BURLINGTON BAY HORSE FERRY

Burlington

United States Department of the Interior

NATIONAL PARK SERVICE
P.O. Box 37127
Washington, D.C. 20013-7127

IN REPLY REFER TO:

TAKE PRIDE IN AMERICA

The Director of the National Park Service is pleased to inform you that the following properties have been entered in the National Register of Historic Places. For further information call 202/343-9542.

DEC 24 1993

WEEKLY LIST OF ACTIONS TAKEN ON PROPERTIES: 12/13/93 THROUGH 12/17/93

KEY: State, County, Property Name, Address/Boundary, City, Vicinity, Reference Number NHL Status, Action, Date, Multiple Name

ARIZONA, MOHAVE COUNTY, Black, Arthur F., House, 707 Cerbat Ave., Kingman, 93001324, NOMINATION, 12/09/93
CALIFORNIA, DEL NORTE COUNTY, St. George Reef Light Station, NW Seal Rock, approximately 6 nautical mi. off coast from Point St. George, Crescent City vicinity, 93001373, NOMINATION, 12/09/93 (Light Stations of California MPS)
CALIFORNIA, SAN DIEGO COUNTY, Olivenhain Town Meeting Hall, 423 Rancho Santa Fe Rd., Olivenhain, 93001395, NOMINATION, 12/17/93
CONNECTICUT, HARTFORD COUNTY, Bulkeley Bridge, I-84 over the Connecticut R., Hartford, 93001347, NOMINATION, 12/10/93
CONNECTICUT, HARTFORD COUNTY, Marlborough Congregational Church, 35 S. Main St., Marlborough, 93001346, NOMINATION, 12/10/93
CONNECTICUT, LITCHFIELD COUNTY, Brooks, Hervey, Pottery Shop and Kiln Site, Address Restricted, Goshen vicinity, 93001362, NOMINATION, 12/10/93
CONNECTICUT, MIDDLESEX COUNTY, Starr Mill, Jct. of Middlefield St. and Beverly Heights, Middletown, 93001379, NOMINATION, 12/14/93
CONNECTICUT, MIDDLESEX COUNTY, Starr Mill Road Bridge, Starr Mill Rd. across the Cochinaug R., Middletown, 93001344, NOMINATION, 12/10/93
CONNECTICUT, NEW HAVEN COUNTY, Red Bridge, Near Oregon Rd. over the Quinnipiac R., Meriden, 93001345, NOMINATION, 12/10/93
CONNECTICUT, NEW LONDON COUNTY, Cogswell, Edward, House, 1429 Hopeville Rd., Griswold, 93001378, NOMINATION, 12/15/93
CONNECTICUT, WINDHAM COUNTY, Chandler, Capt. Seth, House, 55 Converse St., East Woodstock, 93001380, NOMINATION, 12/15/93
CONNECTICUT, WINDHAM COUNTY, Putnam High School, 126 Church St., Putnam, 93001343, NOMINATION, 12/10/93
CONNECTICUT, WINDHAM COUNTY, Scotland Center Historic District, Area around jct. of Huntington, Palmer and Devotion Rds., Scotland, 93001377, OWNER OBJECTION, 12/16/93
INDIANA, JEFFERSON COUNTY, Eleutherian College, IN 250, Lancaster, 93001410, NOMINATION, 12/15/93
IOWA, WINNESHIEK COUNTY, Clarksville Diner, 504 Heivly St., Decorah, 93001356, NOMINATION, 12/10/93
MICHIGAN, WAYNE COUNTY, Grosse Pointe Memorial Church, 16 Lake Shore Dr., Grosse Pointe Farms, 93001351, NOMINATION, 12/06/93
MONTANA, TOOLE COUNTY, Bethany Lutheran Church, 0.25 mi. S of Gus Blaze Rd., Oilmont vicinity, 93001375, NOMINATION, 12/14/93
NEW JERSEY, BURLINGTON COUNTY, High Street Historic District, Roughly, High St. from Pearl St. to Federal St., Burlington, 93001386, NOMINATION, 12/15/93
OHIO, CUYAHOGA COUNTY, Franklin Boulevard--West Clinton Avenue Historic District, 5207--7625 Franklin Blvd., 5802-7325 W. Clinton Ave., Cleveland, 93001334, NOMINATION, 12/06/93
OREGON, TILLAMOOK COUNTY, US Coast Guard Station--Tillamook Bay, US 101, Garibaldi, 93001337, NOMINATION, 12/10/93
PUERTO RICO, MAYAGUEZ MUNICIPALITY, Isla de Mona, Address Restricted, Mayaguez vicinity, 93001398, NOMINATION, 12/17/93
SOUTH CAROLINA, ANDERSON COUNTY, Pelzer Presbyterian Church, 13 Lebby St., Pelzer, 93001407, NOMINATION, 12/13/93
SOUTH CAROLINA, SALUDA COUNTY, Saluda Theatre, 107 Law Range, Salude, 93001406, NOMINATION, 12/13/93
SOUTH DAKOTA, BEADLE COUNTY, South Dakota Dept. of Transportation Bridge No. 03-020-008, Local rd. over unnamed cr., Wessington vicinity, 93001260, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BEADLE COUNTY, South Dakota Dept. of Transportation Bridge No. 03-327-230, Local rd. over Pearl Cr., Cavour vicinity, 93001261, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BEADLE COUNTY, South Dakota Dept. of Transportation Bridge No. 03-338-100, Local rd. over Shue Cr., Cavour vicinity, 93001269, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BON HOMME COUNTY, South Dakota Dept. of Transportation Bridge No. 05-028-200, Local rd. over Choteau Cr., Perkins vicinity, 93001270, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BON HOMME COUNTY, South Dakota Dept. of Transportation Bridge No. 05-032-170, Local rd. over Choteau Cr., Avon vicinity, 93001271, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BON HOMME COUNTY, South Dakota Dept. of Transportation Bridge No. 05-138-080, Local rd. over Emanuel Cr., Tyndall vicinity, 93001272, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BON HOMME COUNTY, South Dakota Dept. of Transportation Bridge No. 05-255-130, Local rd. over Beaver Cr., Tabor vicinity, 93001273, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BUTTE COUNTY, Hay Creek Bridge, Eighth Ave. over Hay Cr., Belle Fourche, 93001274, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, BUTTE COUNTY, Minnesela Bridge, Local rd. over Redwater Cr., Belle Fourche vicinity, 93001277, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)

SOUTH DAKOTA, MINNEHAHA COUNTY, Eighth Street Bridge, S. Eighth St. over the Big Sioux R., Sioux Falls, 93001308, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, MINNEHAHA COUNTY, South Dakota Dept. of Transportation Bridge No. 50-200-035, Co. rd. over the Big Sioux R., Dell Rapids vicinity, 93001267, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, MINNEHAHA COUNTY, Split Rock Park Bridge, Split Rock Park Rd. over Devils Cr. Gulch, Garretson vicinity, 93001309, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, MINNEHAHA COUNTY, Summit Avenue Viaduct, Summit Ave. over the Chicago and North Western RR tracks, Sioux Falls, 93001307, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, PENNINGTON COUNTY, Rapid City Fruit Company, 320 7th St., Rapid City, 93001340, NOMINATION, 12/09/93
SOUTH DAKOTA, SANBORN COUNTY, South Dakota Dept. of Transportation Bridge No. 56-090-096, Local rd. over Sand Cr., Forestburg vicinity, 93001310, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SANBORN COUNTY, South Dakota Dept. of Transportation Bridge No. 56-117-123, Local rd. over the James R., Forestburg vicinity, 93001311, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SANBORN COUNTY, South Dakota Dept. of Transportation Bridge No. 56-174-090, Local rd. over Redstone Cr., Artesian vicinity, 93001312, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, Hall Bridge, Local rd. over Snake Cr., Ashton vicinity, 93001317, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-010-376, Local rd. over Wolf Cr., Tulare vicinity, 93001313, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-021-400, Local rd. over Turtle Cr., Tulare vicinity, 93001314, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-025-370, Local rd. over Turtle Cr., Tulare vicinity, 93001315, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-062-270, Local rd. over Turtle Cr., Redfield vicinity, 93001316, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-120-231, Local rd. over the James R., Redfield vicinity, 93001318, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-140-224, Local rd. over the James R., Redfield vicinity, 93001319, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, SPINK COUNTY, South Dakota Dept. of Transportation Bridge No. 58-218-360, Local rd. over the James R., Frankfort vicinity, 93001320, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, TRIPP COUNTY, South Dakota Dept. of Transportation Bridge No. 62-220-512, Local rd. over the Keya Paha R., Wewela vicinity, 93001321, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
SOUTH DAKOTA, UNION COUNTY, South Dakota Dept. of Transportation Bridge No. 64-061-199, Local rd. over Brule Cr., Elk Point vicinity, 93001322, NOMINATION, 12/09/93 (Historic Bridges in South Dakota MPS)
TENNESSEE, RUTHERFORD COUNTY, Landsberger--Gerhardt House, 435 N. Spring St., Murfreesboro, 93001397, NOMINATION, 12/13/93
VERMONT, CHITTENDEN COUNTY, Burlington Bay Horse Ferry, Address Restricted, Burlington vicinity, 93001384, NOMINATION, 12/15/93

STATE OF VERMONT
AGENCY OF DEVELOPMENT AND COMMUNITY AFFAIRS

DIVISION FOR HISTORIC PRESERVATION
Preserving Vermont's historic, architectural and archeological resources

October 29, 1993

Carol D. Shull, Chief of Registration
National Register Branch, Interagency Resources Division
National Park Service
P.O. Box 37127
Washington, D.C. 20013-7127

Dear Ms. Shull:

Enclosed please find the National Register nomination for the following:

Burlington Bay Horse Ferry
Burlington, Chittenden County, Vermont

This property is being submitted under the Historic Preservation Act of 1966, as amended in 1980, for inclusion in the National Register of Historic Places.

Enclosed is a copy of the Burlington Certified Local Government Commission final review report. The commission and mayor of the City of Burlington approved the nomination

Sincerely,

Eric Gilbertson
Director/Deputy State Historic
Preservation Officer

EG/EG

Enclosures

135 State Street, Drawer 33, Montpelier, Vermont 05633-1201 • (802) 828-3226

NPS Form 10-900
(Rev. 10-90)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

NATIONAL REGISTER OF HISTORIC PLACES REGISTRATION FORM

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in How to Complete the National Register of Historic Places Registration Form (National Register Bulletin 16A). Complete each item by marking "x" in the appropriate box or by entering the information requested. If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions. Place additional entries and narrative items on continuation sheets (NPS Form 10-900a). Use a typewriter, word processor, or computer, to complete all items.

1. Name of Property

historic name Burlington Bay Horse Ferry

other names/site number VT-CH-591/LC85-3

2. Location

street & number Burlington Bay, Lake Champlain

city or town Burlington

state Vermont **code** VT **county** Chittenden **code** 007 **zip code** 05401

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1986, as amended, I hereby certify that this _X_ nomination ___ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property _X_ meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant _X_ nationally _X_ statewide _X_ locally. (___ See continuation sheet for additional comments.)

Signature of certifying official

10/28/93
Date

Vermont State Historic Preservation Office
State or Federal agency and bureau

In my opinion, the property ____ meets ____ does not meet the National Register criteria.
(___ See continuation sheet for additional comments.)

Signature of commenting or other official

Date

State or Federal agency and bureau

4. National Park Service Certification

I, hereby certify that this property is:

____ entered in the National Register
____ See continuation sheet.
____ determined eligible for the National Register.
____ See continuation sheet.
____ determined not eligible for the National Register.

____ removed from the National Register
____ other (explain): _____

_____ _____ _____
Signature of Keeper Date

5. Classification

Ownership of Property (Check as many as apply)	Category of Property (Check only one)	Number of Resources in Property Contributing	Non contributing
____ private	____ building(s)	_____	_____ buildings
____ public-local	____ district	1	_____ sites
X public-State	X site	_____	_____ structures
____ public-Federal	____ structure	_____	_____ objects
	____ object	1	0 Total

Number of contributing resources previously listed in the National Register N/A

Name of related multiple property listing (Enter "N/A" if property is not part of a multiple property listing.)
N/A

6. Function or Use

Historic Functions (Enter categories from instructions)
Transportation/Water-related

Current Functions (Enter categories from instructions)
Recreation and Culture/Outdoor Recreation
Landscape/Underwater

7. Description

Architectural Classification
(Enter categories from instructions)

Other - Horse-powered Ferry

Materials
(Enter categories from instructions)

Other - Wood
Metal - Iron

Narrative Description (Describe the historic and current condition of the property on one or more continuation sheets.)

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing)

- ☒ A Property is associated with events that have made a significant contribution to the broad patterns of our history.
- ☐ B Property is associated with the lives of persons significant in our past.
- ☒ C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- ☒ D Property has yielded, or is likely to yield information important in prehistory or history.

Criteria Considerations (Mark "X" in all the boxes that apply.)

- ☐ A owned by a religious institution or used for religious purposes.
- ☐ B removed from its original location.
- ☐ C a birthplace or a grave.
- ☐ D a cemetery.
- ☐ E a reconstructed building, object, or structure.
- ☐ F a commemorative property.
- ☐ G less than 50 years of age or achieved significance within the past 50 years.

Areas of Significance (Enter categories from instructions)
Archeology: Historic—Non-Aboriginal
Maritime History
Transportation

Period of Significance
c. 1820-1840

Significant Date
c. 1830

Cultural Affiliation
N/A

Significant Person (Complete if Criterion B is marked above)
N/A

Architect/Builder
Unknown

9. Major Bibliographical References

(Cite the books, articles, and other sources used in preparing this form on one or more continuation sheets.)

Previous documentation on file (NPS)
___ preliminary determination of individual listing (36 CFR 67) has been requested.
___ previously listed in the National Register
___ previously determined eligible by the National Register
___ designated a National Historic Landmark
___ recorded by Historic American Buildings Survey # _____
___ recorded by Historic American Engineering Record # _____

Primary Location of Additional Data
_X_ State Historic Preservation Office
___ Other State agency
___ Federal agency
___ Local government
___ University
___ Other

Name of repository: _____

10. Geographical Data

Acreage of Property less than one acre

UTM References (Place additional UTM references on a continuation sheet)

	Zone	Easting	Northing		Zone	Easting	Northing
1	18	639840	4927180	3	__	_____	_____
2	__	_____	_____	4	__	_____	_____

___ See continuation sheet.

Verbal Boundary Description (Describe the boundaries of the property on a continuation sheet.)

Boundary Justification (Explain why the boundaries were selected on a continuation sheet.)

11. Form Prepared By

name/title Scott Arthur McLaughlin / Graduate Student

organization Texas A&M University, Nautical Archaeology Program date 19 July 1993

street & number RR#1 Box 384 Plains Road telephone (802) 899-4036

city or town Jericho state VT zip code 05465

Additional Documentation

Submit the following items with the completed form:

Continuation Sheets

Maps
A USGS map (7.5 or 15 minute series) indicating the property's location.
A sketch map for historic districts and properties having large acreage or numerous resources.

Photographs
Representative black and white photographs of the property.

Additional items (Check with the SHPO or FPO for any additional items)

Property Owner

(Complete this item at the request of the SHPO or FPO.)

name State of Vermont - Division for Historic Preservation

street & number 135 State Street, Drawer 33 telephone (802) 828-3226

city or town Montpelier state VT zip code 05633-1201

DESCRIPTION

Current Condition

The Burlington Bay Horse Ferry Wreck, a late 1820s or 1830s era vessel, is an example of a Langdon turntable powered horse ferry. The shipwreck lies in fifty feet of water in the northern portion of Burlington Bay, Vermont (see figure 1). It is about seven-tenths of a mile (1,125 meters) northwest of the northern end of the Burlington breakwater and about seven-twentieths of a mile (550 meters) southeast of Lone Rock Point. The hull sits leaning slightly to starboard on the hard clay bottom of the bay. The current condition of the horse ferry is remarkable considering its age and vulnerability to accidental damage by anchors from vessels mooring in Burlington Bay. Due to the ferry's upright orientation and sediment filled interior, the timbers and associated artifacts are well preserved and have remained relatively stable since its sinking. About seventy-five percent of the vessel remains intact, retaining its historic integrity.

The forward one-third of the deck is entirely missing. This may be the result of an anchor being raised that was entangled within the forward deck structure (see figure 2). An alternative is that the deck broke loose shortly after the horse ferry struck the lake bottom. It is doubtful that it was removed prior to its sinking because during the excavation of the bow a number of loose timbers and wood fragments were found. Without the deck, these pieces of wood would have floated away. Some of the starboard frames that were exposed during excavation are broken at the turn of the bilge. These frames broke under the pressure when the vessel struck the bottom on its forward starboard quarter. The axle also broke into two pieces on the starboard side from the upward pressure of the paddle wheel striking the lake bottom. The surfaces of the exposed frames, beams, and planking are generally worn from natural degradation. The planking on the after two-thirds of the vessel and the paddle wheel spokes are in an advanced state of deterioration. The softwood paddles have completely deteriorated.

Historic Condition

An almost complete reconstruction is possible using the intact structural remains and the evidence of other structural elements found during the excavation of test units within the hull (see figure 3). Extensive historical background research and an intensive archaeological survey have failed to identity the name and history behind the Burlington Bay Horse Ferry. The reconstruction

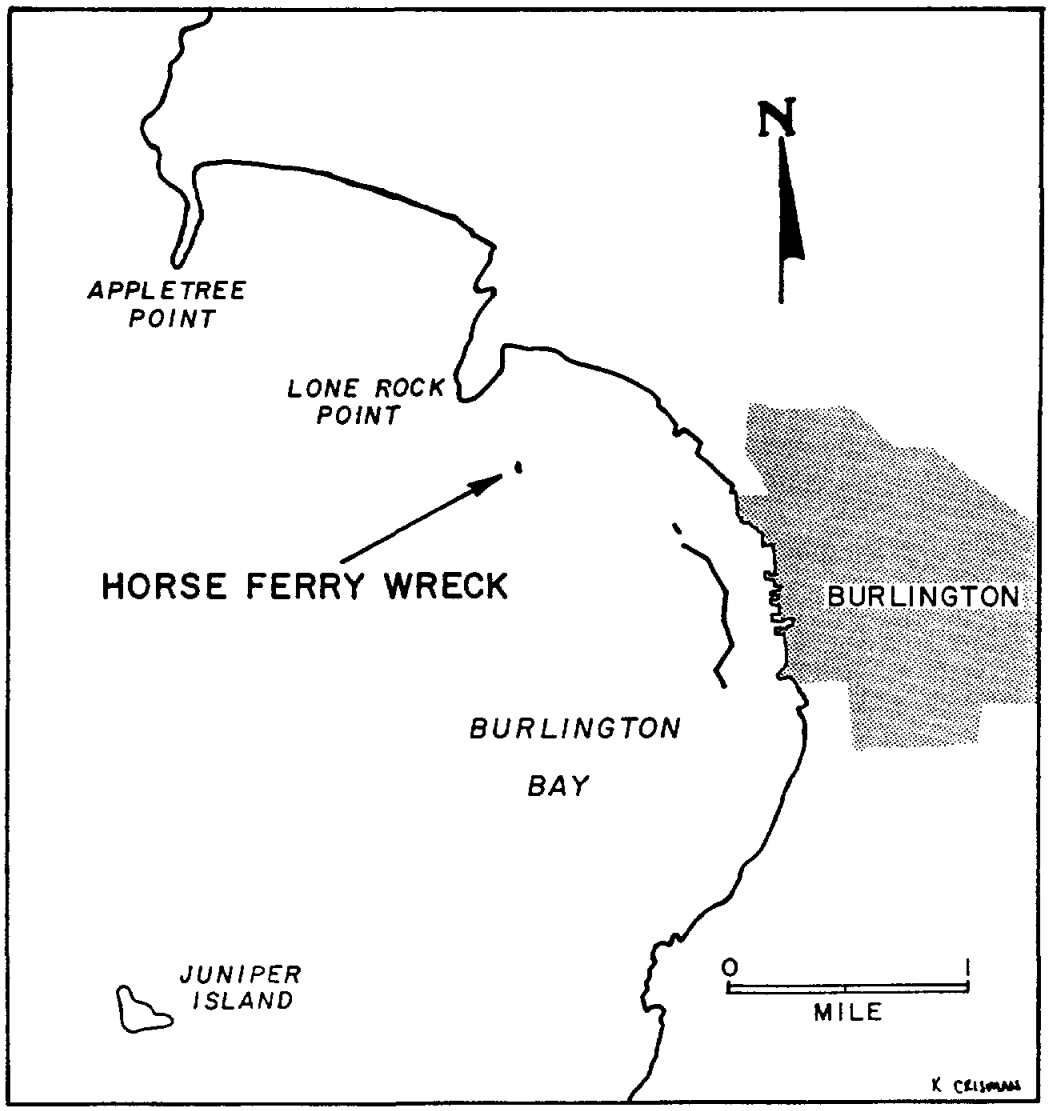

Figure 1
Burlington Bay, Vermont
(Map by Kevin J. Crisman)

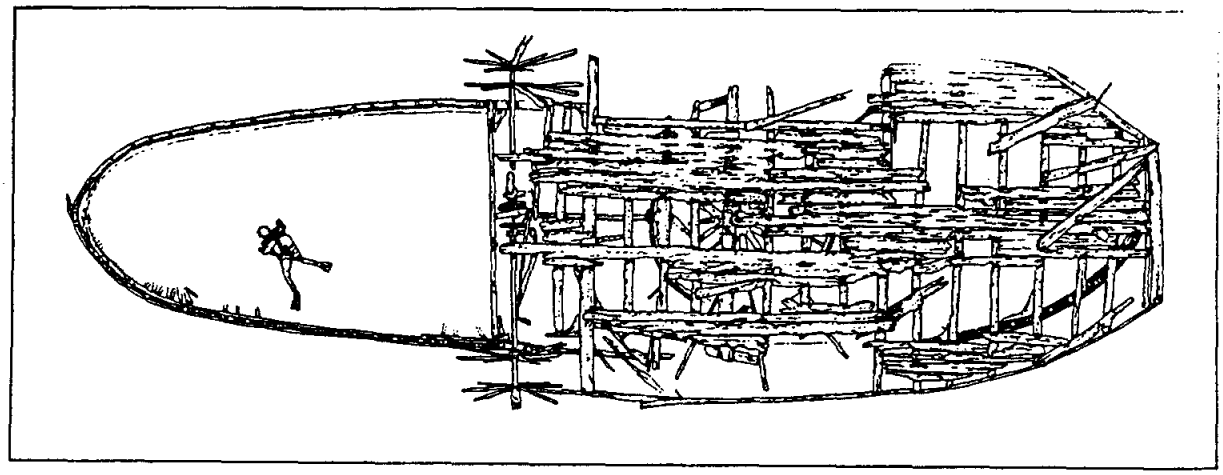

Figure 2
Tracing of Horse Ferry Photomosaic
(Tracing by Kevin J. Crisman)

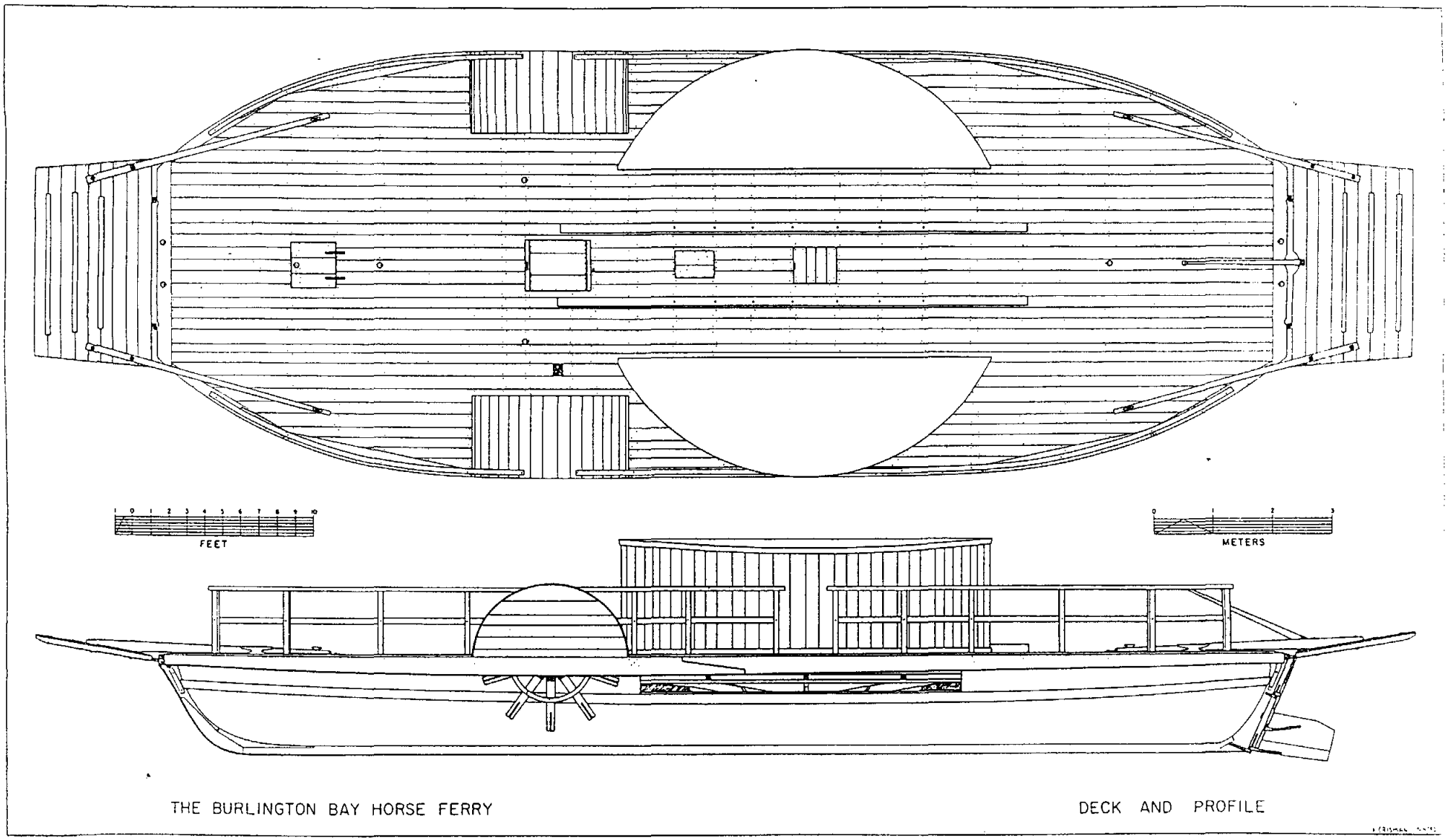

Figure 3
The Burlington Bay Horse Ferry Deck and Profile
(Ship Plans by Kevin J. Crisman)

of the horse ferry is based upon archaeological evidence supplemented by contemporary documents and illustrations.

The horse ferry measured 62 feet 5 inches (19.02 m) in length on deck (minus the ramps that extended from her bow and stern), and had a maximum breadth of 15 feet 3 inches (4.64 m), giving the ferry a length-to-beam ratio of 4:1. The hull had a rabbet-to-sheer height amidships of 4 feet 8 inches (1.42 m), and a depth of hold (from top of keelson to the underside of deck) of 3 feet 11 inches (1.19 m). The hull was double-ended with a curved stem and straight sternpost, a moderately full bow and stern, flat floors, a hard bilge, and vertical sides (see pages 26 - 32).

The Keel

The backbone timbers of the horse ferry consisted of four elements: the keel, stem, sternpost, and keelson. The first three were the first to be laid down on the stocks, and together, they formed the foundation for the hull, defining the overall length of the ferry and providing some indication of its seakeeping abilities.

The keel was one of the least accessible parts of the horse ferry, but the forward and after ends were exposed during the excavation of the stem and sternpost. It was composed of one, or possibly two lengths of red elm, measuring 8 inches (20.32 cm) moulded and 5 inches (12.7 cm) sided, and according to best estimates was 54 feet 4 inches (16.56 m) in length. A 2 ½ inch (6.35 cm) V-shaped rabbet for the garboard planks was chiseled out of the top of the keel's tow sides. The forward most 3 feet 11 inches (1.19 m) of the keel was flat-scarfed to the base of the stem. The after end of the keel did not extend to the rudder, but was instead scarfed to the base of the sternpost.

The Stem

An intact wooden wreck is a joy to behold on the bottom of the lake, but can occasionally be a trial for archaeologists trying to understand the details of design and construction. A case in point was the gracefully curved stem assembly of the horse ferry, which was still so complete that several key timber seams were obscured by the planking.

Only the uppermost two feet of the stem and apron protruded above the mud when the archaeological study of the ferry began. Excavation inside and outside of the hull revealed that the stem assembly, while not very large, was pieced together from at least four timbers: an apron, a white oak upper stem, a lower stem, and a white oak gripe. The seam between the apron and the stem timbers was located in the rabbet and was entirely obscured by the hood ends of the outer planking.

The apron extended the full length of the stem assembly, from underneath the keelson to a point 2 inches (5 cm) above the top of the upper stem. At the forward end of the keelson the apron was 9 ½ inches (24.13 cm) sided; it expanded upward from this point, to a maximum sided dimension of 10½ inches (26.67 cm). The precise moulded dimensions of the apron could not be determined, but the timber extended 3 inches (7.62 cm) above the planking rabbet. Forward of the keelson six ½ inch diameter (1.27 cm) iron drift bolts fastened the apron to the keel, stem timbers, and gripe.

The upper and lower stem timbers occupied the rather narrow space between the apron and gripe. The white oak upper stem measured 4 feet 9 inches (1.44 m) in length, and was moulded 12 inches (30.48 cm) to the rabbet at the top and 3 ¼ inches (8.25 cm) to the rabbet at its base. The stem was sided 3½ inches (8.89 cm) at its forward edge and expanded to 5 inches (12.7 cm) at its after edge. The seam between the upper and lower stem timbers had a 1 ¼ inch diameter wedge stopwater across it to prevent water from working into the hull. The lower stem reached its maximum moulded dimension above the butt of the gripe and keel, and then tapered aft. The lower stem was probably about 5 inches (12.7 cm) sided.

The gripe is the one stem timber for which there are complete measurements, for none of its seams were obscured by the planking rabbet. This white oak timber was 4 feet 6 inches (1.37 m) in length, 8 inches (20.32 cm) moulded and 3½ to 4 inches (8.89 to 10.16 cm) sided. A small stopwater extended across the seam between the gripe and the lower stem timber. The forward face of the entire stem assembly was protected by a 1 inch thick (2.54 cm) by 3½ inch wide (8.89 cm) iron rub rail.

The Stern

The stern of the double-ended horse ferry did not appear to be as complicated an assembly as the stem, but due to its intact condition proved nearly as difficult to measure. It consisted of a straight white oak sternpost and a white oak stern knee that closely resembled the stem's apron, joined together along a curved rabbet that entirely obscured the seam between the two timbers.

The sternpost was a straight white oak timber raking 115 degrees from the keel. The after edge of the sternpost was 5 feet 7 inches (1.7 m) in length (it extended the full height of the hull, from the base of the keel to the sheer). The post was moulded 11 inches (27.94 cm) at the top, 5 ½ inches (13.97 cm) to the rabbet at the upper pintle, and 12 ½ inches (31.75 cm) to the rabbet at the keel scarf; it was sided 5 inches (12.7 cm) forward and tapered to 2 ½ inches (6.35 cm) aft. The post was bolted to the stern knee by two 1 inch diameter (2.54 cm) iron bolts located between the two pintles (there may have been other bolts that extended through the heel of the post).

The joint of the sternpost and the keel differed greatly from standard shipbuilding practices of the time. The post was not tenoned into the top of the keel, but was instead scarfed onto the after end of the keel (it was not possible to dig a trench full length of this scarf). The scarf was curious, for it appeared that the keel lapped over the base of the post, the opposite of what might be expected in this type of joint. A wedge stopwater was inserted across the after seam of the scarf. This scarf deserves more study in the future.

The stern knee extended from underneath the keelson to a point about 3 inches (7.62 cm) above the tip of the sternpost. The knee was sided 9 inches (22.86 cm) across its interior surface, and while the exact moulded dimension could not be determined, it measures 3 inches (7.62 cm) from the inside face to the planking rabbet.

The Frames

While the keel, stem and stern defined the ferry's length and the shape of the ends, it was the frames that defined the breadth and form of the hull from stem to stern. The horse ferry contained a total of thirty-eight full frames (frames composed of a floor timber and two futtocks that crossed the keel at a right angle), a pair of floors without attached futtocks (one each end of

the hull), thirteen pairs of cant frames at the bow and the stern. The location of the midship frame (the widest frame on the hull) has not yet been determined.

The full frames were bolted to the top of the keel on centers that averaged about 15 inches (38.1 cm). Fashioned from white and red oak, these timbers were remarkably uniform in their dimensions, with both the floors and the futtocks averaging 4 inches (10.16 cm) moulded and sided. The floors were straight pieces of timber, with their head lines averaging a distance of 5 feet 3 inches (1.6 m) from the hull's centerline. The heels of the futtocks butted over the keel, and each was laterally fastened to the frame floor with two iron drift bolts. A pair of limber holes for draining bilge water were cut into the base of every square frame, with one on each side of the keelson. The limber holes were located 3 to 4 inches (7.62 to 10.17 cm) out from the side of the keelson, and were 3 inches (7.62 cm) wide and 1 inch (2.54 cm) high.

The method of shaping and assembling the frame futtocks was unlike anything encountered on Lake Champlain shipwrecks to date. The method of frame moulding used can be summed up in three words: saw, steam, and bend (see figure 4). The shipwright began the process of shaping each futtock by selecting a straight 10 foot (3.04 m) length of 4 inch (10.16 cm) square red or white oak. He sawed the timber across its width for a distance of about 4 feet 6 inches (1.37 m), creating two parallel 2 inch (5.08 cm) by 4 inch (10.16 cm) pieces. To prevent the unsawn portion of the timber from splitting during the bending process a ½ inch (1.27 cm) diameter iron bolt was driven into a hole drilled across the base of the saw cut. The futtock was then steamed to make the wood pliable (the shipyard may have had a steambox to concentrate the vapor and speed the softening of the wood fibers). When the timber reached the desired state of flexibility, it was secured on some type of mold and bent by means of a windlass or perhaps large clamps. After bending, the shipwright probably drove a few nails through the saw cut at the ends of the frames to prevent the timber from returning to its former shape.

The use of this technique to shape frames indicates that by the time of the ferry's construction in the late 1820s or 1830s, naturally-curved lengths of timber called compass timber, may have been in short supply. Sawing, steaming and bending futtocks had both advantages and disadvantages. It probably saved a great deal of time and money, for straight lengths of milled oak would have cost the builder much less than compass timber, and the process of sawing, steaming, and bending may have required less labor and time than fashioning futtocks with an adze. Bent timber could also be made to precisely fit the hull design. The sawn futtocks were perhaps slightly weaker than good compass timber, and they were certainly more prone to rot.

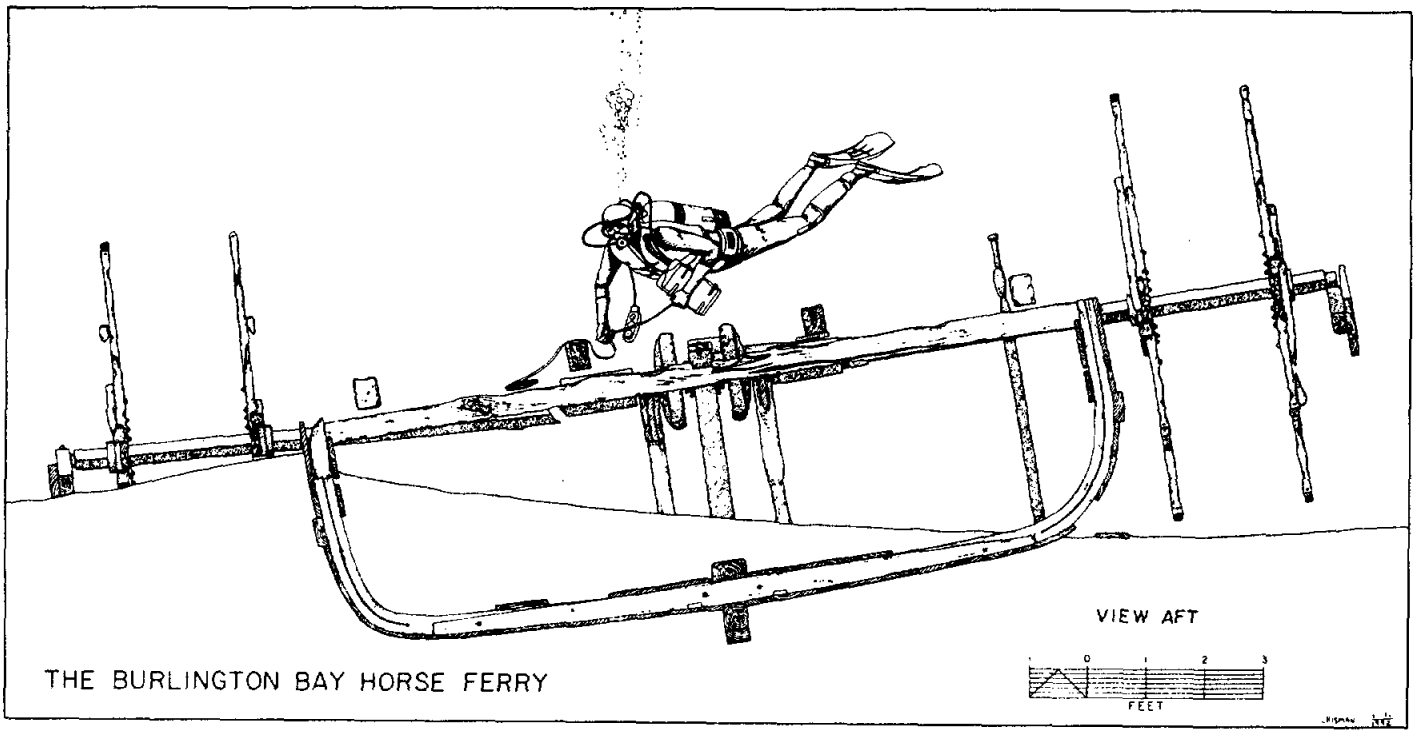

Figure 4
A Section of the Horse Ferry at Frame 8
(Profile by Kevin J. Crisman)

The horse ferry's double ended hull had a nearly identical framing pattern at the bow and stern. The full frames terminated at either end with a single floor timber that was notched down to fit into the top of the apron or stern knee. At each end seven pairs of long can frames extended from the side of the apron or stern knee part of the way up the side of the hull. Six intermediate pairs of shorter cants filled the spaces in between them and extended all the way up to the sheer (see figure 5). The forward most and aftermost pairs of cants were hawse pieces that paralleled the apron and stern knee. The cants were spiked to the outer planking, and the clamp was spiked to the uppermost cants. The forward most pair of cants in the stern were sawn, steamed, and bent, but all other cants were fashioned from compass timber.

After the cant frames were fastened in place the stem and stern were each reinforced by bolting a single curved timber called a breasthook to the interior faces of the cant frames. The breasthooks were 3 ½ inches (8.89 cm) moulded and averaged 4 to 5 inches (10.16 to 12.7 cm) sided.

The Keelson

The white ash keelson of the horse ferry measured exactly 50 feet (15.24 m) in length, and averaged 4 ½ inches (11.43 cm) moulded and 7 ½ inches (19.05 cm) sided. It was probably composed of one or two lengths of timber (the exact number was not determined since the full length of the keelson was not uncovered). The corners of the keelson's forward end were beveled, and the top corners appeared to be chamfered over the full length of the timber. Iron drift bolts fastened the keelson to the frame floors and keel every two to three frames.

A pair of 3 foot 2 inch (96.52 cm) long timbers, moulded 3 ½ inches (8.89 cm) and sided about 8 inches (20.32 cm) were fastened to the tops of the frames beneath the side-wheel axle, five inches (12.7 cm) from the port and starboard sides of the keelson. These pieces served as the foundation for two pairs of stanchion posts that supported the axle and crown gears.

The keelson was probably reinforced with parallel lengths of timber (called "sister keelsons") beneath the bearing for the turntable, since this machinery and the horses walking upon the boat would have placed a tremendous strain on both the keelson and the hull. To verify this additional trenches would have to be excavated.

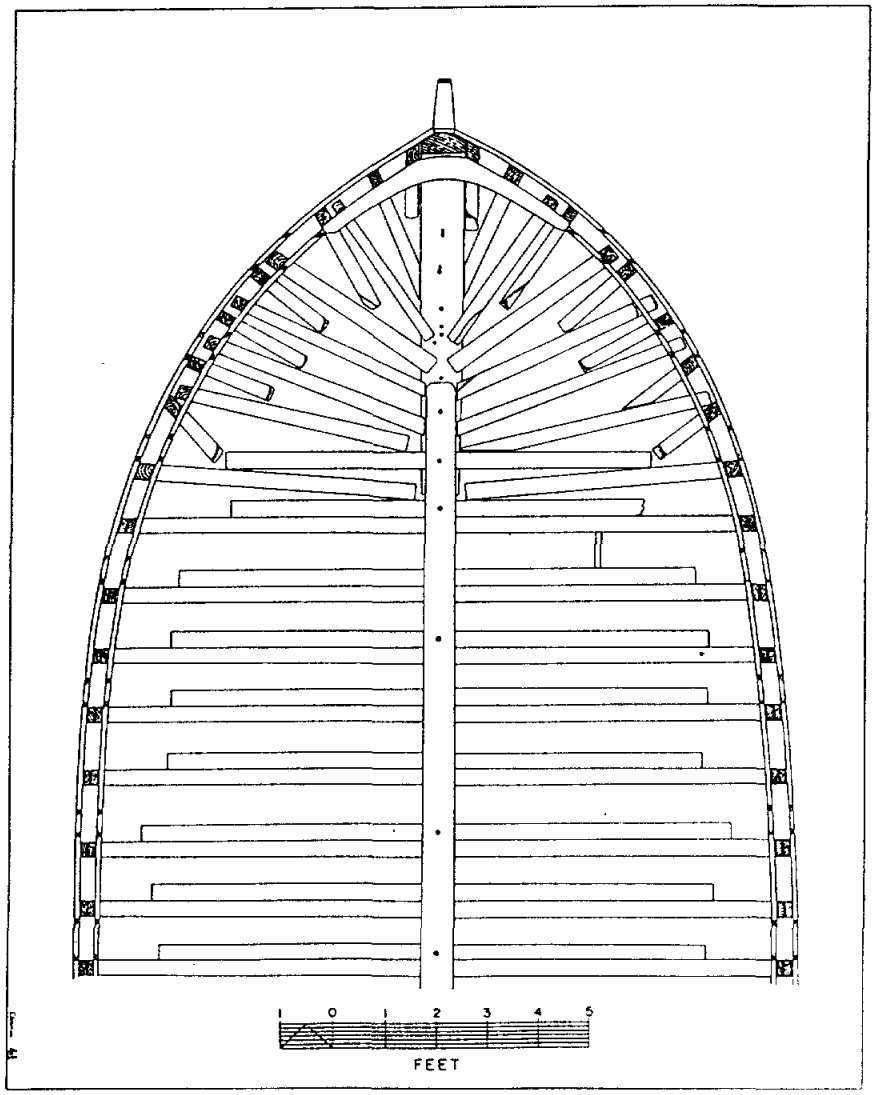

Figure 5
The Horse Ferry's Bow Framing Plan
(Plan by Kevin J. Crisman)

The Planking

The ferry's hull was planked outside with 1 inch thick planks fastened in place with an average of two iron spikes per plank per frame. The planks were heavily eroded on their outer surfaces; some of this erosion occurred during the ferry's career, for some of the bottom planks, protected by mud since the sinking, were found to be only about ½ inch (1.27 cm) thick, and were extremely worn on the outside.

The uppermost planking strake on each side of the hull, the sheer strake, was 11 ½ inches (29.21 cm) wide; its top surface was notched down 6 inches (15.24 cm) at regular intervals to fit the deck beams that overhung the sides of the hull. The strake immediately below the sheer strake was 8 ½ to 9 ½ inches (21.59 to 24.13 cm) in width. The third strake from the top of the hull consisted of 3 inch (7.62 cm) thick, 6 ½ inch (16.51 cm) wide planks scarfed end to end. This feature, the wale, helped to strengthen and support the sides of the hull above the waterline. The ends of the wales were let into 1 inch (2.54 cm) deep mortises cut into the sides of the stem and sternpost.

Planking strakes below the clamp and around the turn of the bilge averaged about 8 to 10 inches (20.32 to 25.4 cm) in width. Three broad strakes, 12 to 14 inches (30.48 to 35.56 cm) in width covered the bottom of the frames, and one or two narrower strakes filled the remaining distance to the side of the keel.

Ceiling planking in the bow consisted of four or five strakes of white pine planks on each side of the keelson. The planks were ½ inch (1.27 cm) thick and their widths ranged from 9 to 13 inches (22.86 to 33.02 cm). They were fastened in place with small iron nails. Between the side-wheel axle to the after end of the turntable, the frames were covered with ceiling from the keelson to the clamp.

The ferry's clamps consisted of planks 10 ½ inches (26.67 cm) wide by 1 inch (2.54 cm) thick, located 4 inches (10.16 cm) below the tops of the frames and the sheer strakes. They served as shelves to support the deck beams, and their upper surfaces were notched down an average 2 inches (5.08 cm) to fit the deck beams. At the ends of the hull the clamps tapered to a point and terminated below the breasthooks, just short of the apron and stem knee. The clamps were fastened in place with two iron spikes per futtock or cant frame. In the forward end of the hull a second strake of planking, 7 inches (17.78 cm) wide by 1 inch (2.54 cm) thick was spiked

to the frame tops directly below the clamp; it extended from the aftermost bow cant frame to the point amidships where the sheer was cut down to permit the turntable to extend beyond the sides of the hull.

The openings for the turntable were an interesting feature. They began at the paddle beam abaft the side-wheels, and extended aft 17 feet 11 inches (5.46 m). The sheer was 19 ½ inches (46.99 cm) lower here than elsewhere on the hull, and was defined by the top of the wale. A 2 inch (5.08 cm) thick strake of ceiling was attached to the frame tops inside each opening, and 6 inch (15.24 cm) wide by 1 inch (2.54 cm) thick cap planks were spiked down over the edges of the ceiling, the frame tops, and the wales on each side of the hull. The turntable openings significantly lowered the ferry's freeboard, and would have allowed water to wash into the hull in any kind of rough wave conditions. It is possible that the ferry's owner may have fastened canvas covers around them to keep water out, although no evidence of this was noted on the wreck.

The Turntable / Side-wheel Mechanism

Perhaps the most intriguing feature of the horse ferry wreck was its propulsion mechanism. This consisted of three major assemblies: the turntable, the driveline, and the paddle wheels (see figure 6). The Langdon turntable was a horizontal, twelve spoked wooden wheel 21 feet 11 inches (6.68 m) in diameter; its top surface was located 13 inches (33.02 cm) below the top of the planked deck and 2 feet 11 inches (88.9 cm) above the top of the keelson. The axis of the turntable was an upright 5 inch (12.7 cm) diameter iron axle that revolved in some type of bearing attached to the top of the keelson. The upper end of the axle was held in place by a small block of wood fastened longitudinally between two deck beams and reinforced by two L-shaped iron brackets.

The hub of the turntable consisted of two 1 ½ inch (3.81 cm) thick iron plates measuring 46 ½ inches (1.18 m) in diameter, placed one above the other. The outer portion of each hub was divided into twelve arms, each 13 ½ inches (34.29 cm) long by 4 ¾ inches (12.06 cm) wide. Sandwiched between the two iron hubs were the turntable's twelve white pine spokes. Each measured approximately 10 feet 6 inches (3.2 m) in length, was 14 inches (35.56 cm) moulded between the hub plates, and tapered to 4 inches (10.16 cm) sided outside of the gear ring. Each spoke was fastened in place between the hubs by three iron bolts.

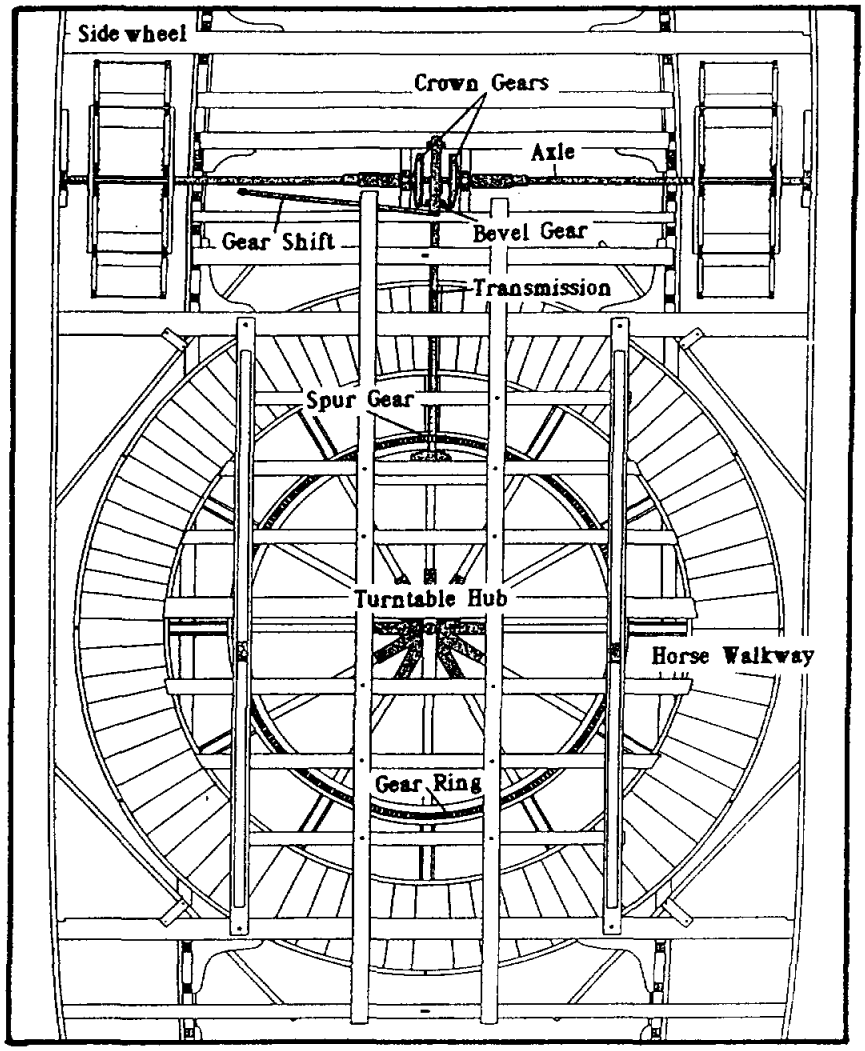

Figure 6
The Turntable / Side-wheel Mechanism Plan
(Plan by Kevin J. Crisman)

The shipwright of this horse ferry did not place rollers under the outside of the turntable to support the weight of the horses. Instead, support arms for each spoke were added beneath the lower hub plate and spoke; the arms were 6 feet 6 ¼ inches (1.98 m) in length, moulded 4 inches (10.16 cm), and sided 3 inches (7.62 cm).

An 8 inch (20.32 cm) moulded by 7 inch (17.78) sided wooden ring with an outer circumference of 35 feet 5 ½ inches (10.8 m) was set 6 ½ inches (16.51 cm) into the top of the spokes, located 3 feet 8 ½ inches (1.13 m) from the outside of the iron hubs. Fastened to the top of the ring were sections of iron gear teeth 1 ½ inches (3.81 cm) thick by 3 inches (7.62 cm) wide. The curved iron sections were attached end-to-end to form a complete circle around the top of the turntable. The total number of gear sections and their individual lengths were not determined.

The walkway for the horses occupied the outermost 2 feet 11 ½ inches (90.17 cm) of the turntable. The inner diameter of the walkway was defined by a small wooden ring spiked to the tops of the spokes that was 8 feet 6 inches (2.59 m) from the center of the turntable. It had an outer circumference of 39 feet 7 ¾ inches (12.08 m), 2 inches (5.08 cm) moulded and 1 ½ inches sided. The outside boundary of the walkway (also the outside edge of the turntable) consist of two rings of wood; one placed above the spokes and one below the spokes. The lower ring measured 6 inches (15.24 cm) moulded and sided, and was notched on its upper surface to fit under the outside ends of the spokes. The upper ring was 3 inches (7.62 cm) moulded and 2 inches (5.08 cm) sided.

Strips of wood measuring 1 inch (2.54 cm) thick by 4 ½ inches (11.43 cm) wide were spiked to each side of every spoke between the gear ring and the outer walkway ring. The strips served as shelves for supporting the ends of the subtread planks that were nailed between the spokes. Most of the softwood subtread planks were missing from the wreck, but two intact pieces indicated that the planks averaged about 6 to 7 inches (15.24 to 17.78 cm) wide and between 1 and 1 ½ inches (2.54 and 3.81 cm) thick. The tops of the subtread planks were even with the top surfaces of the spokes. Hardwood tread planks were placed on top of the subtreads, between the inside and outside wooden rings, to provide the actual walking surface for the horses.

In contrast to the turntable, which was built of wood with a few iron elements, the driveline was assembled entirely from cast and wrought iron. The wrought iron transmission shaft carried the power generated by the revolving turntable to the side-wheel axle; it measured approximately 8 feet 6 inches (2.59 m) in length, and was 3 ½ inches (8.89 cm) square with

rounded corners. The shaft was rounded at each end to permit it to revolve in its support bearings. The iron bearing at the after end of the shaft was attached to the forward face of a deck beam with six bolts; it was about 16 inches (40.64 cm) long and 3 inches (7.62 cm) thick. The forward bearing was an upright iron post 5 inches (12.7 cm) wide and 3 inches (7.62 cm) thick that extended from the top of the keelson to the top of the deck beams. The post was divided into two sections near the top to pivot the transmission shaft from side to side. A cast iron spur gear, 11 ¾ inches (29.84 cm) in diameter, 3 inches (7.62 cm) thick, with sixteen teeth, was fitted to the after end of the transmission, 4 inches (10.16 cm) forward of the after bearing. The spur gear's teeth articulated with the rack of gear teeth fitted to the top of the turntable. A cast iron straight bevel gear, 9 ½ inches (24.13 cm) in diameter and 3 inches (7.62 cm) thick, was fitted to the forward end of the transmission shaft, 2 ¾ inches (6.98 cm) aft of the forward bearing. The beveled gear could be shifted left or right to mesh with a pair of crown gears on the side-wheel axle. The distance between the spur gear and the straight bevel gear on the transmission shaft was 7 feet 2 inches (2.18 m).

The shift mechanism for the transmission shaft was a simple, sturdy arrangement. A plate 2 feet 6 inches (76.2 cm) long, 4 inches (10.16 cm) wide, and 1 ½ inches (3.81 cm) thick was attached by a 1 inch (2.54 cm) diameter bolt to the deck beam forward of the axle. Aft of the axle the shift plate was bolted to the top of the transmission's forward bearing post. The plate was designed to be pivoted from side to side on its deck beam fastening, an action that would tilt the transmission bearing post and bring the forward transmission gear into contact with the crown gears on the axle. The shifting was done by means of a 6 foot 2 inch (1.87 m) long, 2 inch (5.08 cm) square wrought iron bar that was attached to the after end of the shift plate and extended laterally to an upright shift lever. The 5 foot 9 ½ inch (1.76 m) iron lever was fastened to a frame on the bottom of the boat, and protruded above the deck on the port side of the ferry.

One puzzling feature associated with the transmission shaft was an upright iron bar, 1 ¾ inches (4.44 cm) wide by ¾ inch (1.9 cm) thick, slotted into the second deck beam aft of the side-wheel axle. It extended from the bottom of the boat to a point 10 ¾ inches (27.3 cm) above the deck beam. The bar is located directly alongside of the transmission shaft, and seems to be related to its operation.

The axle for the ferry's side-wheels was 22 feet 9 inches (6.93 m) in overall length. The core of the axle consisted of a 3 ½ inch square wrought iron bar. Its weight was supported in the center of the hull by a wooden framework consisting of two pair of upright 4 inch (10.16 cm) by 5

inch (12.7 cm) posts, mortised at their upper ends to fit two fore-and-aft oriented timbers 10 inches (25.4 cm) moulded and 4 inches (10.16 cm) sided. An iron bearing and collar on the top of each fore and aft timber held the axle in place.

The 20 inch (50.8 cm) length of axle between the two axle bearings was fitted with two cast iron crown gears. Each gear had a diameter of 21 inches (53.34 cm), was 5 inches (12.7 cm) thick, and had a 3 ½ inch (8.89 cm) wide ring of teeth around its inside face. The square axle would not have turned smoothly in its support bearings, and so the builder of the ferry slipped round iron collars over the axle, outboard of each crown gear. The collars were about 26 inches (66.04 cm) in length, and measured 4 ½ inches (11.43 cm) in diameter. Outboard of the support bearing a second set of collars was placed over the first; each of the square outer collars measured 5 ¾ inches (14.6 cm) on a side and was 15 inches (38.1 cm) in length. Slightly outboard of the starboard collars the central axle shaft was broken in two.

The outboard ends of the axle were supported by iron bearing blocks fastened to the insides of the guard planks. The bearing blocks were square pieces measuring 7 ½ inches (19.05 cm) long, 6 inches (15.24 cm) high, and 3 inches (7.62 cm) thick. They were held in place by two iron bolts. A 3 inch (7.62 cm) diameter hole in the center of each block contained a copper alloy bushing, within which the rounded end of the axle turned.

The horse ferry's two side wheels each consisted of a pair of ten-spoked wheels separated by a distance of 25 inches (63.5 cm) (see figure 7). The hub of each wheel was fashioned from a plate of iron approximately ½ to ¾ of an inch (1.27 to 1.9 cm) thick and 28 inches (71.12 cm) in diameter. Two iron washers, each 7 inches (17.78 cm) in diameter by 1 ½ inch (3.81 cm) thick, secured each hub to the axle. The outside of the hub was divided into two 6 ½ inch (16.51 cm) long by 3 inch (7.62 cm) wide sockets to fit the spokes.

The oaken spokes originally measured about 42 inches (1.06 m) in length, 5 inches (12.7 cm) in width, and 2 inches (5.08 cm) thick, and were secured in their sockets by two iron bolts. The ends of the spokes were notched to fit softwood paddles (or "buckets") that were approximately 29 inches (73.66 cm) in length, 12 inches (30.48 cm) in width, and 1 inch (2.54 cm) thick. A single bolt at the outside end of each spoke secured each bucket in place. The paddle buckets had entirely disintegrated with the exception of small fragments that were preserved by their contact with the iron bolts at the spoke ends. On each side wheel assembly the

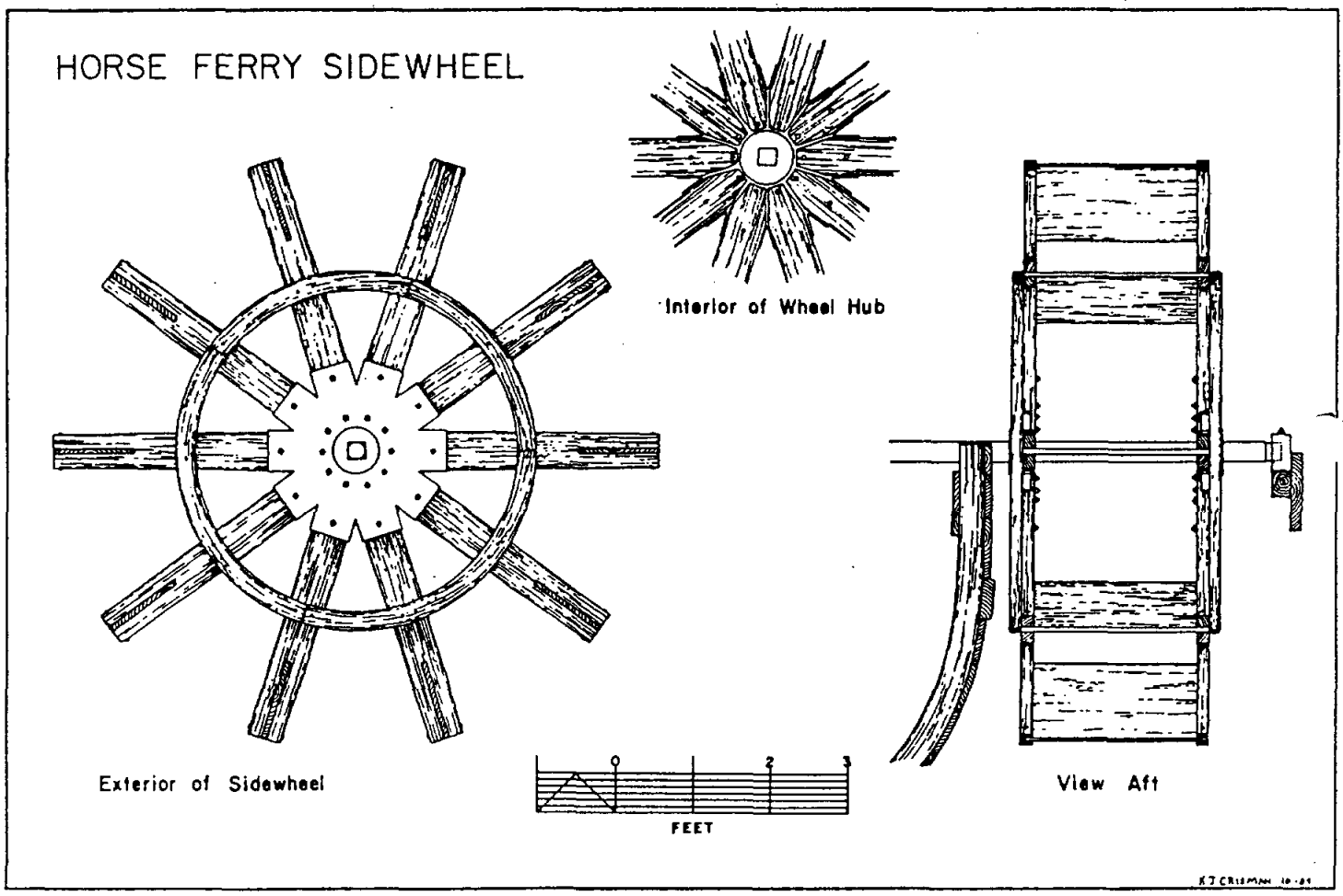

Figure 7
A Burlington Bay Horse Ferry Side-wheel
(Views by Kevin J. Crisman)

spokes were strengthened by a 3 inch (7.62 cm) diameter wooden ring, nailed to the spokes 11 inches (27.94 cm) from the iron hub.

The Deck

The horse ferry's deck was her most prominent feature, for it extended beyond the sides of the hull and covered most of the turntable mechanism (see figure 8). When complete the deck measured 62 feet 5 inches (19.02 m) in length and 23 feet 8 inches (7.21 m) in breadth. It was originally composed of twenty-eight beams of varying dimensions. The forward most nine beams were no longer attached to the hull, although notches in the sheer strake and clamp clearly defined their locations and sided dimensions. The remaining beams were in a degraded condition, but were for the most part complete. Much of the pine deck planking was missing and the rest was in very poor shape.

The white pine deck beams were laid down in an uneven manner, but their spacing forward and aft of the paddle wheel housings averaged about 2 feet 6 inches (76.2 cm). The beams were fit in notches cut 6 inches (15.24 cm) into the top of the sheer strake and 2 inches (5.08 cm) into the top of the clamp. Each beam was fixed in place on each side of the hull by an iron drift bolt that was driven into the sheer strake. The light frames and planking of the upper hull did not provide good attachment points for the beams, a potential weakness that was overcome by bolting horizontally oriented lodging knees between the frame tops and sides of the beams at key locations. This at least lessened the likelihood of the deck tearing free during a collision or in rough weather.

The deck beams averaged 5 inches (12.7 cm) moulded and 5 to 6 inches (12.7 to 15.24 cm) sided. Three of the deck beams in the center of the craft were larger than the rest. The first two, beams number 8 and number 13, were paddle beams, the beams that supported the paddle boxes over the side wheels. The former was located in front of the paddle wheels and the latter was located aft of the paddle wheels and over the after end of the turntable. The second and third large beams anchored the suspended deck above the turntable. Beam 13 was moulded 6 inches (15.24 cm) and sided 9 inches (22.86 cm) , and beam 21 was 8 inches (20.32 cm) moulded and sided.

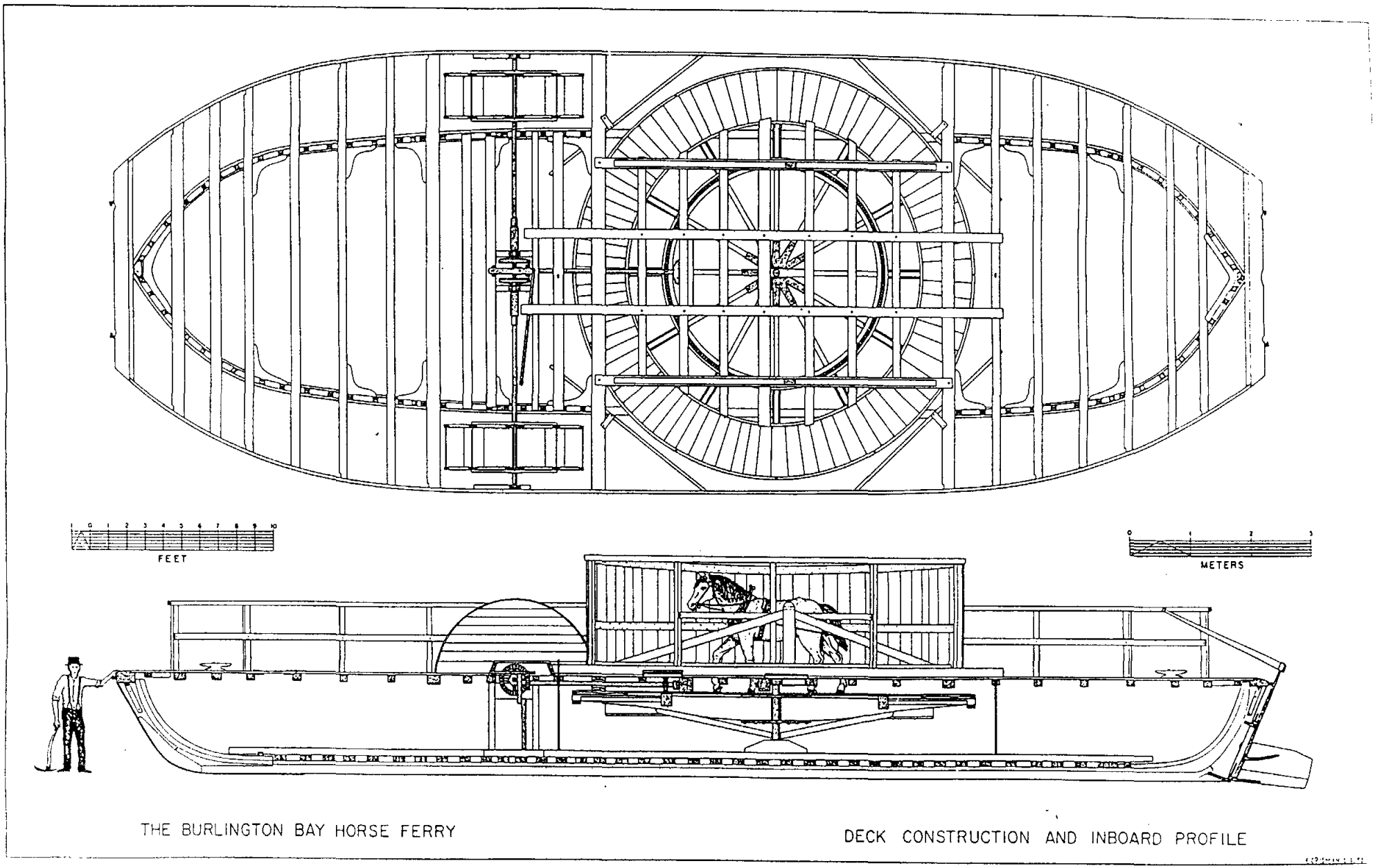

Figure 8
The Burlington Bay Horse Ferry Deck Construction and Inboard Profile
(Ship Plans by Kevin J. Crisman)

It was not possible to fasten deck beams 14 through 20 to the top of the hull since the turntable covered the sides of the vessel amidships. The builder solved this problem by assembling a bridge-like structure to support the central deck above the turntable. The deck beams were bolted to the undersides of the two pairs of longitudinally oriented timbers called deck stringers. The inner pair of white oak stringers measured 26 feet (7.92 m) in length and 5 inches (12.7 cm) moulded and sided. They may have been a later addition to the deck, since they were bolted down over the deck planking. The outer stringers, located slightly inboard of the horse walkways, and were 19 feet (5.79 m) in length, 8 inches (20.32 cm) moulded and 6 inches (15.24 cm) sided (starboard outer stringer was made of white oak, the port outer stringer of white pine).

The outer stringers were each fitted with a king post truss, an arrangement intended to keep both the stringers and the deck from sagging over time. The center of each stringer was mortised to fit an upright post 4 feet 6 inches (1.37 m) long, 7 inches (17.78 cm) wide and 4 inches (10.16 cm) thick. The base of each king post had two square mortises cut through it, identified as a double-mortise "tusk tenon." This type of fastening arrangement allowed a wedge-shaped tenon to be driven into the mortise to lock the king post in place against the underside of the beam. The advantage of a tusk tenon is that it can be tightened or easily disassembled. Tusk tenons are sometimes encountered in the post-and-beam construction of Dutch-derived barns in the Hudson Valley.

A pair of wooden truss braces, each 4 inches (10.16 cm) wide and 2 ½ inches (6.35 cm) thick, extended diagonally from the ends of each stringer to mortises below the top of the king post. The braces locked the king post in place, which in turn supported the center of the stringer and the deck.

The iron transmission shaft connecting the turntable and axle extended several inches above the turntable; and the builder found it necessary to modify some of the deck beams to fit the transmission. The undersides of beams 11, 12, and 14 were notched to fit the shaft. Beam 13 had a greater moulded dimension than the others, and it was necessary to drill a hole through its center to accommodate the transmission. The central portion of beam 15 was increased in sided dimensions to accommodate the strain of supporting the transmission and its after bearing.

The forward most and aftermost beams served as the sill of the deck for the boarding ramps; these deck beams were attached to the tops of the stem and sternpost with 1 inch (2.54

cm) diameter round iron drift bolts and reinforced by a pair of hanging knees. The forward most beam (beam number 1) was missing, but the white oak after beam number 28 was intact, and measured 11 foot 1 ½ inches (3.39 m) long, 4 inches (10.16 cm) moulded and 12 inches (30.48 cm) sided. The forward upper corner of beam 28 was notched down 1 inch (2.54 cm) and over 3 inches (7.62 cm) to form a shelf for nailing down the after ends of the deck planks. The top surface of the beam was also beveled for easy passage between deck and ramp. Two pintles fastened to the after edge of the beam showed that the ramp was hinged for raising and lowering. There was undoubtedly a similar ramp on the forward most deck beam. A semi-circular cut in the center of the deck beam's after edge permitted the rudder post to extend above deck level.

A strake of heavy oaken planks, 12 inches (30.48 cm) wide and 1 ¾ inches (4.44 cm) thick, was attached to the outside ends of the beams on each side of the deck. These guards were an important feature, since they stiffened the deck structure both longitudinally and laterally; they also provided a measure of protection to the deck in the event of a collision. Where they butted, the guard planks were flat-scarfed together and the scarfs were secured with edge-driven iron bolts. Two iron spikes fastened each guard to the end of every deck beam.

The pine deck planks ranged between 7 and 9 inches (17.78 and 22.86 cm) in width, and were 1 inch (2.54 cm) thick. They were fastened to the deck beams with iron nails, with an average of two nails where each plank crossed a beam. The triangular spaces between the outer edge of the turntable and deck beams 13 and 21 lacked surfaces for nailing deck planks, a deficiency that was corrected by spiking planks edge-up between the beams and the guard.

A number of iron ring bolts were set into the deck and the aftermost deck beam, presumably to secure wagons, livestock, and other cargo when the ferry was underway. Notches in the ends of deck beams located abaft the turntable showed where the stanchions for the railing around the deck had once been attached. The two sections of oak deck railing recovered from the wreck in 1991 indicated that the top rail was 2 ½ inches (6.35 cm) wide and 2 ¼ inches (5.71 cm) thick. Mortises in the undersides of the railings suggest that the deck rail stanchions were about 3 inches (7.62 cm) wide and 2 inches (5.08 cm) thick.

Little is known about the side-wheel boxes and the horse stalls that once stood on the deck. The boxes that fit over each side-wheel had entirely disappeared, leaving no discernible traces of their existence. Evidence for the horse stalls was scant, but one clue remained to suggest their possible appearance. This clue was a hardwood stanchion found bolted to a

starboard king post truss brace; the stanchion measured 5 feet 6 inches (1.67 m) in length and was originally about 3 inches (7.62 cm) square. Curiously enough, it was bolted in place with one corner against the truss indicating that the horse shed was not a rectangular structure, but rather was curved to match the curve of the walkway.

Lightweight wooden sheds, planked over with tongue and groove boards, seem a logical possibility for this boat, for they would have been more durable and in the long run probably cheaper than canvas awnings for protecting the horses from sun, wind, and rain. They also would have provided a measure of protection for the crew and passengers during inclement weather.

The Rudder

The horse ferry's rudder was discovered during the excavation of the bow in 1991, and was temporarily recovered for study and then reburied on the bottom. The rudder proved to be an important find, both for its unusual construction and for the clues it provided concerning the length of the horse ferry's career and the nature of her final voyage (see figure 9).

The blade of the rudder consisted of two planks, 2 ½ inches (6.35 cm) wide, edge-fastened with a single iron bolt. The lower plank, which appeared to be of oak, measured 3 feet 8 ½ inches (1.13 m) in length and 7 ½ inches (19.05 cm) maximum width. The upper plank was broken off during the ferry's service and fastened back in place with five small iron nails.

The blade of the rudder was attached to the iron rudder post with two 2 ½ inch (6.35 cm) wide iron straps; the lower strap formed the gudgeon at the base of the post, while the upper strap was bolted to the rudder post, and had clearly been repaired (the broken remnant of the earlier iron strap could still be seen on each side of the post just above the existing strap).

The rudder post was an iron bar 6 feet 9 ¾ inches (81.75 cm) in length, 2 ½ inches (6.35 cm) wide, and 2 ¼ inches (5.71 cm) thick. Two gudgeon loops were welded to the front of the post, the aforementioned gudgeon at the base, and a second located halfway up its length. A rectangular socket at the top of the rudder post once held the ferry's tiller.

The rudder's hinge arrangement is interesting, for it is the reverse of what is seen on most vessels of this era. Typically the sockets (the gudgeons) were bolted to a vessel's stern, while the

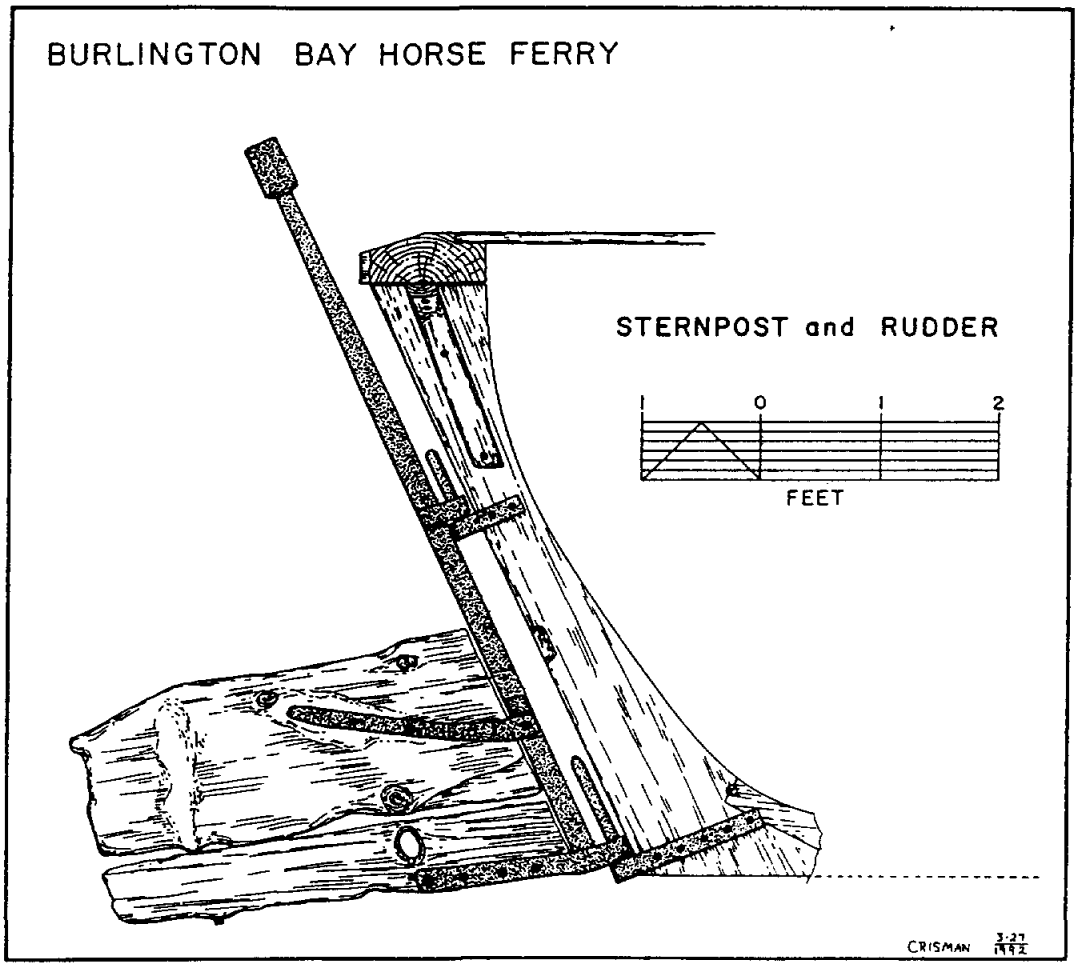

Figure 9
The Burlington Bay Horse Ferry Sternpost and Rudder
(Profile by Kevin J. Crisman)

pintles were attached to the rudder post with the pintles pointing down. The horse ferry's builder fastened the pintles to the sternpost and attached the gudgeons to the rudder. His reason for doing this was to protect the rudder during groundings, which were probably a common occurrence for most horse ferries. When this rudder hit the bottom it could have ridden up a considerable distance without either falling off the boat or damaging the pintle.

The condition of the rudder spoke volumes about the age of the ferry at the time of her sinking. The broken strap and the nailed corner fragment were both the sorts of damage that occur with age and hard use; the appearance of the replaced blade piece suggest that the plank was already very eroded when the repair was made. The discovery of the rudder inside the bow, where it had to have been placed prior to the sinking, provided unequivocal proof that the ferry was not moving under her own power on the day she sank to the bottom of the lake.

SCANTLING LIST FOR HULL

Timber Type	Number	Moulded/Width	Sided/Thickness	Length	Wood Type
Keel	?	5"	8.5"	55'	Red Elm
Stem	1	9"	3½" forward 5" aft	6' 7¼"	White Oak
Gripe	1	max. 8½"	3½" forward 5" aft	4' 7"	White Oak
Sternpost	1	5½"-12¼"	2¼" aft 5" at rabbet	5' 7"	White Oak
Stern Knee	1	3" to rabbet	9"	8' 4"	White Oak
Floors	39	avg. 4"	avg. 4"		White Oak & Red Oak
Square Frames	37	avg. 4"	avg. 4"		White Oak & Red Oak
Bow Cant Frames	12 per side, 24 total	avg. 4"	avg. 4"		White Oak & Red Oak
Stern Cant Frames	12 per side, 24 total	avg. 4"	avg. 4"		White Oak
Bow Hawse Pieces	2	3"	3½"	1' 6" & 1' 10"	Unknown
Stern Hawse Pieces	2	3¾"	3¼"		Unknown
Breasthook	1	3¼"-5¼"	3¼"	4' 9"	Unknown
Keelson	?	7"	6"	50' 4½"	White Ash
Planking	?	avg. 7.5"	1"		White Oak?
Wale	1 per side made up of 2 planks	6.5"	2"		White Oak?
Ceiling Planking	4-5 boards wide per side	10"-12"	1"		White Pine
Clamp	1	10.5"	1"		White Oak?

SCANTLING LIST FOR TURNTABLE & DRIVELINE

Timber Type	Number	Moulded/Width	Sided/Thickness	Length	Diameter	Material Type
Turntable	1				21' 11"	White Pine
Turntable Axis				ca. 3' 6"	5"	Wrought Iron
Turntable Hub	2 iron plates		1.5"		46.5"	Cast Iron
urntable Spokes	12	14" at hub tapering to 4" at outside of turntable	3" at hub expanding to 4" at outside gear ring	10' 6"		White Pine
Spoke Supports	12	4" at hub to 3" at outside of turntable	3"	6'		White Pine?
Wooden Ring #1	?	8"	7"	34' 2"		Unknown
Gear Teeth Ring	9 gear teeth per 18"	3"	1.5"	34' 2"		Cast Iron
Wooden Ring #2	?	2"	1.5"	47' 9 3/8"		Unknown
Wooden Ring #3 (upper)	?	3"	2"	65' 5 3/8"		Unknown
Wooden Ring #4 (lower)	?	6"	2"	64' 4 7/8"		Unknown
Horse Walkway		2' 11"		59' 8¼"		White Pine & Hardwood

SCANTLING LIST FOR TURNTABLE & DRIVELINE (Continued)

Timber Type	Number	Moulded/Width	Sided/Thickness	Length	Diameter	Material Type
Walkway Plank Battens	24	4.5"	1"	4' 2¾"		Unknown
Walkway Support Planks	about 4 planks per section	7½"-9"	1¾"	14"		Hardwood
Walkway Planks	about 5 planks per section	6"-7"	1"-1.5"			White Pine?
Transmission Shaft	1	3.5"	3.5"	8' 6"		Wrought Iron
Aft Transmission Shaft Gear Wheel	1		3"		12.5"	Cast Iron
Forward Transmission Shaft Gear Wheel	1		3"		8.5"	Cast Iron
Axle Gear Wheels	2		5"		21"	Cast Iron
Axle	1	3.5"	3.5"	22' 5"		Wrought Iron

SCANTLING LIST FOR PADDLE WHEELS

Timber Type	Number	Moulded/Width	Sided/Thickness	Length	Diameter	Material Type
Paddle Wheels	2	2' 5"			7' 10"	
ddle Wheel Hub	4		0.5-0.75"		2' 4"	Cast Iron
ıron Washers	2 per paddle wheel		1.5"		7"	Wrought Iron?
Paddle Wheel Spokes	2 sets of 10 per paddle wheel	5"	2"	3' 6"		White Oak
Paddles	10 per paddle wheel	1'	1"	2' 5"		White Pine
Wooden Ring	5 pieces	3"	ca. 2"	13' 7 3/8"		Unknown

SCANTLING LIST FOR DECK

Timber Type	Number	Moulded/Width	Sided/Thickness	Length	Material Type
Deck Beams	28	avg. 5"	avg. 5"-6"		White Pine & White Oak
Lodging Knees	8 existing	vary	vary	vary	Unknown
Deck Planking		7"-9"	1"		White Pine
Outboard Deck Stringers	2	8"	6"	19'	White Oak & White P
King Post	2	7"	4"	4' 6"	Unknown
Diagonal Trusses	2 made up of two beams	4"	2.5"		Uknown
Inboard Deck Stringers	2	5"	5"	26'	White Oak
Railing	?	2¾"	2½"		White Oak?

WOOD SAMPLES FROM HULL

Timber Type	Wood Type
Keel	Red Elm
Upper Stem	White Oak
Gripe	White Oak
Sternpost	White Oak
Stern Knee	White Oak
Ceiling Plank #5	White Pine
Ceiling Plank #6	White Pine
Ceiling Plank #7	White Pine

WOOD SAMPLES FROM FLOORS

Timber Type	Wood Type
Frame 2A	Red Oak
Frame 3A	White Oak
Frame 4A	White Oak
Frame 5A	White Oak
Frame 6A	White Oak
Frame 7A	Red Oak
Frame 8A	White Oak
Frame 9A	White Oak
Frame 10	Red Oak
Frame 11A	White Oak
Floor CC	White Oak

WOOD SAMPLES FROM SQUARE FRAMES

Timber Type	Wood Type
Frame 2B	Red Oak
Frame 3B	Red Oak
Frame 4B	White Oak
Frame 5B	White Oak
Frame 6B	White Oak
Frame 7B	White Oak
Frame 8B	White Oak
Frame 9B	White Oak
Futtock CC	White Oak
Futtock DD	White Oak
Frame EE	White Oak

WOOD SAMPLES FROM BOW CANT FRAMES

Timber Type	Wood Type
Frame 12	White Oak
Frame 13	White Oak
Frame 14	White Oak
Frame 15	White Oak
Frame 16	White Oak
Frame 17	White Oak
Frame 18	White Oak
Frame 19	White Oak
Frame 20	White Oak
Frame 21	White Oak
Frame 22	Red Oak

WOOD SAMPLES FROM STERN CANT FRAMES

Timber Type	Wood Type
Stern Cant Frame SC1	White Oak
Stern Cant Frame SC3	White Oak
Stern Cant Frame SC5	White Oak
Stern Cant Frame SC7	White Oak
Stern Cant Frame SC9	White Oak

STATEMENT OF SIGNIFICANCE

The Burlington Bay Horse Ferry is eligable for National Register listing under criteria C as a property that embodies the distinctive characteristics of a type, period, and method of construction and under criteria D as a property that has yielded and is likely to yield, information important to history. The areas of significance within these criteria are archaeology, maritime history, and transportation.

Horse ferries were an important element in the North American transportation network during the first half of the nineteenth century, although the story of these humble craft has long been obscured by the contemporary advances in steamships, canals, and other forms of maritime technology. Inexpensive and dependable, horse boats carried people and goods across narrow rivers, lakes, and bays, and thereby served needs of a growing and increasingly mobile population. Their construction peaked in the period between 1820 and 1850, and then declined in the following decades as steamboats and railroads consolidated their hold on the inland transportation system. The appearance and operation of one early type of horse ferry, the turntable boat, remained shrouded in mystery until 1983, when the Burlington Bay Horse Ferry Wreck was discovered during a side-scanning sonar survey. The horse ferry is the only known surviving example of this once common North American vessel type. The ferry has been the focus of an intermittent archeological study since its discovery. The study of the Burlington Bay Horse Ferry Wreck and the development of horse-powered ferries has revealed a forgotten chapter in the maritime history of the United States and generated numerous questions about the operation and construction of these unique watercraft.

Archeology

The archeological research conducted on the Burlington Bay Horse Ferry has been the effort of a number of researchers. This research has been the key to the understanding of how a horse-powered ferry hull was constructed and the mechanics of its propulsion system. The wreck , first discovered in the fall of 1983, is the only known surviving example of a horse-powered ferry. Researchers Scott C. Hill and James W. Kennard of New York discovered the wreck during a side-scan sonar survey

of Burlington Bay. The survey produced a detailed sonar image showing the hull and deck beams of the vessel. An inspection by divers that followed revealed the 62 foot horse-powered ferry. The wreck has since been the subject of several intermittent archaeological studies under the supervision of the Vermont Division for Historic Preservation. The survey results were submitted to the State Archeologist in the form of field reports.

In 1984 Scott Hill enlisted the help of fellow divers and made a total of 550 overlapping photographs of the wreck. These photographs were pieced together to form a photomosaic view of the wreck (see Section 7, figure 2). Futher inspection of the wreck took place in February 1988 by *National Geographic* photographer Emory Kristof and Donald G. Shomette of the Library of Congress at the invitation of Scott Hill. They inspected the remains using sector-scan sonar and a video-equipped remotely operated vehicle (ROV). Extensive video footage was taken of the wreck using the ROV. The horse ferry was also visually inspected to evaluate its current condition and the possible cause of its sinking. The results of their survey and Hill's photomosaic were featured in a *National Geographic* article in 1989.

It was not until 1989 that a comprehensive study of the vessel's exposed structure was conducted by divers under the direction of Kevin J. Crisman (now a professor at Texas A&M University, Nautical Archeology Program) (see figure 1). From 1990 to 1992, Dr. Crisman with a crew of divers excavated test units inside the bow and stern of the vessel and exposed the sternpost and stem with deep trenches beneath the wreck (see figure 2). This survey was conducted to collect the necessary information to draw construction plans for the vessel, and to determine its construction sequence and the mechanics of the propulsion system. It was also hoped that through excavation the identity of the wreck would be revealed, as well as the reason why she sank.

The limitations that the horse-powered mechanism imposed on vessel design and construction were evident in the design and construction of the hull. The ferry had to be both lightly built and very shallow in draft for the horses to be able to make any sort of headway, particularly against winds, strong currents, or high waves. These characteristics probably meant that the vessel was easily stressed and that she required continuous maintenance throughout her career. She may also have been difficult to

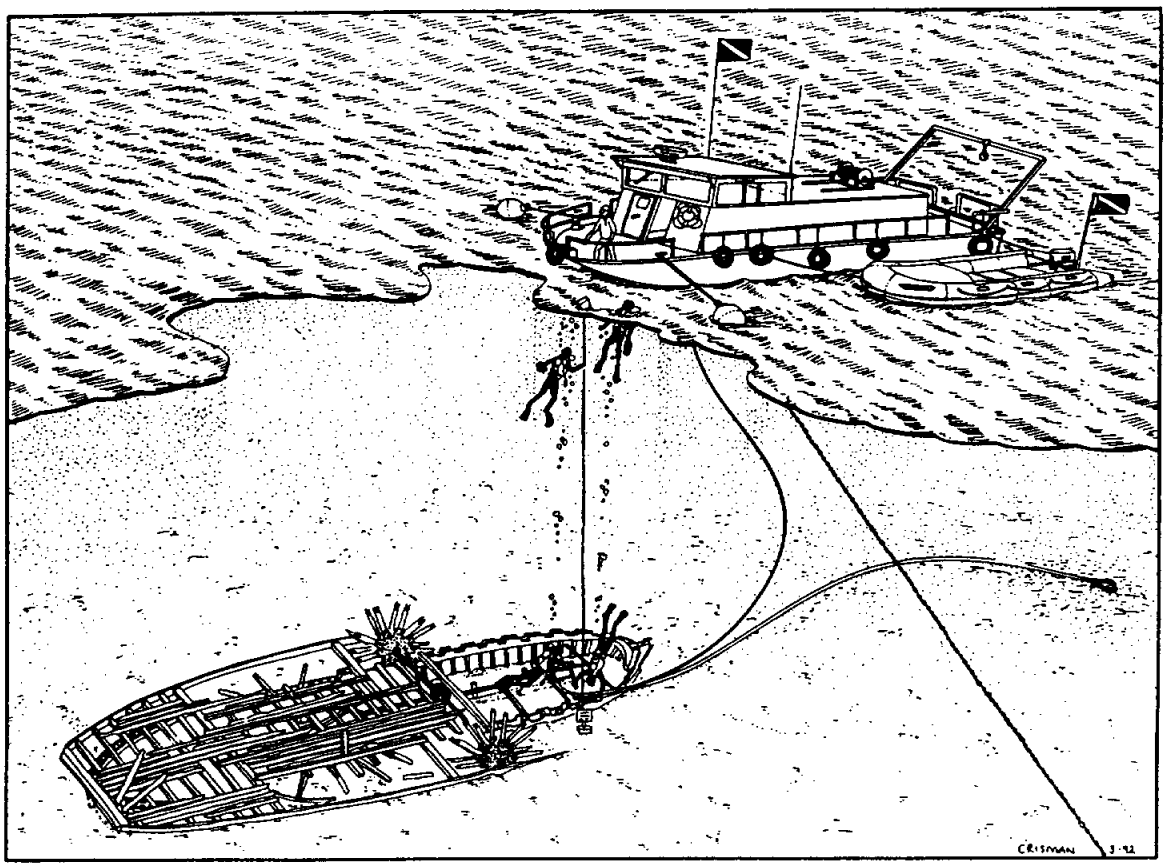

Figure 1
Method of Mooring Over the Horse Ferry During the 1991 & 1992 Field Seasons
(Drawn by Kevin J. Crisman)

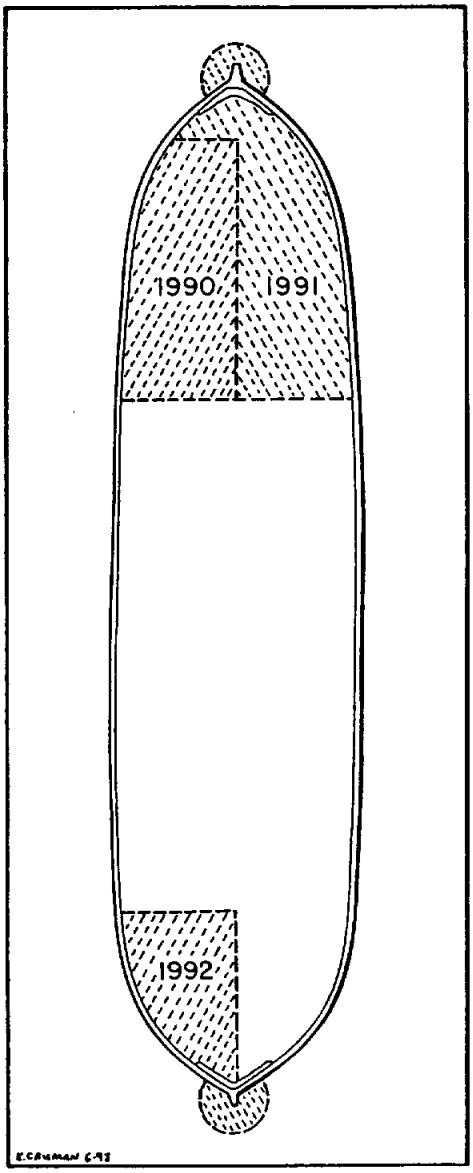

Figure 2
Horse Ferry Excavations, 1990 to 1992
(Drawn by Kevin J. Crisman)

control in rough weather. The shallow keel and shallow draft were well-suited to certain aspects of ferry boating; however, for they allowed her to pull in close to sloping shorelines to load and unload wagons, passengers, and livestock. The light hull could have been easily hauled ashore on a slipway for inspection, repairs, and over-wintering.

Two potential problems with the ferry's design were identified during the analysis of the hull. The first of these were the 17 foot 11 inch (5.46 m) long, 19 ½ inch (49.53 cm) high openings that permitted the turntable to extend out from the sides of the hull. The ferry did not have much freeboard to begin with, and the lowering of the sides by over a foot and a half (45.72 cm) must have resulted in copious amounts of water sloshing into the hull whenever the vessel was struck broadside by large waves. The operator of the ferry may have minimized this hazard by tacking canvas covers around the underside of the deck and sides of the openings.

The second weakness in the design was the suspended deck over the turntable. The longitudinal deck stringers and king post trusses would have provided adequate support for a time, but sooner or later, the steady traffic of heavily laden wagons and livestock would have seriously weakened the entire structure. The quality of the workmanship and materials seen in the hull was adequate, but not exceptional. The shipwright who directed the construction clearly was not a stickler for precise measuring and fitting. Much of the shaping and assembling work was obviously "by eye", without the benefit of careful measurements; the slightly irregular spacing of the frames and deck beams is a good indicator of this practice. The use of rot prone red oak for frame timbers suggest either that the builder was indiscriminate in his use of woods, or that good shipbuilding timber was increasingly hard to come by in the Champlain Valley in the late 1820s and early 1830s. It is suspected the latter is to be the case. The construction of the stem from four small pieces instead of one large timber may be a further indication that finding large timbers of white oak was a problem.

The truly unusual feature in the horse ferry's construction was the method of fashioning the frame timbers, in which the frame futtocks were sawn, steamed, and bent to achieve the desired shape. This is the only archaeological example of this technique that has been seen to date in the Champlain Valley. Shaping frames in this manner was probably fast and relatively inexpensive in terms of labor and materials.

The results, however, may have been slightly weaker and more rot prone than conventional framing methods. The futtocks have not forgotten their original straight grain, and wherever the deck is missing or is no longer securely attached, the frames have spread slightly, distorting the hull shape.

The horse ferry probably operated with a crew of two to three men; a minimum of two were required when the boat was underway, one to steer and one to shift gears and supervise the horses. The number of people, livestock, and wagons that the ferry could carry no doubt depended upon the state of winds and waves upon the lake, and how the captain balanced the factors of safety and profit. In good weather the ferry was probably able to support a minimum of four , and perhaps as many as six, medium-sized wagons and teams.

The size of the boat and the dimensions of the horse walkway openings over the turntable together indicate that the boat was propelled by two horses working on opposite sides of the deck. The speed at which the horse ferry moved over the water is difficult to estimate, since it would have depended on the efficiency of the hull form, friction in the driveline, the strength and endurance of the horses, the weight of the deck cargo, as well as the strength and direction of the current, winds, and waves. Some idea of the speed of these craft may be deduced from a contemporary newspaper report that the six-horse *Eclipse* regularly made the three mile crossing between Essex, New York and Charlotte, Vermont in thirty minutes: at this rate she averaged six miles per hour. The Burlington Bay ferry was slightly smaller than the *Eclipse* and was propelled by fewer horses, and it is likely that she moved a little slower.

The turntable / side-wheel gear ratio for the horse ferry was determined by measuring the diameter of the turntable walkway and the gear ring, and counting the number of teeth in the gear ring and various gear wheels. From these figures it was calculated that two horses moving one mile (1,609.35 m) per hour (a pace of 88 feet or 28.2 meters per minute) spun the turntable at the rate of 1.47 revolutions per minute, and the side-wheels at the rate of 9.7 revolutions per minute.

The wreck has been called the "Burlington Bay Horse Ferry" due to its present location, but this title is in a sense misleading: there is no evidence that any horse

ferries ever operated out of Burlington. The city is on one of the widest, least protected parts of the lake, a location patently unfavorable for running a team boat line. This vessel, no doubt, came from one of the ferrying enterprises at the northern or southern end of the lake.

Artifactual and structural evidence from the wreck all hinted that the ferry had seen many years of service on the lake, but was not in service at the time of her demise. The artifacts recovered from the wreck's interior were, with few exceptions, refuse and junk, worn-out or broken items that were tossed in the bilges on the slight chance that they might be useful at some future date. The ferry's structure and machinery, the heavily eroded outer planks, the worn spur and bevel gears and the copper alloy axle bushing, the broken and patched rudder, all told of a lengthy career on Lake Champlain's waters.

How lengthy a career? Archival and archaeological evidence together suggest probably not less than eight years, nor any more than fifteen. After many years of work at some other location, this vessel was brought to Burlington to be either repaired or to be sold. When it was clear that the boat was no longer wanted, she was towed out into the deep water north of Burlington harbor and scuttled.

Some of the damage seen in the hull and machinery can perhaps be attributed to the hull striking the bottom when it sank. The present position of the wreck indicates that the ferry went down with a pronounced list to starboard; at this angle, the first parts to hit the hard clay bottom would have been the outside edge of the deck and the starboard paddle wheel. The shock of the impact may have ripped the lightly fastened forward beams loose from the hull, permitting the fore deck and paddle wheel covers to float back to the surface (air trapped under the paddle wheel covers may even have torn them free when the ferry first slipped under the water). The starboard paddle wheel's impact with the bottom was probably responsible for the break in the axle just outboard of the bearing collars.

The sinking of the ferry caused a great deal of structural damage in the space of a few moments, but once the hull had settled on the bottom, it was effectively protected from the effects of weathering and most forms of traumatic injury (excluding dragging anchors). Time

has not exactly left the wreck unchanged; over the past one and one-half centuries the slow but steady process of oxidation, decay and erosion have worked upon the machinery, fastenings, and timbers. Nevertheless, enough of the ferry is left to provide us with a detailed look at how nineteenth century Americans used horses to propel watercraft.

With the data from the researchers involved in the study of the horse ferry, a detailed reconstruction of the vessel and the reasons why it rest on the bottom of Burlington Bay have been made possible. Archeology has played an important and invaluable role in today's understanding of the importance of animal-powered ferries in United States history. It is now recognized that these vessels played an important role in the transportation of goods and people throughout the United States in the nineteenth century. Like other common aspects of common occurrences in every day life, horse-powered ferries were not well been documented by contemporaries during the age of horse ferries. The excavations at the Burlington Bay Horse Ferry has permitted an excellent glimpse of this unique watercraft. The horse ferry could also yield more information through continued archaeological and historical research.

Maritime History

Throughout most of maritime history, people have depended upon the wind or human strength to propel their watercraft. Human power was not always practical and the wind was not always reliable. The need for a vessel that did not rely on these methods of propulsion lead to the experimentation with animal-powered watercraft. The concept of animal-powered watercraft dates as far back as the fourth century AD., when Roman designers proposed an oxen-powered side-wheel warship.

Interest in animal-powered watercraft resurfaced in Europe during the 17th-century. Designers for such craft went so far as to construct working models and prototypes. One of the earliest known examples was a boat built on the Thames River in England in the 1680s by Prince Palatine Rupert. This vessel (or one built to a similar design) was in use as a "tow vessel" at the Chatham Dockyard in 1682; it reportedly was capable of towing the largest ships of the Royal Navy. Prince Rupert's experiment proved that horse-powered boats were strong and efficient, but this did not make a lasting mark on Europeans. The lack of interest

in the new technology can probably be attributed to the nature of European economies and culture at the time.
Ferries propelled by sails, sweeps, or poles had been efficiently operating on rivers and other waterways for centuries, the human labor necessary to work these types of ferries was plentiful and cheap, and the pace of daily life did not really require faster, paddle-powered vessels. Quite simply, there was neither the public demand nor the commercial incentive for building horse-powered boats in seventeenth century Europe.

This was not the case on the other side of the Atlantic Ocean at the beginning of the nineteenth century. In North America the geographical, cultural, and technological circumstances combined to set the stage for widespread and commercially successful use of animal-powered ferries. Overland travel in North America was impeded by a multitude of rivers, lakes, and bays, all of which had to be crossed by ferries. Human labor was relatively scarce and expensive, and labor-saving devices of all sorts were welcomed by entrepreneurs. As many European tourists in America observed, Americans always seemed to be in a hurry. These circumstances called for ferryboats capable of traversing bodies of water briskly, regardless of winds and water currents, yet requiring a minimum of human labor.

In 1791 inventor John Fitch designed and built a horse-powered ferry on the Delaware River; unfortunately, this boat proved to be a commercial failure. Other inventors were not disheartened by Fitch's setbacks. Animal-powered ferries went into regular service in North America during the last two decades of the 18th century. The use of horse-powered ferries or "team boats" was probably slowed by flaws in their early designs and a reluctance by the public and ferry boat owners to accept this "new" craft in United States waters. Many of the early team boats had a shallow draft hull with low sides to allow them to navigate in shallow water and along the coast. The earliest recorded commercially successful horse-powered ferry navigated the waters around Manhattan Island, New York in the spring of 1814. For the next three and one half decades, North America would experience a horse ferry boom. During this time horse ferries would play a vital role in the continent's transportation network. Whereas steamboats were chiefly employed as long-distance conveyors up and down the length of rivers, lakes, and bays, horse boats performed the traditional ferryboat task of transporting people and goods across narrow bodies of water. They were

well-suited to short distance crossings of between one quarter of a mile and three miles; where they would be protected from strong winds and high waves.

With the success of the Manhattan horse ferry, there grew an interest in this unique watercraft. These early horse ferries were designed with a capstan-like mechanism around which harnessed horses would walk in a tight circle upon the deck. This was recognized as being harmful to the animals and taking up too much valuable deck space that could be used to carry cargo. Barnabas Langdon, an inventor from the Lake Champlain port of Whitehall, New York, patented his solution to the problem in 1819. He designed a turntable revolving on an axis that lay just below the deck. The horses could walk in place on the turntable while standing in openings cut through the deck. The turntable concept did not originate with Langdon, but was in use to power mills and other small land-based industries. Langdon's turntable design was a significant improvement over the previous capstan design mechanism. Soon after he patented his design, the horizontal turntable was installed in most of the horse ferries built during the following two decades.

The island-studded waters of the lake's northern end and the narrow, relatively protected southern end were both well-suited to horse-powered ferry operations (this was not the case; however, with the open, wind-swept waters of the central lake, which would have been heavy going for light, shallow draft ferry boats). Despite Lake Champlain's suitability for horse-powered ferries, the widespread use of these craft on the lake came surprisingly late in North America's horse ferry era, in the late 1820s and 1830s. This delayed start is all the more perplexing in light of the busy commerical team boat operations on the nearby Hudson River. It is possible that until the late 1820s there was simply not enough cross-lake traffic to warrant the expense and effort of building horse boats.

The Burlington Bay Horse Ferry Wreck is a combination of early nineteenth century advances in mechanical engineering and old fashioned horse power. Its propulsion system is an excellent example of the Langdon turntable design. This horse ferry is not the only horse-powered ferry that navigated Lake Champlain waters. Based on research it appears that more than twelve team boats navigated the lake between the period 1820 to 1865, providing daily service at as few as seven ferry crossings (see figure 3 and 4).

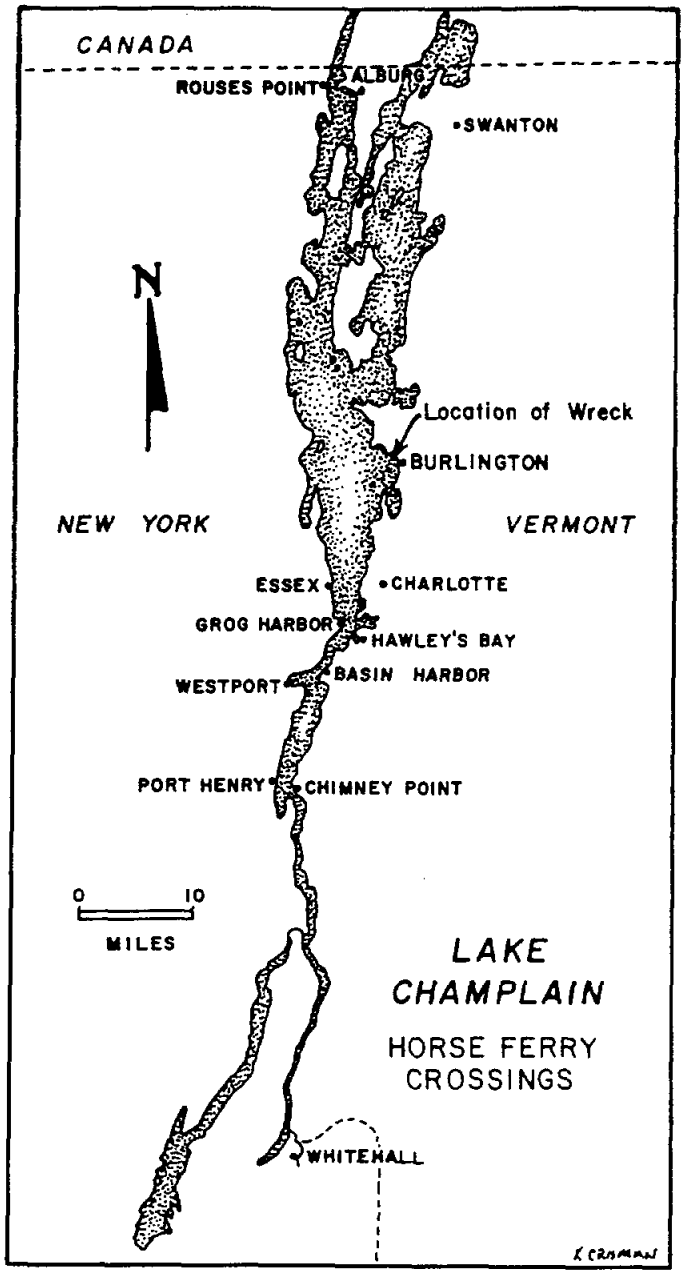

Figure 3
Lake Champlain Horse Ferry Crossings
(Map by Kevin J. Crisman)

LAKE CHAMPLAIN HORSE-POWERED FERRIES

Name of Ferry	Owner	Dates of Operation	Dimensions	Mechanism Type	Number of Horses	Ferry Crossing
Eclipse	Charles McNeil & Henry H. Ross	1828-1847	68' long	Langdon-Type Turntable	Six Horses	Essex, NY-Charlotte, VT
	Elijah Loomis	1828				Alburgh, VT-Hogs Island, Swanton, VT
	William Mott	1828			Two Horses	Alburgh, VT-Rouses Point, NY
	Nathan & John Niles	1829				Alburgh Area
	Samuel Strong & James Whalon	1828				Kingsland Bay, VT-Grog Harbor, NY
		c. 1828				Chimney Point, Addison, VT-Port Henry, NY
Eagle	Captain Asahel Havens	1833				Basin Harbor, VT-Westport, NY
P.T. Davis		c. 1847-1850s			Four Horse	Chimney Point, Addison, VT-Port Henry, NY
Gypsy	Asahel Barnes Jr.	1858-?		Treadmill	Four Horse	Chimney Point, Addison, VT-Port Henry, NY
		1821-1827		Treadmill	Six Horse	Basin Harbor, VT-Westport, NY

Figure 4

Transportation

The horse ferry was a work vessel that made daily crossings carrying passengers and goods between destinations. These vessels played a role in bridging the gap that separated people. This was especially true in areas such as the Champlain Valley where there were no bridges over Lake Champlain until the end of the nineteenth century. Ferries and other vessels helped to hold the Champlain Valley together as a greater community, as goods and services were exchanged between the two states of Vermont and New York. Lake Champlain was a highway for the transport of goods and people, moving both east - west and north - south. During the mid-nineteenth the Champlain Valley prospered from its rich sources of iron ore, pulp wood, quarried granite and marble, lumber industries, and finished wooden articles. Most of this material left the valley by boat, which returned with finished goods that were not produced in the valley. The horse-powered ferries most likely played a role in helping to move these goods around the valley by providing the means of transport.

Horse boats were an important means of transportation on Lake Champlain from the 1830s to 1850s, but little is still known about them: exactly how many were built, who built them, and how long some of the individual boats were in service. At least nine different horse ferry operations have been identified, but this number may not accurately represent the total of ferries built, since most boats lasted less than a decade before they had to be retired or completely rebuilt. The demise of the horse ferry on Lake Champlain can likely be attributed to changes in transportation technology and patterns of regional commerce. Perhaps the most significant of these changes was the increased use of railroads to haul freight and livestock to markets, a shift that would ultimately result in the decline of nearly all commercial shipping on the lake.

The horse-powered ferry was a type of transportation that was used throughout the United States during the nineteenth century. Like in the Champlain Valley, alternative transportation was developed to replace the horse-powered ferries in the American race for saving time.

Conclusion

It was decided soon after its discovery to leave the Horse Ferry in place and not attempt to raise it. This decision was based on two reasons. The long-term responsibilities involved in raising the hull, preserving it, and placing it on exhibit would be prohibitively expensive. Second, raising the hull would put the ferry in jeopardy of being damaged during a salvage operation. The eroded timbers and corroded iron fastenings are clearly no longer capable of withstanding the stress involved in raising the hull.

In 1985 the Vermont Division for Historic Preservation first implemented the Vermont Underwater Historic Preserve program in response to the growing interest in Lake Champlain's underwater cultural resources by the local sport diving community. The program, designed like an underwater park, provides sport divers easy access to some of the more significant shipwrecks on the Vermont side of Lake Champlain. Each wreck has one or two mooring buoys to which divers can moor their boats and avoid dropping an anchor on the wreck. The divers follow the buoy chain to a concrete pad on the lake bottom. From the concrete pad, the divers then follow a yellow polypropylene line that leads to a sign posted on or near the wreck. Fragile parts of the wreck are clearly marked with warning signs. Underwater signs, supplemented by free pamphlets available at the local dive shops, provide information about the history of the wreck, its location and layout, emergency information, diving safety tips, Underwater Preserve program guidelines, and serve notice that vandalism and souvenir-hunting are prohibited by state law. After a noticeable rise in visitors to the site, it was decided in August of 1989 to add the Burlington Bay Horse Ferry be added to the preserve system. This would enable the diving community to safety visit the site without placing it in danger of inadvertently being damaged by dropping anchors. Today the site is being visited by hundreds of divers each year, providing an exciting educational and recreational experience.

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GEOGRAPHICAL DATA

Verbal Location and Chart Description

The Burlington Bay Horse Ferry is located in fifty feet of water in the northern portion of Burlington Bay, Vermont (see section 7, figure 1). The vessel is about seven-tenths of a mile (1,125 meters) northwest of the northern end of the Burlington breakwater and about seven-twentieths of a mile (550 meters) southeast of Lone Rock Point. The vessel is marked by two large yellow Vermont Division for Historic Preservation Underwater Historic Preserve buoys. The UTM coordinates are zone 18, easting 639840, and northing 4927180. The Loran C coordinates are N442912 W731458.

Area Definition and Boundary Justification

The site area is defined as a circle with a 200 foot radius surrounding the wreck. The Burlington Bay Horse Ferry wreck is part of the Vermont Underwater Historic Preserve program. Each wreck in the preserve system has one or two mooring buoys placed beside or near it (the horse ferry happens to have two mooring buoys placed beside each forward quarter) (see figure 1). Under the Preserve guidelines, all boats and other watercraft must remain at least 200 feet from the mooring buoys when a vessel is moored and displaying a "divers down" flag and/or an Alpha flag. This limit is to protect the sport divers visiting the wrecks from overhead boat traffic. A vessel is also not permitted to anchor within this 200 foot buffer zone around each mooring buoy. This is to protect not only the divers below, but also the wreck itself from anchors inadvertently being dropped on the vessels. It has been decided to use this buffer zone to define the site, even though the vessel is intact and there appears to be no scattered remains.

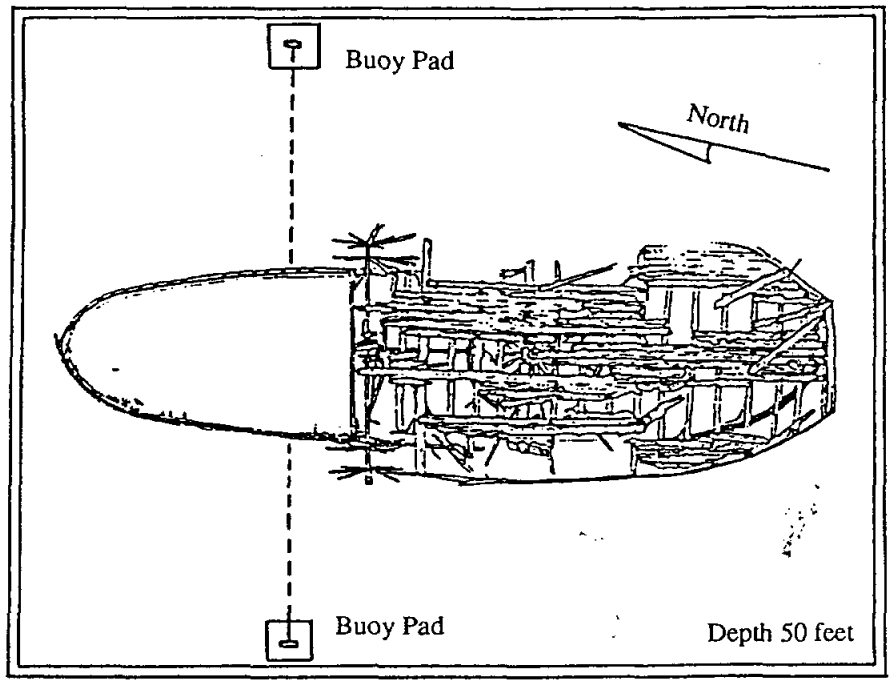
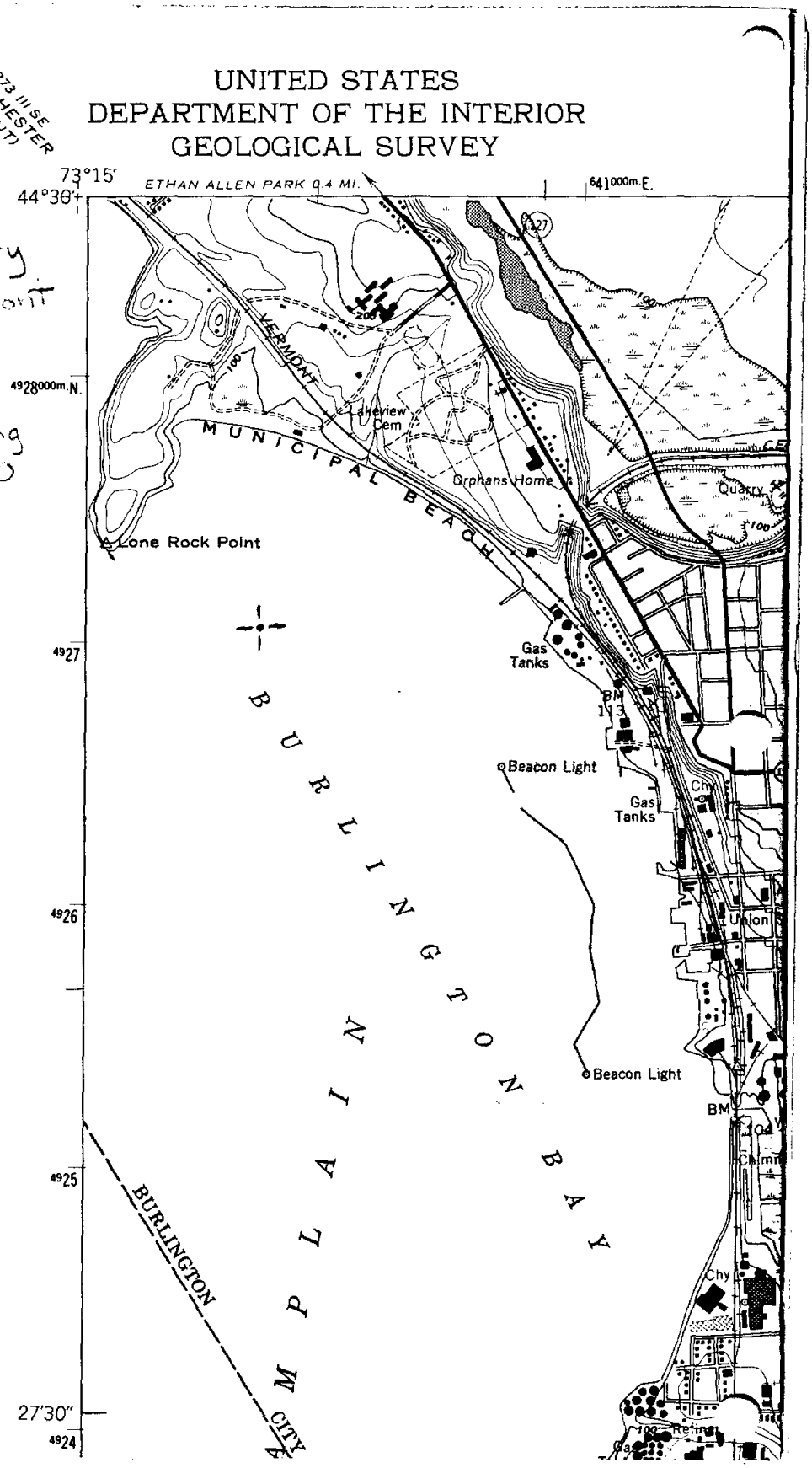


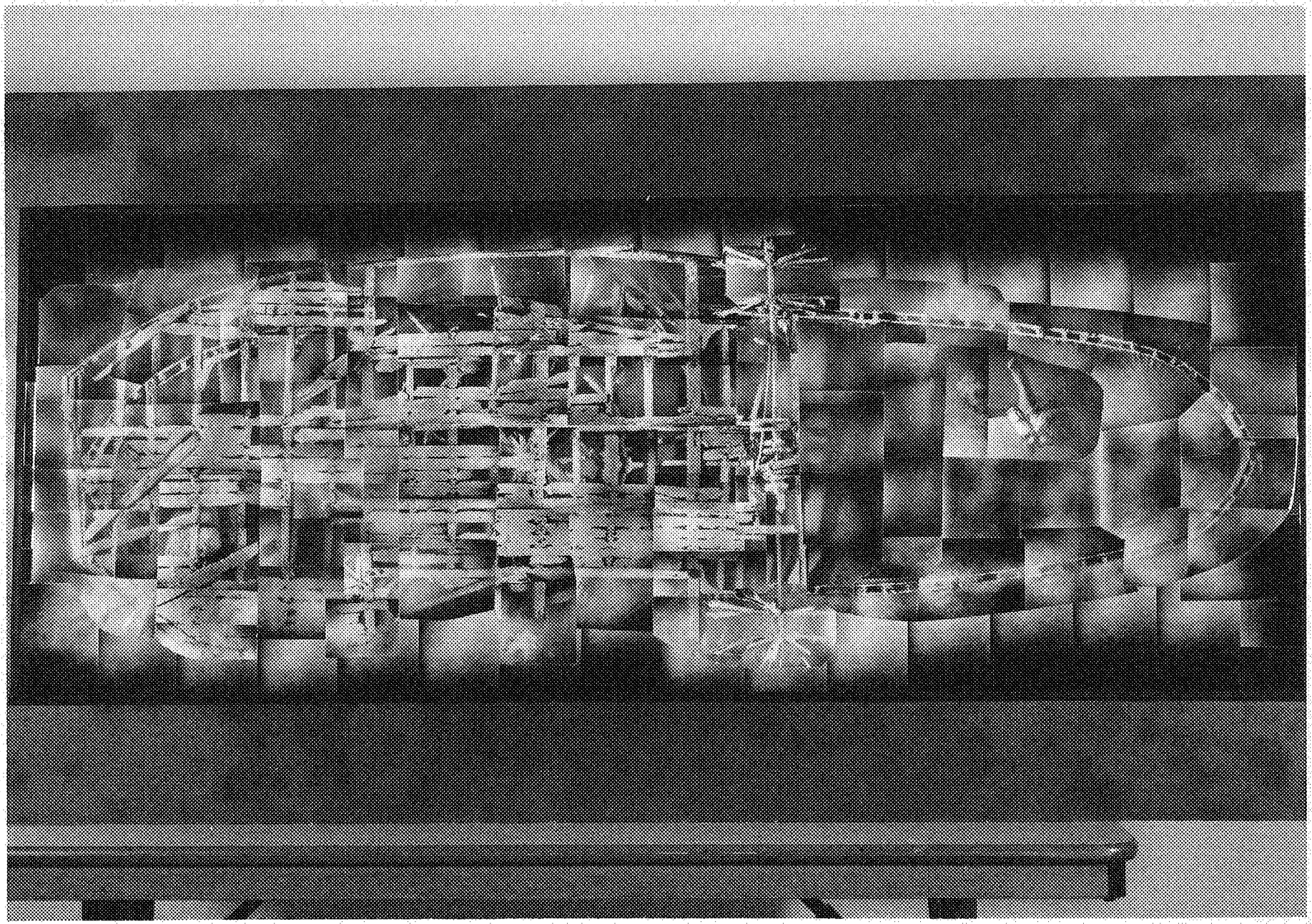
Figure 1
Preserve Mooring System at the Horse Ferry Wreck
(Map by Kevin J. Crisman)

Burlington Bay Horse Ferry
Chittenden County, Vermont

UTM Reference

Zone	Easting	Northing
18	639340	4928180





84-B-2 #2

Burlington Bay Horse Ferry
Chittenden County, Vermont
Credit: Scott Hill
Date: 1984
Negative filed at the Vermont Division for Historic Preservation
Description: Burlington Bay Horse Ferry Photomosaic
Photograph: #1