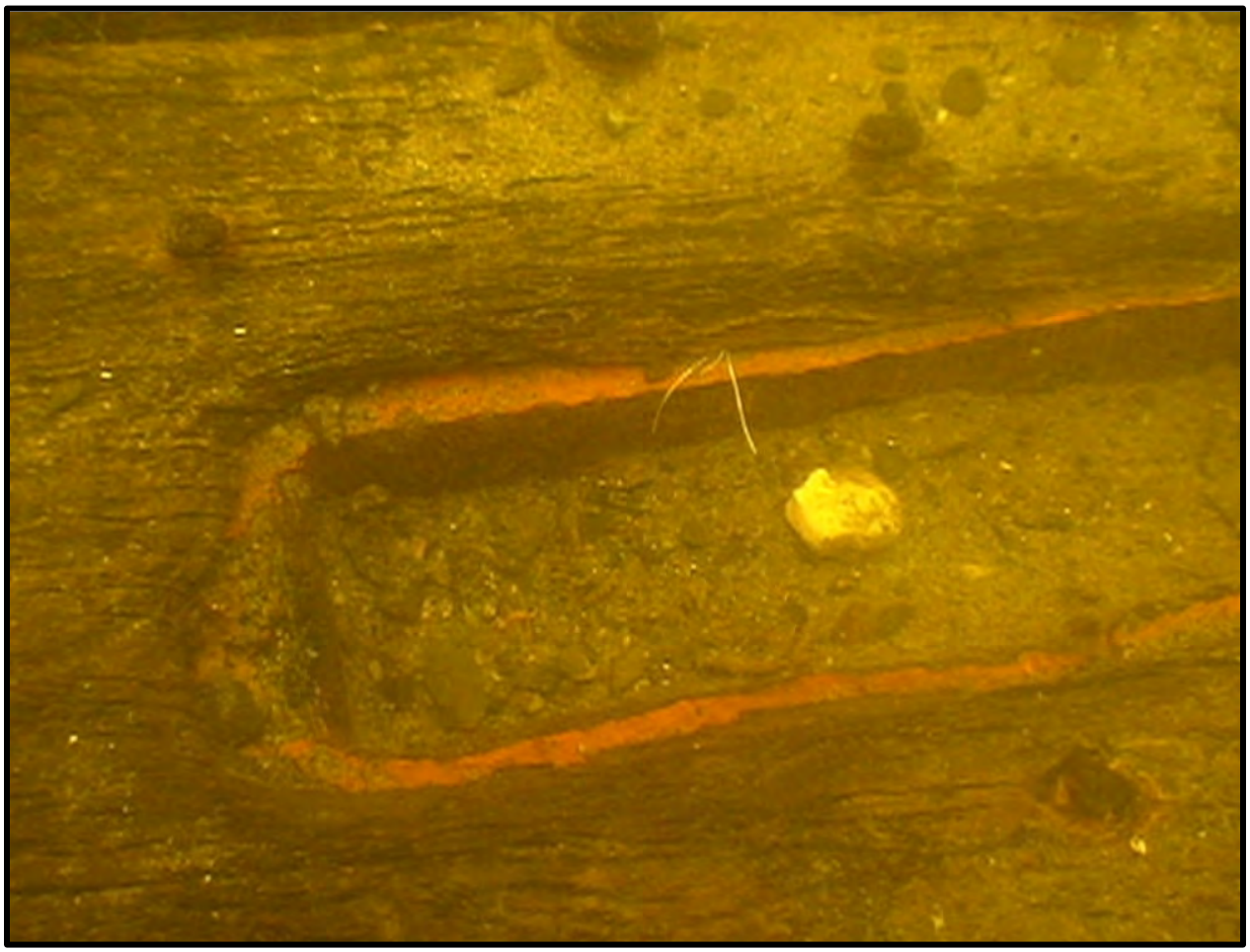

Figure 6-20. Photograph of the Daggerboard Slit taken During the 2005 Phase II Investigations.

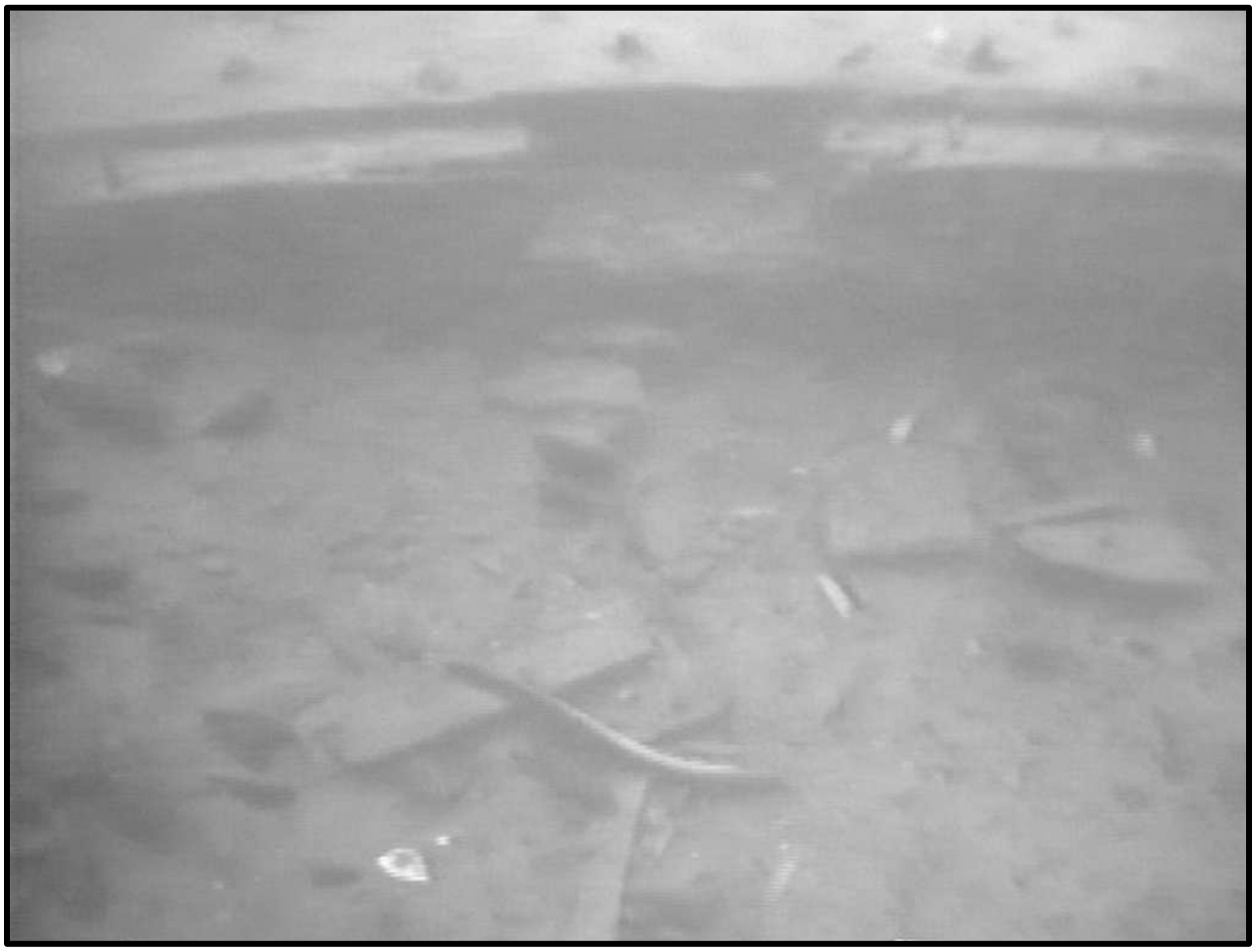

Figure 6-21. Video Image of the Notch of Daggerboard Trunk that Once Housed Frame 14, Facing East.

The first step in reconstructing the cross sections of U-2 was to reassemble, as a schematic, the remains of the most complete frame recorded in original position. Frame 11, the only frame section documented in situ that was intact beyond the turn of the bilge, was drawn to establish the breadth of the vessel and determine the general hull form (Figure 6-22). This schematic indicates that U-2 was flat bottomed with straight sides and a curved turn of the bilge. The calculated beam at Frame 11 is 13 ft 6 in (4.1 m). This was determined by doubling the half frame dimension from the center of the daggerboard assembly to the outboard face of the futtock (13 ft 4 in [4.06 cm]), and then adding the thickness of two hull planks (2.5 in [6.3 cm]).

The remains of U-2 were severely fragmented and incomplete; it is therefore impossible to reconstruct cross sections from documented timbers alone. Missing details, including deck structure, must be based on construction data from vessels similar to U-2. To identify potential candidates, we must first hypothesize as to the type of vessel that U-2 represents. Characteristics of this shipwreck do not closely match any contemporary vessel types of upper Hudson region, but archaeological evidence from Lake Champlain suggests that U-2 is an unusual variant of the early sailing canal boats that were becoming commonplace on the upper Hudson River between 1819 and 1830 (Feedercanals.org 2009).

The most convincing evidence for this identification is the 13-ft 6-in (4.1-m) beam calculated at Frame 11. This is the common width of documented canal boats used during the first few decades of the Champlain Canal (Cohn 2003), and is based on the standard lock width of 15 ft (4.57 m). It is likely that the vessel was constructed with such a breadth to closely match the width of the new locks, and not by chance. The straight, parallel sides of U-2 are also inherent to canal boats, as the hulls of these vessels were specifically designed to match the shape of canal locks in order to maximize cargo capacity.

Two additional design elements indicate that U-2 is an early canal boat. A curved turn of the bilge like that seen on U-2 is also a design component of *Troy* (Kane and Sabick 2002). Later canal boats were exclusively constructed with a hard chine. The square hull shape created by the later design allowed vessels to carry more cargo through canal locks, and earn greater profit, than shapelier ships such as U-2.

The employment of a daggerboard, however, is the most reliable temporal marker for the construction date of U-2. Daggerboards were first introduced to the northern United States/Great Lakes region in or around 1806 (Lewiston 1877). The flexibility this device offered to shallow water sailors buoyed its popularity, and the daggerboard was in regular use in small vessels less than seven years later. Proof of their relative success was the adoption of slip keels by the United States military. Major-General James Wilkinson commissioned the construction of a dozen small slip keeled boats in 1813 (Brannan 1823). The popularity of daggerboards, particularly on small sailing schooners, continued over the next five to seven years. Their popularity began to wane, however, after the 1811 introduction of the pivoting centerboard, the housing of which was easier to keep watertight. Daggerboards ceased to be employed in significant numbers by 1820, and they were almost exclusively replaced by centerboards by 1825 (Kennard 2008).

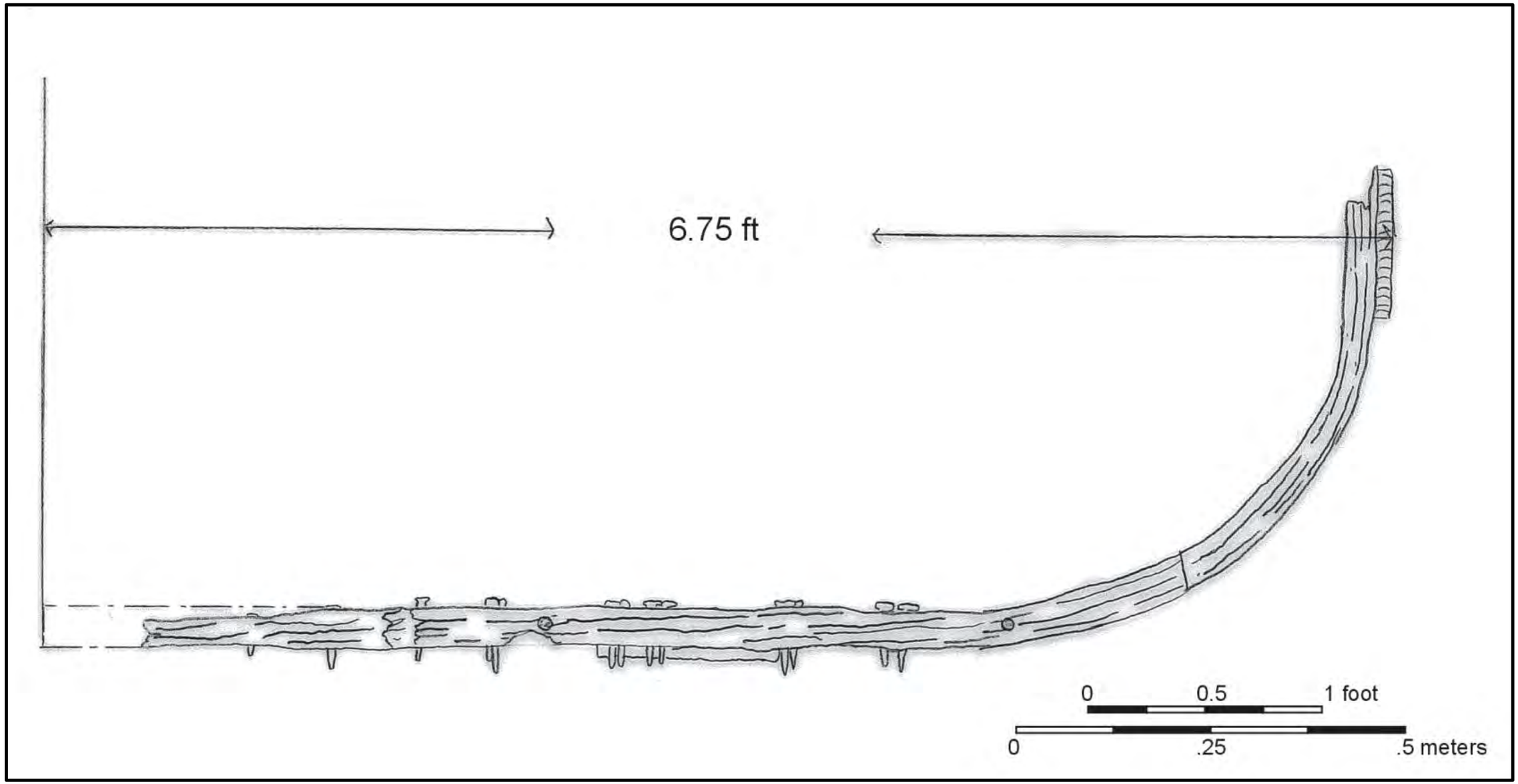

Figure 6-22. Half Breadth Schematic of Frame 11.

The use of the daggerboard in the northern United States is not thoroughly understood, but available historical data suggests that there was a 19-year window (1806 to 1825) during which daggerboards were commonly constructed. A relative construction date for U-2 can be surmised by correlating the use dates of the daggerboard with the opening and early history of the Champlain Canal. Construction of the Champlain Canal began in 1817, and the first arm of the canal, which extended from Fort Edward to Lake Champlain, was opened in 1819. The canal was open to Waterford, New York by 1825, along with a few smaller side canals and locks. These data indicate that U-2, which appears to be purpose built as a canal boat, was likely constructed between 1819 and 1825, towards the end of the use dates of the daggerboard. It is possible that it was constructed earlier, in 1817 or 1818, in anticipation of canal completion, or slightly later, between 1826 and 1830, when daggerboards were becoming anachronistic.

The construction date can be further refined by examining the number of canal boats plying the Champlain Canal in the first four years of its existence. There was a paucity of working canal boats on the Champlain Canal in 1821, when there were but 10 examples of this vessel type (Feedercanals.org 2009). This number, however, had grown to 100 by 1823 (Feedercanals.org 2009). It is possible, but unlikely, that U-2 was one of the first 10 canal boats in use on the Champlain Canal and that it was constructed between 1819 and 1821. It is more likely that it was constructed during the first canal boat construction boom that began in 1822. Therefore, it appears most likely that U-2 was constructed between 1822 and 1825, but the possible construction window is between 1817 and 1830. These dates place U-2 at the very beginning of the canal boat timeline.

Unfortunately, there are few archaeological correlates from this region and time period. Recent efforts by LCMM have resulted in the discovery and partial documentation of two early canal boats that share some basic characteristics and design elements with U-2. These are the wreck identified as the Shoreham Sloop and the aforementioned canal schooner *Troy*.

Four cross sections (A through D) were reconstructed during the current analysis to address alternative interpretations of the means by which the daggerboard trunk was attached, or not attached, to the remainder of U-2. A daggerboard assembly has never been documented archaeologically in a canal boat. As discussed in Section 3, canal boats were almost exclusively constructed with centerboard assemblies. These construction features are similar to, but much larger than, the daggerboard assembly of U-2. They are attached to the underside of deck beams of later canal boats via notches or mortise holes and are often situated in a large hatch. The distance from the base of the centerboard trunk to the top of the centerboard box in these examples largely defined the depth of hold of those canal boats. The average depth of hold for all documented canal boats is 4 ft 5.5 in (1.36 m).

The first set of reconstructed cross sections (Cross Sections A and B; Figures 6-23 and 6-24) is based on an assumption that the top of the daggerboard box was notched into the underside of the deck beams, which would result in overall depth of hold of 2 ft 9 in. (83.8 cm). The height of the daggerboard assembly of U-2 was 2 ft 4.5 in (1.08 m) and the additional 4.5 inches result from the height of the deck beams and floors. In these cross sections, the daggerboard assembly is situated in a hatch, as seen with the centerboard assembly of *Troy*. Cross Section A was drawn at Frame 12, because this location illustrates how the daggerboard trunk may have been married to the deck. Cross Section B was drawn at Frame 15, which illustrates the interior of the daggerboard assembly.

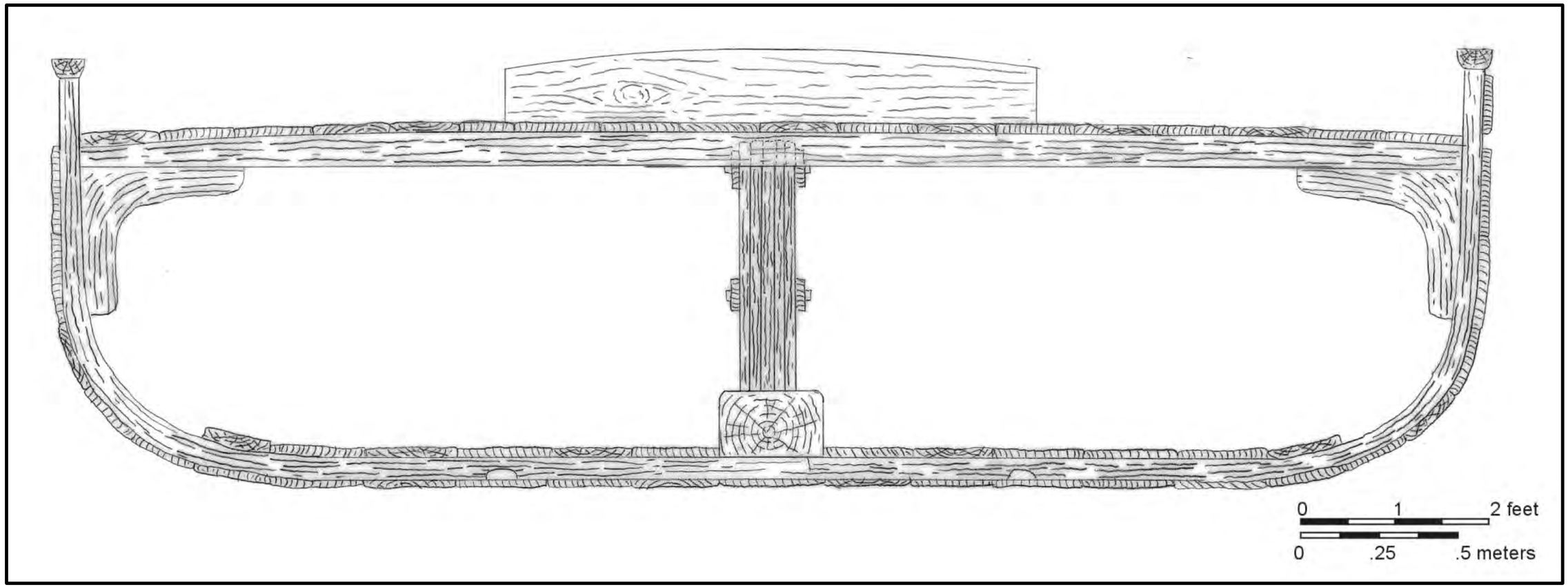

Figure 6-23. Reconstructed Cross Section A at Frame 12.

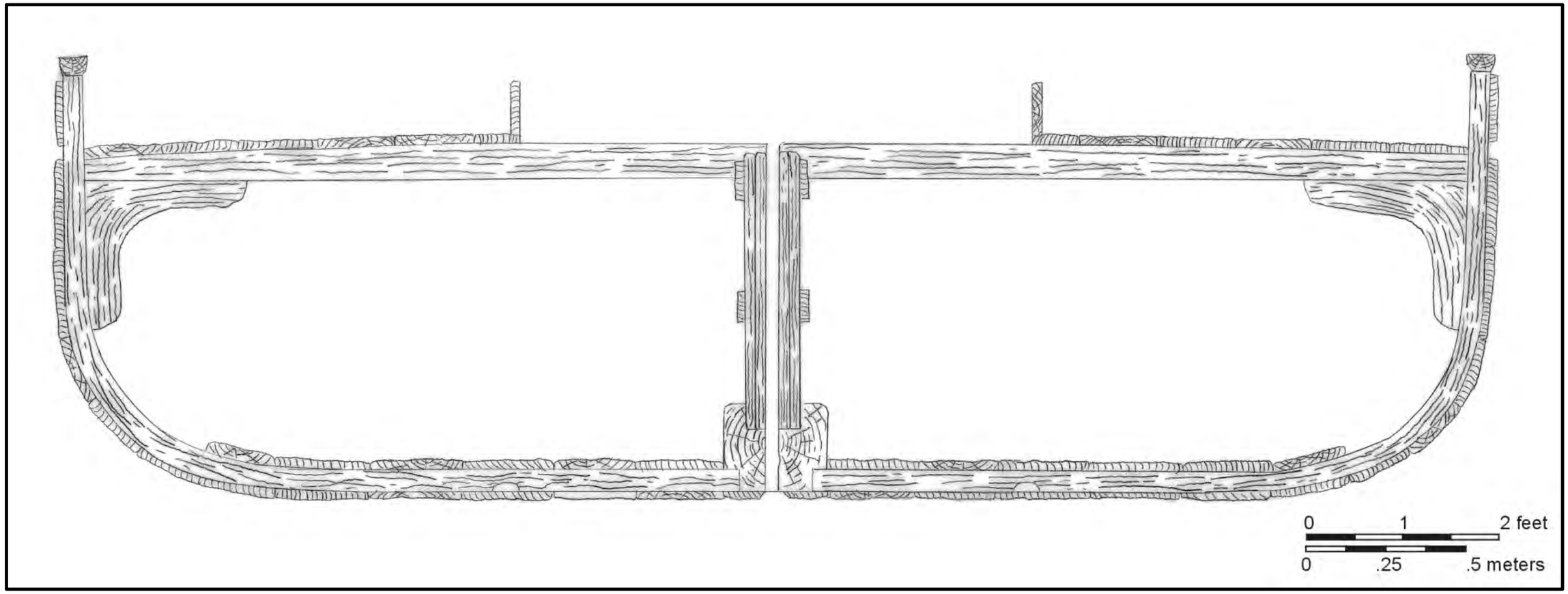

Figure 6-24. Reconstructed Cross Section B at Frame 15.

Under this interpretation, the vessel would have had longitudinal stiffness and the underside of the boat would have been protected from springing or rending if a deployed daggerboard contacted hard bottom while drifting laterally. A drawback to this reconstruction is a very truncated depth of hold, which greatly reduces the vessel's cargo capacity. The slight endposts of the daggerboard trunk (2.5 in by 2.5 in [6.3 cm by 6.3 cm]) would also not be able to translate much lateral force to the larger deck beams. There is also no archaeological evidence for the notching or fastenings necessary to attach the daggerboard assembly to the underside of the deck beams.

The second set of reconstructed cross sections (Cross Sections C and D; Figures 6-25 and 6-26) assumes that the daggerboard assembly was floating on the interior of the vessel. The depth of hold of this alternate is designed to be 4 ft 5.5 in (1.36 m), which is the average of 17 known sailing canal boats from Lake Champlain of this period. Under this interpretation, the daggerboard assembly is not situated in a hatch (Cross Section D); the daggerboard itself would simply protrude from a 4-in (10-cm) slit in the deck as seen on the wreck of a 200-year old daggerboard schooner discovered on Lake Ontario by Daniel Scoville and Jim Kennard (Kennard 2008). Cross Section C is located along a theoretical keelson at Frame 11, which illustrates how the deck beam and keelson are joined. Cross Section D was drawn at Frame 15, which illustrates the interior of the daggerboard assembly.

Under this interpretation, the vessel would have had greater cargo capacity than the canal boat represented by Cross Sections A and B. However, it would leave the vessel vulnerable to stresses, particularly springing and rending that could occur if an active daggerboard contacted rocks while drifting laterally.

6.5.1 CROSS SECTION A AT FRAME 12

The dimensions of the floors, futtocks, hull planking, and daggerboard trunk for the Frame 12 cross section were taken directly from U-2 (Figures 6-23). The floors and futtocks measured approximately 2-in (5.08-cm) moulded. The hull planking measured approximately 10-in (25.4-cm) wide and 1.25-in (3-cm) thick on the sides and bottom, 8 in (20.3 cm) in width and 1.25 in (3 cm) in thickness along the turn of the bilge. Although no ceiling planking was observed on U-2, fasteners on the interior of the floors indicate that ceiling was present on the bottom of the vessel, but did not extend beyond the turn of the bilge. The dimensions of the ceiling planking were kept consistent with that of the hull planking. The daggerboard trunk measured 9.5-in (24.1-cm) sided and 13.5-in (34.3-cm) moulded, and the box measured 2 ft 4.5 in (72.4 cm) in height and 6.5 in (16.5 cm) in width. The breadth of the vessel at Frame 12 was considered to be the same as at Frame 11, or 13 ft 6 in (4.1 m).

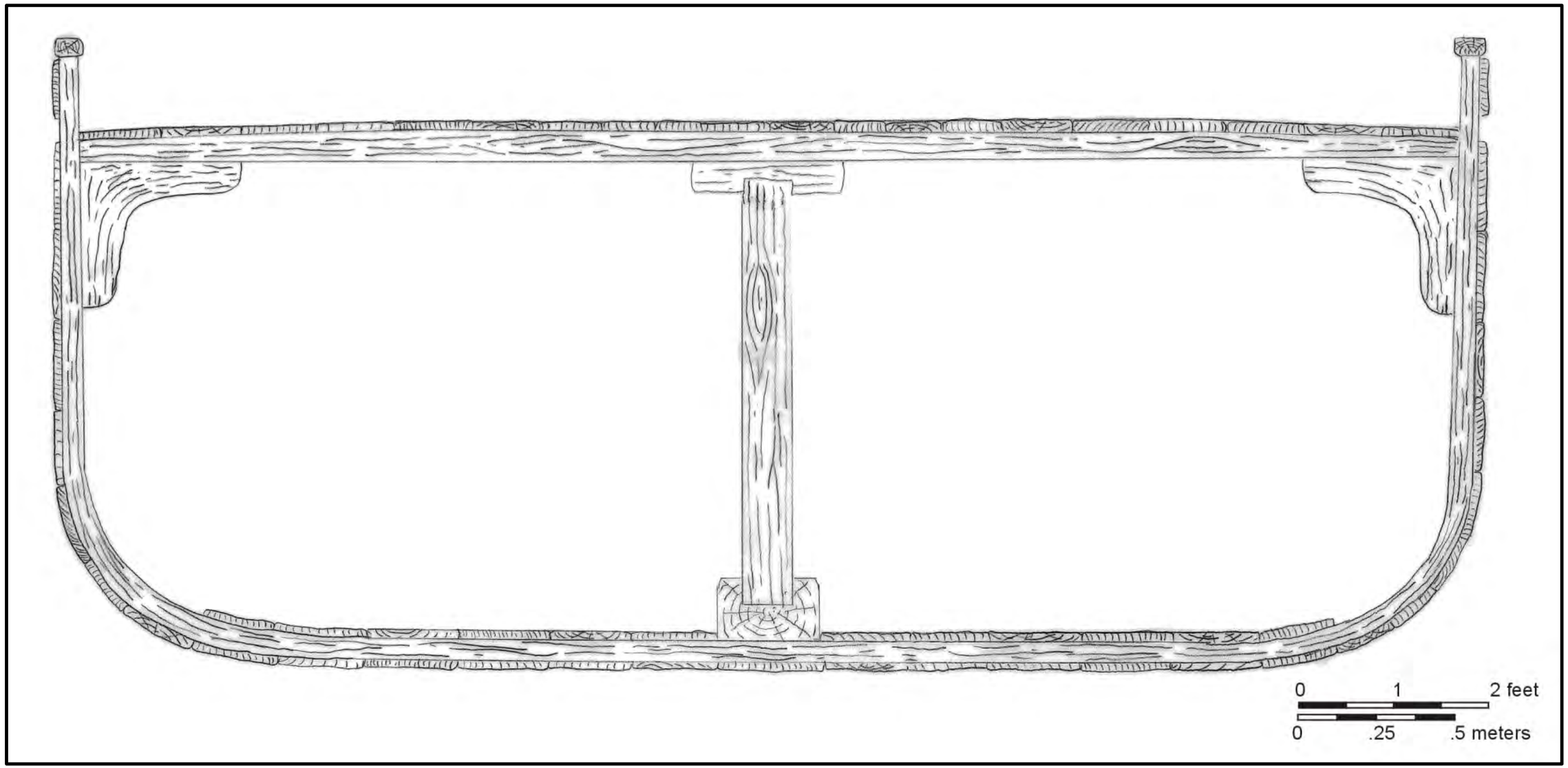

Figure 6-25. Reconstructed Cross Section C at Frame 11.

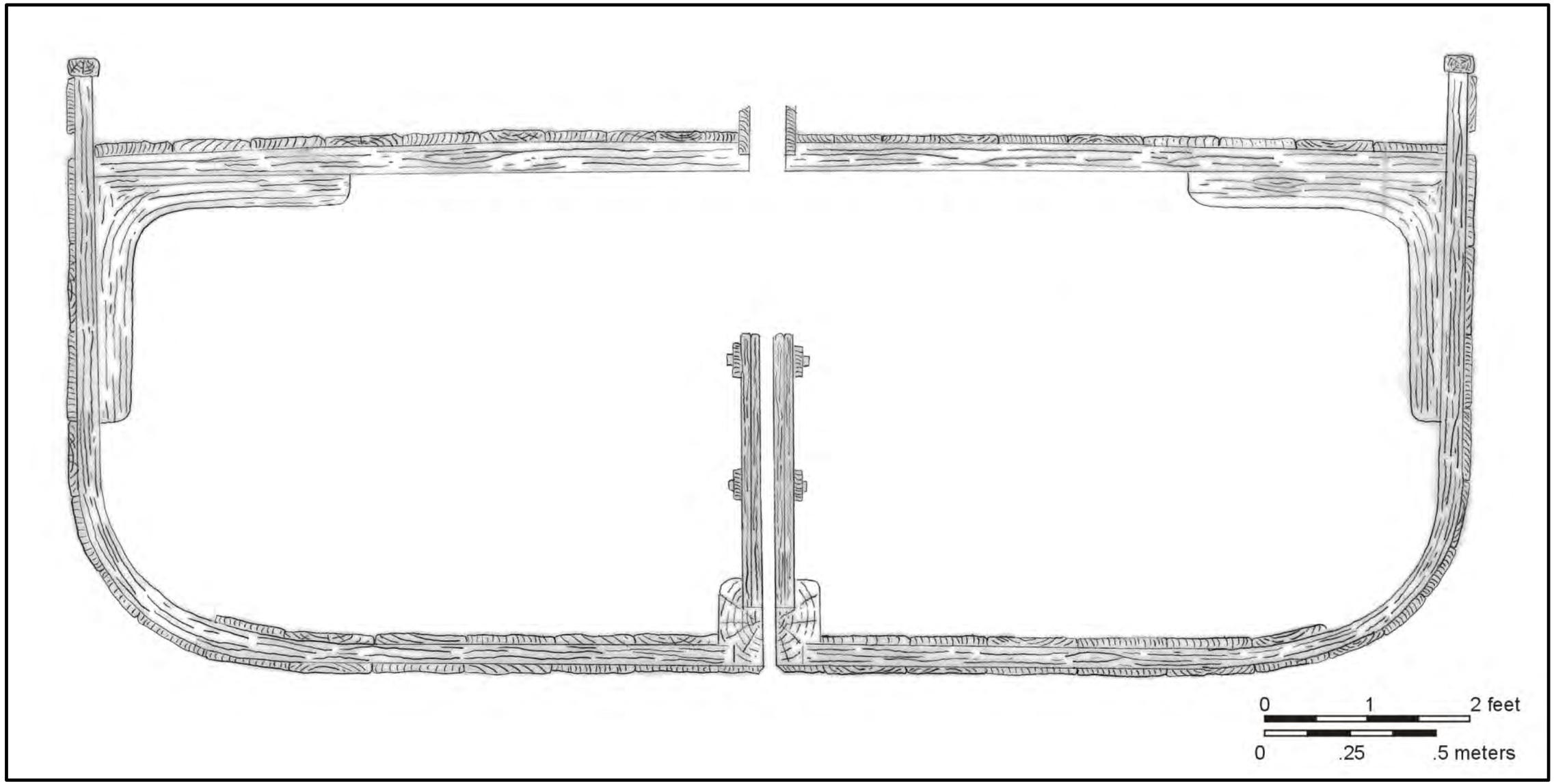

Figure 6-26. Reconstructed Cross Section D at Frame 15.

The remainder of Cross Section A is based on observations from *Troy* and the Shoreham Sloop. Similar points of reconstruction are the rail, deck beam, and deck planking; the reconstructions differ concerning the incorporation of the daggerboard assembly, the size of the hanging knees, and the depth of hold. There are few exact measurements available from *Troy* and the Shoreham Sloop; the majority of the dimensions are common sense estimates.

As seen on *Troy*, the U-2 futtocks likely continued above the deck to form the side rail. The rail height of the U-2 reconstruction is 12 in (30.5 cm), which is derived from the estimated rail height of the Shoreham Sloop. The reconstructed rail of U-2 extends 14 in (35.6 cm) above the deck planking and is topped with a beveled cap that is 2-in (5-cm) moulded. A single 10-in (25.4-cm) wide, 1.25-in (3-cm) thick plank is affixed to the exterior of the rail, as seen on *Troy*.

The lateral deck beam depicted in both cross sections is 3-in (7.5-cm) moulded (and 4-in [10-cm] sided throughout) at the centerline and 2-in (5-cm) moulded at the rail. The centerline dimension of the deck beam is based on an example from the Shoreham Sloop, while subtle crown to the deck is based on video evidence from *Troy*. The deck beams are supported by large hanging knees.

The deck of Cross Section A is sheathed in deck planking that is 8 in (20.3 cm) in width and 1.25 in (3 cm) in thickness. These dimensions are based on an estimated width ratio between the deck and hull planking of *Troy*, the deck planking of which appeared 15 percent narrower than the hull planking.

Hanging and lodging knees were observed on the Shoreham Sloop and presumably *Troy* as well. The dimensions of these knees are based largely on what would be needed to support a substantial deck load. The knees of Cross Section A measure 18 in (45.7 cm) laterally and vertically. The sided dimension of the knee, while not depicted in cross section, would match the width of the deck beam at 4 in (10 cm). The end of the daggerboard box of Cross Section A was set in a half mortise cut into the deck beam. This marriage of deck beam and daggerboard box would have provided the necessary deck strength, while also stabilizing the daggerboard assembly by offering some measure of protection from lateral torsion stress. The overall depth of hold for this vessel in Cross Section A would have been 2 ft 9 in (83.8 cm). This is less than that of the Shoreham Sloop, which was estimated at 4 ft (1.2 m). This difference results from the vertical dimension of the daggerboard assembly and the assumption that the top of the daggerboard box was at deck level, much like the centerboard box of *Troy* and the Shoreham Sloop.

The centerboard of *Troy* was set in a hatch that appeared 7-ft (2.1-m) wide. The aft end of that centerboard terminated at a deck beam at the end of the hatch, while the other terminated inside the hatch. The daggerboard for Cross Section A is set inside a hatch for this reason. The hatch opening is limited to a width of 5 ft 3 in (1.6 m). The hatch in this interpretation was likely narrower because the hold was shallow and additional deck space would have been valuable for carrying passengers and cargo. The hatch combing depicted in this cross section is 7 in (17.8 cm) in height, which was estimated from the combing of *Troy*.

6.5.2 CROSS SECTION C AT FRAME 11

The cross sections reconstructed at Frame 11 (Figure 6-25) utilized many of the dimensions documented during the U-2 excavation, including floors, futtocks, hull and ceiling planking and daggerboard trunk. The many points of reconstruction reviewed for the Frame 12 cross sections

also hold true for this reconstruction. The cross section at Frame 11 differs from those of Frame 12 in that the vessel is assumed to have a 4-ft 5.5-in (1.38-m) depth of hold, and it illustrates how a keelson/stanchion/saddle union might have been used to support the deck of the vessel.

In this reconstruction, a 6-in by 6-in (15.2-cm by 15.2-cm) stanchion was mortised 2.5-in (6.3-cm) into a keelson with the same dimensions as the daggerboard trunk. This was then mortised 2-in (5-cm) deep into a saddle that was 18-in (45.7-cm) sided by 4-in (10.1-cm) moulded. This saddle was then fastened to the deck beam, and served to disperse the upward force translated to the beam.

6.5.3 CROSS SECTIONS B AND D AT FRAME 15

The cross sections reconstructed at Frame 15 (Figures 6-24 and 6-26) again utilized many of the dimensions documented during the U-2 excavation, and the many points of reconstruction reviewed for the Frame 12 cross sections also hold true for these reconstructions. The cross sections at Frame 15 illustrate the interior of the daggerboard assembly. As previously noted, Cross Section B depicts a vessel with a 2-ft 9-in (84-cm) depth of hold, and Cross Section D depicts a vessel with a 4-ft 5.5-in (1.41-m) depth of hold.

These cross sections assume that a single, non-crowned, lateral deck beam was fixed to the centerboard mid-hatch, as was found on the *Troy*. There may have been other beams at an unknown interval, but none of these remain. This beam approached the centerboard slit, but did not cross it, and its means of attachment to the centerboard box is undetermined. A similar deck beam that measures 3-in (7.5-cm) moulded was employed for the U-2 reconstruction in these cross sections. It is attached to the daggerboard box via a mortise. It is possible that this beam was further supported by port and starboard stanchions, but there was no visible evidence for this on U-2 or *Troy*. The hatch combing employed is 7-in (17.8-cm) moulded and 1.25-in (3-cm) sided.

The deck of Cross Section D was floating for the length of the daggerboard assembly. Robust hanging knees measuring 32-in (81.2-cm) moulded (laterally and vertically) by 4-in (10-cm) sided were employed to support the deck at this beam. Lodging knees (not depicted) would also have been employed on either side of the beam. The daggerboard itself protrudes from a 4-in (10-cm) slit in the deck that is lined by 5-in (12.7-cm) combing.

7.0 SUMMARY OF FINDINGS

Resource U-2 was initially identified during a Phase I archaeological survey of Phase 1 dredge areas in the Upper Hudson River. Subsequent data recovery was conducted before the resource was removed as debris during Phase 1 dredging. These efforts included field excavation and documentation, vessel analysis, artifact analysis and conservation, and technical report preparation. Documentation included the creation of detailed plan and profile maps of the 13-ft by 35-ft (4-m by 10.7-m) site, fastening patterns, a list of scantlings, and an in-depth study of the daggerboard box assembly.

Analysis of the vessel remains indicates that U-2 likely represents an early sailing canal boat constructed between 1822 and 1825. The vessel was likely rigged as a schooner or sloop, and was used to transport goods and people through the Champlain Canal system. This assessment is based on the construction elements and general design of ship. U-2 maintained a flat bottom, curved turn of the bilge, and straight, parallel sides that are common to early canal boats. The strongest evidence for the identification of canal boat, however, is the vessel's breadth of 13 ft 6 in (4.1 m), which is the same as other known early canal boats and was constrained by the 15-ft (4.6 m) width of the first generation of Champlain Canal locks.

U-2 was a badly fragmented vessel that appears to have been previously sitting upright, where it was exposed to the erosive effects of the Hudson River for many years. The condition of several badly eroded frame ends that were buried at the time of discovery of the wreck supports the supposition that U-2 was at one point lying on the keel and was either not completely buried or periodically exposed. Given that the U-2 hull fragment was found in 2005 upside down, it is believed that after resting upright for many years the hull was moved and re-deposited along the eastern bank of the Hudson River during maintenance dredging operations. When U-2 was discovered, only a small portion of the hull remained intact buried beneath several feet of dredge spoils, mill ends, and historic debris.

Archeological investigation of U-2 indicated that this vessel had design elements commonly associated with vessels designed for lake sailing, as well as elements of early canal boats. This combination of vessel morphology is indicative of a very early stage of vessel transition from traditional sailboat designs used on the lakes and rivers to sailing canal boats that were specifically designed for operation within the Champlain Canal system. As noted, the strongest indicator that this vessel was designed for canal use is the reconstructed beam, which matches the maximum beam of the earliest lock designs along the Champlain Canal system.

Analysis of U-2's framing indicates that U-2 was plank on frame constructed with a shallow draft of approximately 2 ft 9 in (83.3 cm), and a flat bottom. The turn of the bilge was curved and quickly transitioned to straight parallel sides. The rounded turn of the bilge is associated with more traditional sailing vessels of this region.

The length of U-2 was estimated at 62 ft (18.9 m). This length was estimated by comparing the length and breadth ratio of two of the early transitional or experimental period canal vessels, the *Troy* and the Shoreham Sloop. The *Troy* measured approximately 60 ft by 13 ft 6in (18.3 m by 4.1 m), with a hold of 3.1 ft to 4.0 ft (.9 m to 1.2 m). The calculated length to breadth ratio is 4.4:1. The Shoreham Sloop measured 64 ft (19.5 m) with a beam of 13 ft 6in (4.1 m), which yields a ratio of 4.7:1. Both of these vessels share some of the same design elements of U-2,

such as the beam of 13ft 6 in (4.1 m), the rounded turn of the bilge, and relatively shallow depths of 3 ft to 4 ft (.9 m to 1.2 m).

Perhaps the greatest indicator of U-2's importance as one of the early experimental sailing canal boats is the presence of a daggerboard located just ahead of the tripled frame sets. Daggerboards were used on sailing vessels for a relatively short period of time, roughly between 1806 and 1825, when the use of pivoting drop keels or centerboards replaced the smaller, and less effective daggerboard. A review of the archeological record does not reveal other canal vessels using a daggerboard, which strongly suggests that U-2 was constructed during the early transitional period of canal boat development from 1819 to 1825.

Each of these experimental or transitional canal boats, such as U-2, represented a unique work of a master shipwright who was experimenting with multiple ship construction elements and trying to find a balance of efficient cargo handling, seaworthiness, and economy while being limited to transiting the Champlain Canal and lock system. U-2 was likely constructed at a time when few canal boats had been built and tested. Shipwrights, therefore, incorporated more traditional elements, such as curved bilges and daggerboards, into their design because they had confidence that they could survive the rigors of river transport. More recent design elements, such as chine logs and pivoting centerboards, were gradually added to the canal boat template, and this experimentation culminated in the efficient, more standardized canal boat model that emerged later in the 19th century.

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Appendix A:

Qualifications of Investigators

Daniel F. Cassedy has over 30 years of experience as a supervisory archaeologist specializing in cultural resource management in eastern North America. He has conducted dozens of projects throughout the Northeast, including Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, and many in the state of New York. These include projects for the New York Department of Transportation; a 300-mile corridor from the St. Lawrence River to Connecticut for the Iroquois Gas Transmission System, and extensive studies along the Hudson River from Fort Edward to Troy for General Electric. He has successfully worked with a wide range of Federal and State Regulatory agencies to achieve solutions to complex cultural resource issues, including the Federal Energy Regulatory Commission, the Environmental Protection Agency, the Federal Highway Administration, the New York State Office of Parks, Recreation, & Historic Preservation (OPRHP), the New York State Department of Environmental Conservation. Dr. Cassedy received his Doctorate of Philosophy in Anthropology from the State University of New York at Binghamton.

Christopher Polglase has over 30 years of professional experience in archaeological excavations, research, and compliance studies. He is a Principal Anthropologist in URS Gaithersburg's Environmental Resource Management Group. He has geographically wide-ranging compliance and research experience, having managed projects and conducted cultural resource investigations throughout the U.S. and overseas during the course of his professional career. Mr. Polglase has extensive cultural resource experience in Virginia, beginning with his archaeological field school on the James River in 1979 and extending through dozens of archaeological projects. Highlights of this experience in Virginia includes three seasons as crew chief at the site of Fort Christanna in Brunswick County and preparation of Integrated Cultural Resource Managements Plans for Fort Belvoir, NSGA Northwest, NAS Oceana, NSWC Yorktown and FISC Cheatham Annex. He also has directed underwater archaeological studies, over 2,000 acres of archaeological survey, over 40 Phase II studies, and Phase III data recovery excavations. He received his Bachelor's Degree in Anthropology and Classical Studies at the College of William and Mary and his Master's Degree in Anthropology from the State University of New York at Binghamton.

Jean Bernard (J.B.) Pelletier has over 20 years of experience in marine geophysics, nautical archaeology, marine and terrestrial remote sensing, remotely operated vehicle operation and maintenance, underwater photography and video, technical diving, and diving safety. He is URS' Lead Nautical Archaeologist and Marine Remote Sensing Specialist. He exceeds the *Secretary of the Interior's Professional Qualification Standards for Archaeology*. Mr. Pelletier is an expert in the use of side-scan sonar, sub bottom profilers, single-beam echo sounders, and marine magnetometers and gradiometers. He also has extensive knowledge of Hypack Max software for data collection and interpretation. He has served a wide array of Federal, State, and private sector clients including the: USACE; U.S. Navy; MMS; National Oceanic and Atmospheric Administration; Delaware, Rhode Island, Florida, and Maryland DoTs; Maryland Department of Natural Resources; Maryland Port Authority; and BP. He received his Master's Degree in History and his Bachelor's Degree in Geological Sciences from the University of Maine at Orono.

Anthony Randolph has 17 years of experience in cultural resources management, and exceeds the *Secretary of Interior Standards for Archaeology* (36CFR Part 61). Mr. Randolph has extensive experience in the management and execution of archaeological investigations. He has managed reconnaissance and investigations on prehistoric, historic and maritime sites throughout

the eastern United States, Caribbean, and Europe. He also has extensive experience as an archaeological conservator through positions at Mariners Museum, and the government of Portugal. He received his Master's Degree in Anthropology from Texas A&M University and his Bachelor's Degree in Neuroscience/Anthropology from the University of Pittsburgh.

Jeffrey Harbison had over 18 years of experience participating in all phases of cultural resource investigation. He supervised the excavations of numerous historic and prehistoric archaeological sites in the Northeast and Mid-Atlantic regions of the United States and was the primary archaeological field supervisor for the GE Hudson River project from 2005 through 2009. He received a Master's Degree in anthropology from Temple University.

Justin Bedard has five years of experience in cultural resource management, and meets the *Secretary of the Interior's Professional Qualification Standards for Archaeology* (36 CFR Part 61). He has managed Phase I surveys and Phase II archaeological investigations throughout the eastern United States. He has also participated in Phase III mitigations in Maryland, Virginia, Mexico, Belize, and New York. Mr. Bedard also has extensive experience as a prehistoric ceramicist. Justin received his Master's Degree from Yale University in Archaeological Studies in 2007 and his Bachelor's Degree in Archaeology from The George Washington University in 2003.

Bridget Johnson has a broad background in historic and archaeological research. She has experience in data collection and management for archaeological and historical projects. Ms. Johnson also has experience conducting historic research on a variety of topics and regions throughout the United States. She received her Master's Degree in Anthropology from Texas A&M University in Nautical Archaeology and her Bachelor's degree in History and Archaeology from St. Mary's College of Maryland.

Appendix B:

Artifact Catalog

FS #	Provenience	Artifact Count	Class	Material	Object	Typology	Surface Decoration	Comments	Length	Width	Thick	Begin Date	End Date
1	Wood Piece with Frame	1	Wood		Wood Fragment			wood piece with 2 metal nails	7.0	2.0	1.5		
2	The Ray Gun	1	Wood		Wood Fragment			large square fragment with drill hole	4.0	2.5	2.5		
3	The Thing Next to the Ray Gun	1	Wood		Wood Fragment			square fragment with drilled hole	3.5	2.5	2.3		
4	Center Board Trunk Lining	4	Wood					small fragments all about 2 inches in size					
5	Top Center Board Trunk Strut	3	Wood		Wood Fragment			small fragments about 2 inches in length					
6	Bottom Center Board Trunk Strut	2	Wood		Wood Fragment			small fragments 1" and 2" in length					
7	Frame 17 on Center Board Trunk	1	Wood		Wood Fragment			square wood fragment	5.5	1.4	1.3		
8	Center Board Trunk End Strontion	1	Wood		Wood Fragment			long fragment, broken in two pieces	17.0	2.0	1.0		
9	A - no provenience	1	Wood		Wood Fragment			conserved, large curved wood piece	26.0	3.0	3.0		
10	B - Center Board Trunk	1	Wood		Wood Fragment			conserved, round shaped tapered bung	7.0	1.0	1.0		
11	C - Plank Sample	1	Wood		Wood Fragment			conserved, flat fragment	6.0	2.5	0.2		
12	D - Repair Plank	1	Wood		Wood Fragment			conserved, large flat plank fragment	8.5	6.0	0.3		
13	E - Plank on Center Board Trunk	1	Wood		Wood Fragment			conserved	9.5	1.0	0.5		
14	F - Plank on Forward Futtocks	1	Wood		Wood Fragment			conserved	7.5	2.0	1.0		
15	G - Floor	1	Wood		Wood Fragment			conserved	4.5	2.0	1.0		

FS #	Provenience	Artifact Count	Class	Material	Object	Typology	Surface Decoration	Comments	Length	Width	Thick	Begin Date	End Date
16	H - Futtock 1	4	Wood		Wood Fragment			conserved, 3 small fragments 1" and one larger fragment 3"					
17	I - Futtock 2 Frame 11	1	Wood		Wood Fragment			conserved	3.0	1.8	2.0		
18	J - Forward Futtock	1	Wood		Wood Fragment			conserved	3.5	2.0	0.8		
19	U-2 From JB Pelletier dive	1	Ceramic	Clay	Pipe Bowl	White Ball Clay							
19	U-2 From JB Pelletier dive	1	Ceramic	Clay	Pipe Stem	White Ball Clay							
19	U-2 From JB Pelletier dive	4	Metal	Iron	Nail	Cut		bag labeled F4 Fasteners					
20	General Collection - No Provenience	1	Ceramic	Clay	Kiln Furniture	White Ball Clay		Stilt, broken in 2 pieces	2.5				
20	General Collection - No Provenience	1	Ceramic	Clay	Pipe Bowl	White Ball Clay		with spur, discolored					
20	General Collection - No Provenience	1	Ceramic	Clay	Pipe Stem	White Ball Clay							
20	General Collection - No Provenience	1	Ceramic	Coarse Earthenware	Hollowware	Redware	Lead Glazed						
20	General Collection - No Provenience	1	Ceramic	Coarse Earthenware	Pipe	Red Bodied							
20	General Collection - No Provenience	1	Ceramic	Porcelain	Plate	Chinese Porcelain	Painted	Rim Sherd					
20	General Collection - No Provenience	1	Ceramic	Refined Earthenware	Flatware	Creamware	Undecorated					1762	1820
20	General Collection - No Provenience	2	Ceramic	Refined Earthenware	Flatware	White Granite	Undecorated					1842	1930
20	General Collection - No Provenience	1	Ceramic	Refined Earthenware	Hollowware	White Granite	Undecorated	well made, no crazing				1842	1930
20	General Collection - No Provenience	1	Ceramic	Refined Earthenware	Hollowware	Whiteware	Unknown					1820	2009

FS #	Provenience	Artifact Count	Class	Material	Object	Typology	Surface Decoration	Comments	Length	Width	Thick	Begin Date	End Date
20	General Collection - No Provenience	1	Ceramic	Refined Earthenware	Hollowware	Whiteware	Unknown	tall footring, early style				1820	1860
20	General Collection - No Provenience	1	Ceramic	Stoneware	Hollowware	Gray/Buff Bodied Salt Glazed	Albany-Type Slip	Albany slip interior only				1805	1940
20	General Collection - No Provenience	1	Ceramic	Stoneware	Hollowware	Gray/Buff Bodied Salt Glazed	Unidentified	burnt					
20	General Collection - No Provenience	1	Ceramic	Stoneware	Hollowware	Westerwald	Stamped	stamped blue floral designs with scratched geometric patterns				1700	1775
20	General Collection - No Provenience	1	Ceramic	Stoneware	Hollowware	White Salt Glazed	Scratch Blue	thin sherd				1744	1775
20	General Collection - No Provenience	2	Glass		Bottle	Mold Blown							
20	General Collection - No Provenience	2	Glass		Hollowware	Milk Glass							
20	General Collection - No Provenience	3	Glass	Non Lead	Bottle	Mouth Blown		all mend, small oval shaped bottle, hinge mold	2.8	1.0		1750	1920
20	General Collection - No Provenience	1	Metal	Copper Alloy	Hinge			both leaves with pin, each leaf has 3 holes	3.0	1.5			
20	General Collection - No Provenience	1	Metal	Iron	Bolt			head is dome shaped , short shaft	2.0	1.5			
20	General Collection - No Provenience	1	Metal	Iron	Indeterminate			possibly a frame					
20	General Collection - No Provenience	1	Metal	Iron	Nut			square	1.0				
20	General Collection - No Provenience	1	Metal	Iron	Washer				1.5				
20	General Collection - No Provenience	1	Wood		Wood Fragment			tag in the bag says "9", red paint on one edge	2.5	1.5	0.5		