Third Five-Year Review Report for the Hudson River PCBs Superfund Site

APPENDIX 4

CAPPING EVALUATION

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THIRD FIVE-YEAR REVIEW REPORT FOR THE HUDSON RIVER PCBs SUPERFUND SITE

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EXECUTIVE SUMMARY

Background

The purpose of this appendix is to assess the current condition of the Hudson River PCBs Superfund Site (Site) multi-component subaqueous caps, which were installed during Phase 1 and Phase 2 of the in-river remedial action conducted from 2009 to 2015 to address the presence of polychlorinated biphenyls (PCBs) at the Site, with no dredging occurring in 2010 due to peer review of Phase 1. The cap monitoring program encompasses a tiered approach that consists of a series of hydrographic and bathymetric surveys, visual investigations, and physical investigations. Bathymetric surveys were completed immediately post-construction and one year after construction to establish a baseline (reference surface) for each cap for future survey comparisons. The most recent cap surveys were conducted in 2016 and 2018 for the Phase 1 and Phase 2 caps (Table A4-1), respectively.

Analyses

The analyses performed for this appendix are based on two metrics of cap erosion: (1) total capped area with >3 inches of erosion for each Certification Unit (CU), and (2) the largest contiguous capped area with >3 inches of erosion for select CUs. These metrics were calculated to track net erosional cap area over time. This quantification allows for direct comparison to the Measurable Loss criteria (defined thresholds in the tiered monitoring approach explained in greater detail in Section 2.2.2) and will be performed after Tier 1 surveys moving forward.

Technical Assessment

The cap monitoring program objectives are:

A) Determine whether the physical integrity of individual cap components has been maintained.

The analyses performed for this appendix indicate that, as expected, some caps exhibit areas of erosion; however, no caps are exhibiting erosion in excess of the Measurable Loss criteria, based on the most recent Tier 1 bathymetric surveys. Tier 1 bathymetric surveys will continue to be performed per the consolidated survey schedule (letter from General Electric Company [GE] to United States Environmental Protection Agency [EPA] dated January 30, 2017). The subsequent surveys were completed in 2023 and that data is in the post-collection processing phase.

B) Determine whether the effectiveness of the chemical isolation cap component has been maintained.

Data to support the determination of chemical isolation effectiveness of the cap has yet to be collected. The initial chemical isolation monitoring effort at select Sentinel Areas is anticipated to be conducted in 2026, and this effort will inform the assessment of chemical isolation effectiveness of caps in future five-year reviews.

C) Determine whether there is a need for additional protective measures and institutional controls (e.g., additional controls for caps in the navigational channel, notifications to boaters regarding permissible actions in capped areas).

The analyses performed for this appendix indicate that there were no Measurable Losses (as defined in Section 2.2.2) across the Phase 2 Year 1 caps as of 2016 and the remaining Phase 2 and Phase 1 caps as of 2018, thus no additional Tier 2 surveys or mitigation measures were required at the time of the Tier 1 surveys. Additional Tier 1 surveys will be performed per the consolidated survey schedule (letter from GE to EPA dated January 30, 2017), after which time the need for additional protective measures and institutional controls will be reassessed.

1 INTRODUCTION

1.1 Background and Overview

Although the remedy did not call for capping, during Phase 1 and Phase 2 of the remedial action conducted at Operable Unit 2 (OU2) of the Hudson River PCBs Superfund Site (Site) between 2009 and 2015, multi-component subaqueous caps were installed to isolate residual polychlorinated biphenyls (PCBs) contamination in the river sediment. These caps were installed in certain areas of the Upper Hudson River (UHR) in accordance with the requirements of the Phase 1 and Phase 2 Residuals Engineering Performance Standards (EPA 2004, 2010) and with the approval of the EPA. The Hudson River OU2 remedy focused on the dredging of river sediment to remove PCB mass with limited capping under certain circumstances, as described in this appendix. The components of the caps were based on the degree of residual PCB contamination detected within a specific Certification Unit (CU), with their configuration also dictated by the requirement that they be able to withstand defined river flow velocities.

During dredging, 107 acres of caps were installed where dredging could not fully remove the PCB contaminated sediment. EPA established a criterion used during dredging to limit capping of sediments with remining PCB inventory. Approximately 13 percent of the area capped was for inventory while the remaining areas were capped due to residual PCB contamination typically on bedrock that could not be removed by the dredge bucket. The cap monitoring program assesses the long-term physical stability and effectiveness of caps constructed during the Phase 1 and 2 dredging activities in accordance with the requirements of the 2005 Consent Decree, as amended by the 2010 Phase 2 Operations, Maintenance, and Monitoring (OM&M) Scope (Attachment E to the 2010 Statement of Work; EPA, 2010b) and additional updates and modifications based on discussions between EPA and GE. This appendix specifically presents the results of the cap monitoring events conducted in 2016 and 2018, which consisted of consolidated five-year Tier 1 and 10-year Tier 1 bathymetric surveys for the caps.

1.2 Purpose and Objectives of Cap Monitoring Program

The purpose and objectives of the cap monitoring program, are to:

- Determine whether the physical integrity of individual cap components has been maintained;
- Determine whether the effectiveness of the chemical isolation cap component has been maintained; and
- Determine whether there is a need for additional protective measures and institutional controls (e.g., additional controls for caps in the navigational channel, notifications to boaters regarding permissible actions in capped areas).

1.3 Document Organization

This appendix is organized into the following sections:

- Section 1 (Introduction): Provides the purpose and objectives for the cap monitoring program.
- Section 2 (Program Description): Presents an overview of the cap monitoring program, a summary of the data collected from the 2016 and 2018 Tier 1 bathymetric surveys, and an overview of future cap monitoring surveys.
- Section 3 (Analysis Methods): Describes bathymetric data processing for the evaluation presented in the appendix.
- Section 4 (Results and Discussion): Presents the results of the net cap erosion calculations.
- Section 5 (Conclusions): Summarizes appendix findings.
- Section 6 (Abbreviations and Acronyms): Defines the acronyms and abbreviations used in this appendix.
- Section 7 (References): Provides the complete references for documents cited in this appendix.

2 PROGRAM DESCRIPTION

2.1 Overview of Cap Types

In accordance with the requirements of the Phase 1 and Phase 2 Residuals Engineering Performance Standards (EPA 2004, 2010) and based on EPA approval, caps with various component layers and thicknesses (often termed multi-component caps) were installed during the Phase 1 and Phase 2 remedial activities. Cap component layers typically included a 6-inch-thick armor layer of coarse gravel or cobble, a chemical isolation layer, and a 9-inch to 10-inch-thick layer of backfill, resulting in caps that at a minimum ranged from 12 to 16 inches in thickness. Configuration of these cap layers was based on the degree of residual PCB contamination within a specific CU or portion thereof and the requirement that the caps be able to withstand specific flow velocities. In Phase 1, Type A and Type B isolation caps were installed in Low-Velocity and Medium- to High-Velocity configurations. In areas with lower residual average PCB concentrations (>1 milligram per kilogram [mg/kg] Tri+ PCBs[1] but ≤6 mg/kg Tri+ PCBs), caps were designed to withstand a minimum 10-year flood event (i.e., 34,500 cubic feet per second [cfs] as measured at the United States Geological Survey [USGS] gauging station at Fort Edward, New York [Station No. 01327750]). In areas with higher residual average PCB concentrations (>6 mg/kg Tri+ PCBs), caps were designed to withstand a minimum 100-year flood event (i.e., 47,300 cfs as measured at the Fort Edward USGS gauging station). In Phase 2, Type C and Type D isolation caps were installed in Medium to High-Velocity configurations in areas with residual PCB concentrations >1 mg/kg Tri+ PCBs in the surface sediment and were designed to withstand a 100-year flood event. Additional details of isolation cap construction can be found in the Phase 1 and Phase 2 OM&M Plans (GE, 2011, 2012, 2013, 2014, 2015, 2016).

To confirm the proper placement of the cap components, construction quality control (QC) activities were performed. Representative samples of cap materials were collected throughout cap placement operations and tested for physical and chemical characteristics consistent with the design specifications. In addition, post-placement bathymetric and hydrographic surveys were performed to document the top elevation of the caps to confirm that the thickness and horizontal extent of the placed cap materials met the design requirements. The surveyed, as-built conditions of each cap were reviewed and approved by EPA as part of the process for CU Backfill/Engineered Cap Completion Approval.

[1] Tri+ PCBs represents the sum of all measured PCB congeners with three or more chlorine atoms per molecule. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners have from one to 10 chlorine atoms per molecule, each with its own set of chemical properties.

2.2 Overview of Cap Monitoring Program

2.2.1 Hydrographic and Topographic Survey Methods

The cap monitoring program encompasses a tiered approach that consists of a series of hydrographic and topographic surveys, visual investigations, and physical investigations. Bathymetric surveys serve as the primary means to evaluate cap physical integrity. Multi-beam bathymetric surveys are preferred, but single-beam bathymetric survey and/or topographic land survey techniques can be conducted for areas in which multi-beam bathymetric surveys cannot be completed (e.g., shallow water depth areas). Hydrographic surveys are conducted in accordance with the EPA-approved Standard Operating Procedure for Bathymetric Surveys contained in Appendix C of the OM&M Plan for Phase 2 Year 1 Caps and Habitat Replacement/Reconstruction (GE, 2012). These surveys are conducted using United States Army Corps of Engineers (USACE) Hydrographic Survey standards (USACE, 2013). Transect spacing was varied with water depth to allow for sufficient coverage of the capped area being surveyed (estimated coverage is approximately 3.4 times the water depth for each boat pass). In many instances, multi-beam surveys can produce vertical accuracy of approximately 3 inches, although performance can vary based on site conditions. In near-shore areas, or areas where water depths do not allow for multi-beam hydrographic surveys, topographic survey techniques, including handheld Global Positioning System (GPS) surveys, are employed.

2.2.2 Tier 1 and Tier 2 Bathymetric Surveys

Tier 1 bathymetric surveys are intended to determine if the caps have remained in place over time as compared to the established reference elevation. Specifically, these surveys are intended to evaluate whether there has been a "Measurable Loss" of cap material. Measurable Loss is defined as a loss of >3 inches of cap thickness over a contiguous 4,000-square-foot (ft^2) area or a contiguous area representing over 20 percent of the cap area, whichever is less, considering the accuracy of the measurement technique and the nature of the cap surface. If a Measurable Loss of cap material is observed during the Tier 1 bathymetric surveys, Tier 2 follow-up visual (and, as necessary, physical) investigations are to be conducted to confirm whether there has been a "Significant Loss" of cap material. A Significant Loss of cap material is defined by the same criterion as a Measurable Loss; however, the additional lines of evidence serve to confirm that the observed loss has indeed occurred. If the investigations confirm a Significant Loss, affected areas of the cap will be repaired, as necessary.

The 2010 Phase 2 OM&M Scope (EPA, 2010b) stated that Tier 1 surveys were to be conducted at five-year and 10-year intervals after cap construction and to continue at 10-year intervals in perpetuity. The consolidated survey schedule (letter from GE to EPA dated January 30, 2017) consolidated the staggered five-year and 10-year Tier 1 surveys into one cap monitoring event in 2018. The 10-year Tier 1 surveys for Phase 2 caps were conducted in 2023; the next 10-year Tier 1 surveys for Phase 1 caps will be conducted in 2028 (Table A4-1). Additionally, if a flood event occurs with a magnitude at or exceeding the design recurrence interval for the caps (i.e., a 10-year

recurrence interval for Type A caps installed in Phase 1, and a 100-year recurrence interval for Phase 2 caps), bathymetric surveys are to be performed as soon as practicable to inspect cap condition.

2.2.3 Chemical Isolation Layer Monitoring

The effectiveness of the Phase 2 caps with respect to chemical isolation will be evaluated via a targeted coring program in EPA-selected areas referred to as "sentinel areas." The locations of the six sentinel areas were selected by EPA and supplied to GE in 2021. The sentinel areas were chosen from areas with a comparatively higher concentration range of PCBs underlying the cap, as well as areas that exhibit critical conditions that may exist in certain reaches of the river (e.g., high groundwater upwelling rates). The monitoring program, which is anticipated to be conducted in 10-year intervals starting in 2026, will generate data to verify the basic design assumptions for the caps with regard to the prevention of contaminant migration upwards and through the caps.

2.3 Monitoring of Select Areas

As described in the 2002 Record of Decision (EPA, 2002) and outlined in the Phase 1 and Phase 2 Dredging Area Delineation Reports (GE, 2005, 2007), areas that met certain criteria were excluded from dredging activities. These criteria required that the Total PCB (TPCB) concentration was less than 5 mg/kg anywhere in the top 12 inches and that the peak TPCB concentration occurred below 24 inches (GE, 2005, 2007). Cores that met these criteria (termed "select" criteria) and exceeded surface PCB dredging criteria were considered "select cores."

A total of 224 select cores were identified at the time that the Phase 1 and Phase 2 DAD Reports were prepared. Of these, 117 core locations were dredged during the Phase 1 and Phase 2 in-river remedial activities. The remaining 107 core locations, that were not dredged, were further evaluated by GE to identify select core locations that would have been included within a dredge area based on the design criteria outlined in the Phase 1 and Phase 2 DAD Reports. Of those 107 cores, 92 cores were identified as "Select Areas," which will be subject to recurring bathymetric surveys to monitor whether erosion has occurred (GE 2005, 2007).

To monitor "Select Area" stability over time, bathymetric surveys will be conducted at these "Select Areas" in conjunction with scheduled cap monitoring surveys. Initial bathymetric surveys were conducted for the Select Areas in 2003 (GE, 2003) prior to dredging. Subsequent surveys for some of the Select Areas were performed during the Phase 1 and Phase 2 in-river remedial activities. It is anticipated that all the Select Areas will be surveyed in 2023 and 2033.

2.4 Data Used in Current Five-Year Review

2.4.1 Reference Surfaces

Under the cap monitoring program, "Year 1" surveys were conducted the year following cap installation to assess for potential consolidation and associated settlement of cap material. If

consolidation was observed, the Year 1 survey would be used as the reference surface for future comparisons. If no consolidation was observed, the post-placement surveys were used. The results of this comparison indicated that no significant consolidation occurred in the first year and the post-placement surface was used as the reference surface for all caps. These "reference surfaces" were established and reported in a series of letters submitted by GE and approved by EPA from 2012 to 2016 (letters from GE to EPA dated November 15, 2012, January 8, 2014, January 16, 2015, and January 22, 2016). These approved surfaces serve as the cap surface reference ("reference surfaces") that are used to evaluate current and future Tier 1 surveys. Further details regarding the initial establishment of cap reference surfaces can be found in Phase 2 Cap/Habitat OM&M Plans (GE, 2011, 2012, 2013, 2014, 2015, and 2016).

2.4.2 Cap Survey Locations

Tier 1 bathymetric surveys were conducted for all caps in 2018, except those in areas dredged in Phase 2 Year 1 (i.e., CUs 9-16, and 19-25), for which surveys were conducted in 2016 (Table A4-1), and CU 60-1, which was evaluated through wader-based visual observation. The 2018 bathymetric surveys serve as the five-year Tier 1 surveys for CUs 26-99 and the 10-year Tier 1 surveys for Phase 1 caps (i.e., CUs 1-8 and 18)[2].

2.4.3 Summary of Available Data

Several evaluations regarding the physical stability of the Phase 1 and Phase 2 caps are documented in the *Second Five-Year Review Report for the Hudson River PCBs Superfund Site* (EPA, 2019), including an evaluation of the "Year 1" surveys, a survey triggered in response to a high-flow event that occurred in 2011, and the five-year Tier 1 surveys conducted in 2014. These evaluations assessed the short-term and long-term cap stability and provided insight into how well the Phase 1 caps withstood 100-year flood conditions.

The Tier 1 surveys conducted in 2016 and 2018 provide a basis to further evaluate long-term cap stability, specifically through the evaluation of elevation difference plots and the calculation of the net erosion within specific CUs.

[2]The five-year Tier 1 surveys for Phase 2 caps installed from 2011 to 2015 and the 10-year Tier 1 surveys for Phase 1 caps installed in 2009 were completed in 2018, in accordance with the consolidated survey schedule (letter from GE to EPA dated January 30, 2017).

3 ANALYSIS METHODS

3.1 Methods for Evaluation of Net Cap Erosion

As discussed in Section 2.2.1, Tier 1 surveys included a combination of multi-beam bathymetric surveys, single-beam bathymetric surveys, and/or land-based topographic surveys (i.e., GPS rod-shot). Post-processing of these surveys was performed by GE and generally included the combination, tinning, and trimming of the datasets to produce a set of Tier 1 survey bathymetric surfaces for each cap at a 1 ft^2 resolution (GE, 2018). Previous evaluations of Tier 1 survey results performed by GE included elevation difference plots, which present the difference between the Tier 1 bathymetric survey and the established cap reference surface elevations. This analysis has been performed for all CUs following Tier 1 surveys and is presented in the 2016 and 2018 Monitoring, Maintenance, and Adaptive Management Reports (GE, 2017, 2019).

For this five-year review (FYR), two metrics of cap erosion were calculated to track net erosional cap area over time: (1) total capped area with >3 inches of erosion for each CU, and (2) the largest contiguous capped area with >3 inches of erosion for select CUs (i.e., CUs that may have been approaching the Measurable Loss criteria as explained below). This quantification allows for direct comparison to the Measurable Loss criteria and will be performed after subsequent Tier 1 surveys moving forward.

As stated above, the elevation difference between the established cap reference surfaces and the Tier 1 surveys was calculated to determine the total capped area with >3 inches of erosion for each CU. Total capped area with >3 inches of erosion is not a metric of the Measurable Loss criteria but was used to identify caps that may have been approaching Measurable Loss criteria (i.e., loss of >3 inches of cap thickness over a contiguous 4,000 ft^2 area or a contiguous area representing over 20 percent of the capped area, whichever is less) for further evaluation. Specifically, CUs with caps that had a total of >3,000 ft^2 or 15 percent of the cap area with >3 inches of erosion (i.e., 75 percent of the Measurable Loss criteria thresholds) were identified, and the largest contiguous capped area with >3 inches of erosion was calculated, and bathymetric comparison maps were produced in ArcGIS. Further, for CUs with caps that had a contiguous area of >1,000 ft^2 of >3 inches of erosion (i.e., 25 percent of the Measurable Loss criteria thresholds), "Year 1" and post-placement elevation difference plots were prepared to compare to the Tier 1 evaluation, to characterize how net erosion changed over time. Elevation difference comparison maps for all Tier 1 surveys are available in the 2016 and 2018 MM&AM reports (GE, 2017, 2019).

Net erosion calculations were performed with Tier 1 bathymetric survey data, specifically using the following:

- Ten-year Tier 1 surveys collected in 2018 for Phase 1 caps at CUs 1-8, and 18, and
- Five-year Tier 1 surveys collected in 2016 or 2018 for Phase 2 caps at CUs 9-16, 19, 21-22, 24-30, 32, 35-37, 39-47, 49-51, 53, 55-57, 61-79, 82-85, 87-97, and 99.

4 RESULTS AND DISCUSSION

4.1 Comparison of Tier 1 and Reference Bathymetric Surveys

4.1.1 Comparison of Net Erosion Calculations

Table 4A-1 presents the results of the most recent Tier 1 and reference surface net erosion calculations. While the multi-beam bathymetric instrumentation has a specified accuracy of ± 2 centimeters (approximately 0.8 inches) under ideal conditions, typical performance produces vertical accuracy of approximately 3 inches, thus, the loss of at least 3 inches of material is considered erosion. As detailed in Section 2.1, multicomponent caps were designed to be at least 12 to 16 inches in thickness, thus 3 inches of erosion into the capped surface would typically be within the top third of the cap thickness, indicating most of the cap would likely remain intact with this level of erosion.

The total area of observed erosion, specifically the total capped area with >3 inches of erosion, is evaluated to (1) generally track erosion over time, and (2) to determine if any caps need to be evaluated against the Measurable Loss criteria (i.e., assessment of the largest contiguous area of >3 inches of erosion). As expected, some erosion was observed in most caps. The total capped area within each CU with >3 inches of erosion ranged from 0 ft^2 (CUs 3, 5, 15, and 49) to 10,289 ft^2 (CU 26). The majority of the capped areas showed very little erosion (on average, 2 percent of the total capped area was measured with >3 inches of erosion). To further evaluate the potential impacts of erosion on the caps and to minimize potential influences of survey measurement tolerance, a review was completed to calculate the total capped area with >6 inches of erosion. This evaluation shows that an average of only 1 percent of the total capped surface had measured erosion >6 inches, and these areas were typically located within the largest contiguous areas of erosion for their respective caps.

Contiguous areas of erosion were evaluated for caps that may have been approaching the threshold of >3 inches of erosion over a contiguous 4,000 ft^2 area or a contiguous area representing over 20 percent of the capped area, whichever is less. Nine capped areas had either a total loss of >3,000 ft^2 or 15 percent of the capped area with >3 inches of erosion (i.e., 75 percent of Measurable Loss criteria thresholds), including caps at CUs 6, 26, 36, 61, 69, 73, 77, and 89 (Table A4-2 and Figures A4-1 through A4-8d). The contiguous areas with >3 inches of erosion at these caps ranged from 252 ft^2 (CU 61) to 1,850 ft^2 (CU 73).

The contiguous area of erosion evaluation showed that no caps met the Measurable Loss criteria at the time of the Tier 1 surveys. It is important to note that there were several areas of >3 inches of erosion that were adjacent to, but not connected with the largest contiguous capped area of >3 inches of erosion at the time of the Tier 1 survey. If those areas were to become "connected" in the future (i.e., new areas of >3 inches of erosion occur between and "connect" two existing,

adjacent areas of >3 erosion), the Measurable Loss criteria may be met in the future, thus these areas will continue to be monitored.

4.1.2 Discussion of Caps at CUs 73 and 77

Figures A4-1 through A4-9d present the maps of the bathymetric comparisons between the Tier 1 and reference surfaces for caps in select CUs that may have been approaching Measurable Loss criteria thresholds at the time of the Tier 1 surveys, specifically consisting of CUs 6, 26, 36, 61, 69, 73, 77, and 89. These figures show the spatial distribution of erosion across these caps, and present the largest contiguous cap area with >3 inches of erosion for each CU. The contiguous area evaluations showed that two capped areas (CUs 73 and 77) exceed 1,000 ft^2 of contiguous areas >3 inches of erosion (i.e., 25 percent of the criteria). A more detailed discussion of these two areas is included below.

CU 73 (1,850 ft^2)

Figure A4-6a presents the comparison of the five-year Tier 1 survey completed in 2018 to the established cap reference surface for CU 73. The largest contiguous capped area with >3 inches of erosion in CU 73 is located along the eastern boundary of cap CU 73-B, totaling 1,850 ft^2 (Table A4-2). Comparison of the five-year Tier 1 survey with Year 1 (2014) survey data showed that the majority (approximately 80 percent) of the cap elevation difference in the largest contiguous area with >3 inches of erosion occurred in Year 1 (Figure A4-9). The limited difference between Year 1 and five-year Tier 1 elevation difference plots indicates that this area experienced little erosional change in the last four years indicating it is unlikely that this is a continually erosional area and that the difference in elevation may be associated with initial settlement or a unique event. EPA will continue to monitor this area closely in future surveys.

CU 77 (1,462 ft^2)

Figure A4-7a and A4-7b present the comparison of the five-year Tier 1 survey completed in 2018 to the established cap reference surface for CU 77. The largest contiguous capped area with >3 inches of erosion in CU 77 is located along the eastern boundary of cap CU 77-C, totaling 1,462 ft^2 (Table A4-2, Figure A4-7a). Comparison of the Tier 1 survey with Year 1 (2014) survey data showed that the largest contiguous capped area of >3 inches of erosion has increased in size between the Year 1 (2014) and five-year (2018) surveys (Figure A4-10). This is particularly evident at the upstream portion of the largest contiguous area of >3 inches of erosion observed during the five-year Tier 1 survey, which contains a localized area of >9 inches of erosion (approximately 30 feet by 18 feet) that was not present at the time of the Year 1 survey. Though no structures nor obstructions were observed in the adjacent area, this localized area of erosion is bounded upstream by a narrow crescent-shaped area of thicker cap material (approximately 21 inches of material above the cap surface at its thickest), indicating that bathymetry may be the product of a physical disturbance (e.g., buoy or similar structure, prop wash) resulting in a thin band of deposition and subsequent scour. Though CU 77 does not meet the Measurable Loss

criteria, the presence of the localized erosion at the time of the five-year Tier 1 survey indicates that close monitoring of this cap will continue, to determine if this is a localized issue/one-time event or continues to grow in the future.

4.2 Summary and Future Surveys

The analyses performed for this appendix indicate that there was no Measurable Loss across the Phase 2 Year 1 caps as of 2016 and the remaining Phase 2 and Phase 1 caps as of 2018 (Table A4-2), thus no additional Tier 2 surveys or mitigation measures were required at the time of the Tier 1 surveys. Three areas have >1,000 ft^2 of contiguous erosion >3 inches; these areas will continue to be monitored closely by EPA. Per the consolidated schedule (letter from GE to EPA dated January 30, 2017), the Tier 1 bathymetric surveys for Phase 2 caps were performed in 2023 and the next Tier 1 surveys for Phase 1 caps will be performed in 2028. Additional cap assessment via the initial chemical isolation monitoring effort at select Sentinel Areas is anticipated to be conducted in 2026, as discussed in Section 2.2.3.

5 CONCLUSIONS

Analysis of the Tier 1 bathymetric surveys collected in 2016 and 2018 indicate that even though caps within CUs 6, 26, 36, 61, 69, 73, 77, and 89 may have been approaching Measurable Loss criteria thresholds (>3 inches of erosion over a contiguous 4,000 ft^2 area or contiguous area representing over 20 percent of the cap area, whichever is less), no caps exhibited Measurable Loss at the time of the Tier 1 surveys. Of these CUs, two had areas of contiguous erosion greater than 1,000 ft^2 (i.e., 25 percent of the threshold); EPA will continue to closely monitor these caps in the future. The analyses conducted to date indicate that the physical integrity of the caps was maintained, and no mitigation measures were required at the time of the 2016 and 2018 Tier 1 surveys.

Per the consolidated survey schedule (letter from GE to EPA dated January 30, 2017), additional Tier 1 surveys will be conducted, after which time the physical stability and effectiveness of caps will be reassessed via the analyses applied in this appendix and additional analyses. Additional cap assessment via the initial chemical isolation monitoring effort at select Sentinel Areas is anticipated to be conducted in 2026. In the event that future monitoring indicates that the physical integrity and/or chemical isolation effectiveness of the caps is not being maintained, additional protective measures and institutional controls will be implemented to enhance cap effectiveness. GE is required to assess and maintain the caps into perpetuity.

6 ABBREVIATIONS AND ACRONYMS

cfs	cubic feet per second
CU	Certification Unit
DAD	Dredging Area Delineation
ft^2	square foot
EPA	United States Environmental Protection Agency
FYR	Five-Year Review
GE	General Electric Company
GPS	Global Positioning System
mg/kg	milligram per kilogram
MM&AM	Monitoring, Maintenance, and Adaptive Management
OM&M	Operations, Maintenance, and Monitoring
OU	Operable Unit
PCB	Polychlorinated Biphenyls
QC	Quality Control
ROD	Record of Decision
Site	Hudson River PCBs Superfund Site
TPCB	Total PCB
Tri+ PCB	Tri+ PCBs represents the sum of all measured PCB congeners with three or more chlorine atoms per molecule.
UHR	Upper Hudson River
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

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APPENDIX 4

Tables and Figures

Tables

Table A4-1

Cap Monitoring Survey Schedule

Dredging activity	Year Dredged	Post-Placement Survey	Year 1 Survey	5-Year Tier 1 Survey	10-Year Tier 1 Survey	Additional Tier 1 Surveys
Phase 1	2009	2009	2010	2014	2018	Every 10 years until 30 years after installation.
Phase 2 Year 1	2011	2011	2012	2016	2023	Every 10 years in perpetuity.
Phase 2 Year 2	2012	2012	2013	2018	2023	
Phase 2 Year 3	2013	2013	2014	2018	2023	
Phase 2 Year 4	2014	2014	2015	2018	2023	
Phase 2 Year 5	2015	2015	2016	2018	2023	

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Table A4-2

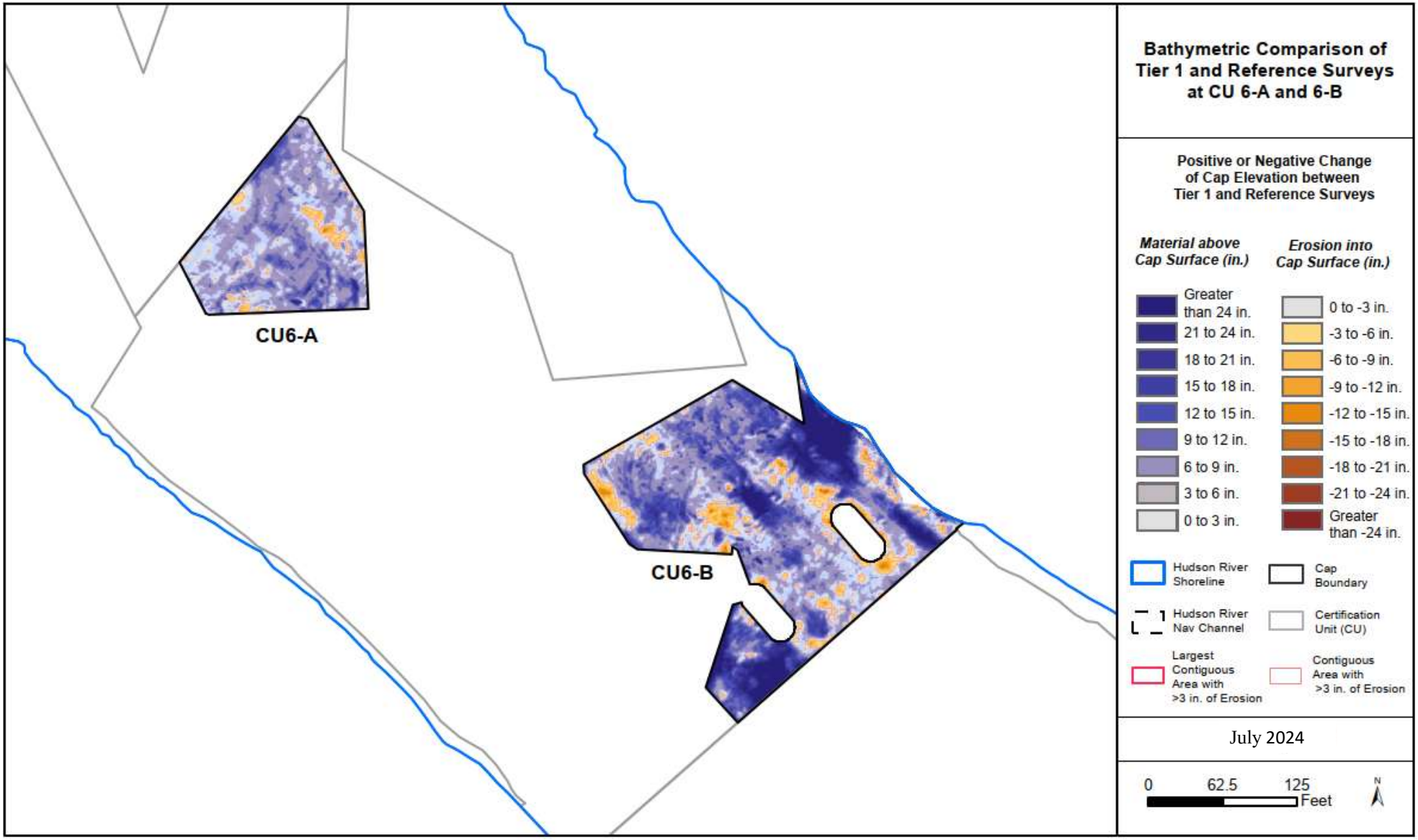
Summary of Erosion Area based on Tier 1 and Reference Bathymetric Surveys in CUs with Caps

Certification Unit	Capped Area (acres)	Capped Area (ft^2)	Total Capped Area with >3 in. of Erosion between Tier 1[1] and Reference Surveys (ft^2)	Total Capped Area with >3 in. of Erosion between Tier 1[1] and Reference Surveys (%)	Largest Contiguous Capped Area with >3 in. of Erosion between Tier 1[1] and Reference Surveys (ft^2)
CU-1	3.30	143,827	899	1%	-
CU-2	3.44	149,736	1,424	1%	-
CU-3	1.33	57,722	0	0%	-
CU-4	3.55	154,824	266	0%	-
CU-5	0.73	32,009	0	0%	-
CU-6	1.33	58,002	4,365	8%	510
CU-7	0.96	41,848	2,963	7%	-
CU-8	1.56	67,813	1,712	3%	-
CU-9	0.44	19,036	84	0%	-
CU-10	0.22	9,714	64	1%	-
CU-11	0.74	32,104	117	0%	-
CU-12	0.86	37,549	699	2%	-
CU-13	0.46	20,038	25	0%	-
CU-14	1.15	50,094	1,641	3%	-
CU-15	0.64	27,835	0	0%	-
CU-16	0.21	9,104	127	1%	-
CU-18	1.11	48,528	1,437	3%	-
CU-19	1.70	74,008	303	0%	-
CU-21	0.49	21,388	72	0%	-
CU-22	0.43	18,687	43	0%	-
CU-24	0.72	31,494	1	0%	-
CU-25	1.01	43,865	1,399	3%	-
CU-26	1.99	86,814	10,289	12%	686
CU-27	0.20	8,588	60	1%	-
CU-28	0.86	37,595	17	0%	-
CU-29	0.95	41,579	285	1%	-
CU-30	0.60	26,179	710	3%	-
CU-32	0.44	18,981	904	5%	-
CU-35	3.03	132,085	1,277	1%	-
CU-36	2.19	95,519	3,941	4%	455
CU-37	0.94	41,046	1,043	3%	-
CU-39	0.58	25,451	2,873	11%	-
CU-40	0.81	35,288	459	1%	-
CU-41	1.24	53,884	257	0%	-
CU-42	1.06	46,348	452	1%	-
CU-43	1.78	77,666	1,328	2%	-
CU-44	0.43	18,845	313	2%	-
CU-45	1.41	61,270	1,187	2%	-
CU-46	1.71	74,640	1,369	2%	-
CU-47	0.23	10,192	1,399	14%	-
CU-49	0.26	11,392	0	0%	-
CU-50	0.95	41,390	26	0%	-
CU-51	0.84	36,699	232	1%	-
CU-53	0.94	41,043	386	1%	-
CU-55	0.49	21,470	583	3%	-
CU-56	1.09	47,627	569	1%	-
CU-57	0.26	11,186	11	0%	-
CU-61	2.21	96,065	3,195	3%	252
CU-62	0.76	33,135	1,369	4%	-
CU-63	1.23	53,461	116	0%	-
CU-64	0.51	22,217	31	0%	-
CU-65	0.69	29,991	27	0%	-
CU-66	0.75	32,739	830	3%	-
CU-67	1.93	84,200	2,562	3%	-
CU-68	1.98	86,153	2,054	2%	-
CU-69	1.63	70,866	3,809	5%	582
CU-70	3.79	165,093	2,217	1%	-
CU-71	0.73	31,810	2,364	7%	-
CU-72	1.03	44,717	1,224	3%	-
CU-73	1.80	78,344	3,092	4%	1,850
CU-74	0.62	27,216	305	1%	-
CU-75	0.53	23,218	670	3%	-
CU-76	3.51	152,788	2,169	1%	-
CU-77	2.21	96,272	3,550	4%	1,462
CU-78	0.67	29,024	866	3%	-
CU-79	0.30	12,952	100	1%	-
CU-82	2.71	118,002	2,595	2%	-
CU-83	1.44	62,512	29	0%	-
CU-84	1.53	66,539	28	0%	-
CU-85	0.98	42,492	923	2%	-
CU-87	1.22	52,938	225	0%	-
CU-88	2.52	109,558	278	0%	-
CU-89	2.49	108,601	3,438	3%	874
CU-90	1.35	58,926	728	1%	-
CU-91	0.80	34,868	395	1%	-
CU-92	4.03	175,417	1,801	1%	-
CU-93	1.03	45,074	345	1%	-
CU-94	0.56	24,526	1,413	6%	-
CU-95	2.85	124,249	676	1%	-
CU-96	3.55	154,642	2,112	1%	-
CU-97	0.66	28,541	2,368	8%	-
CU-99	1.07	46,419	80	0%	-

Note:

[1]Tier 1 bathymetric surveys were conducted for all caps in 2018, except those in areas dredged in Phase 2 Year 1 (i.e., CUs 9 - 16, and 19 - 25), for which suveys were conducted in 2016.

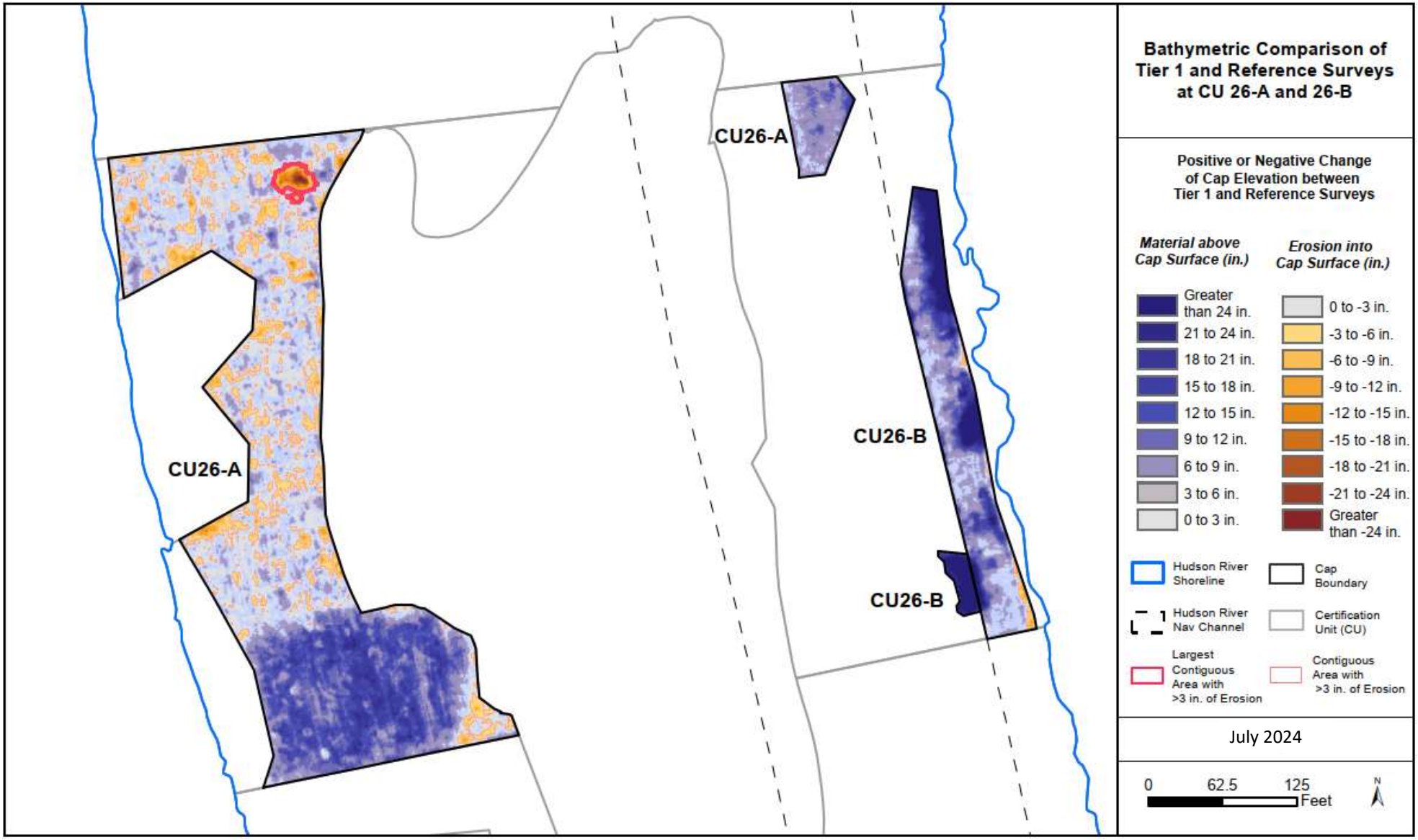
Figures



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 6-A and 6-B

Figure A4-1

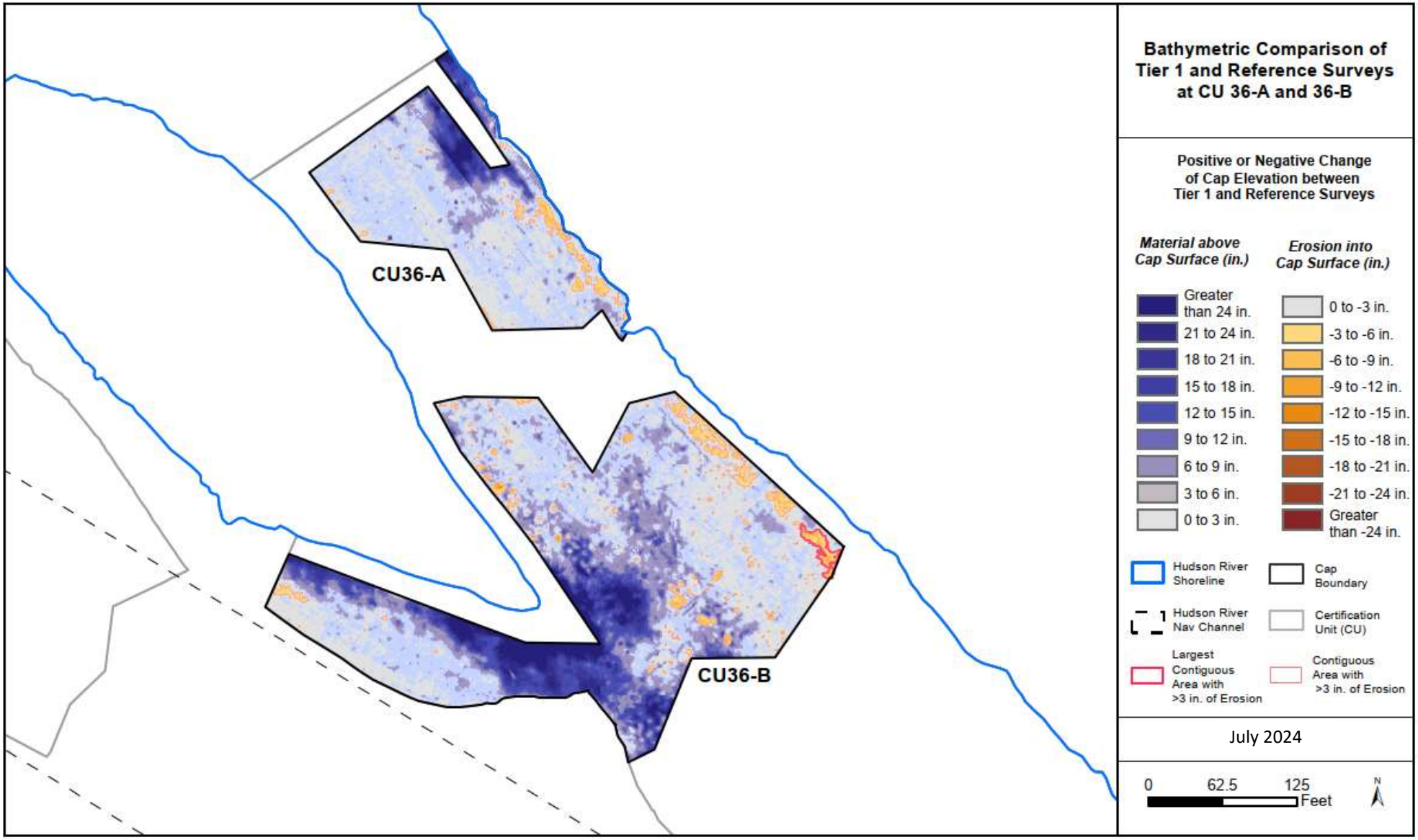
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 26-A and 26-B

Figure A4-2

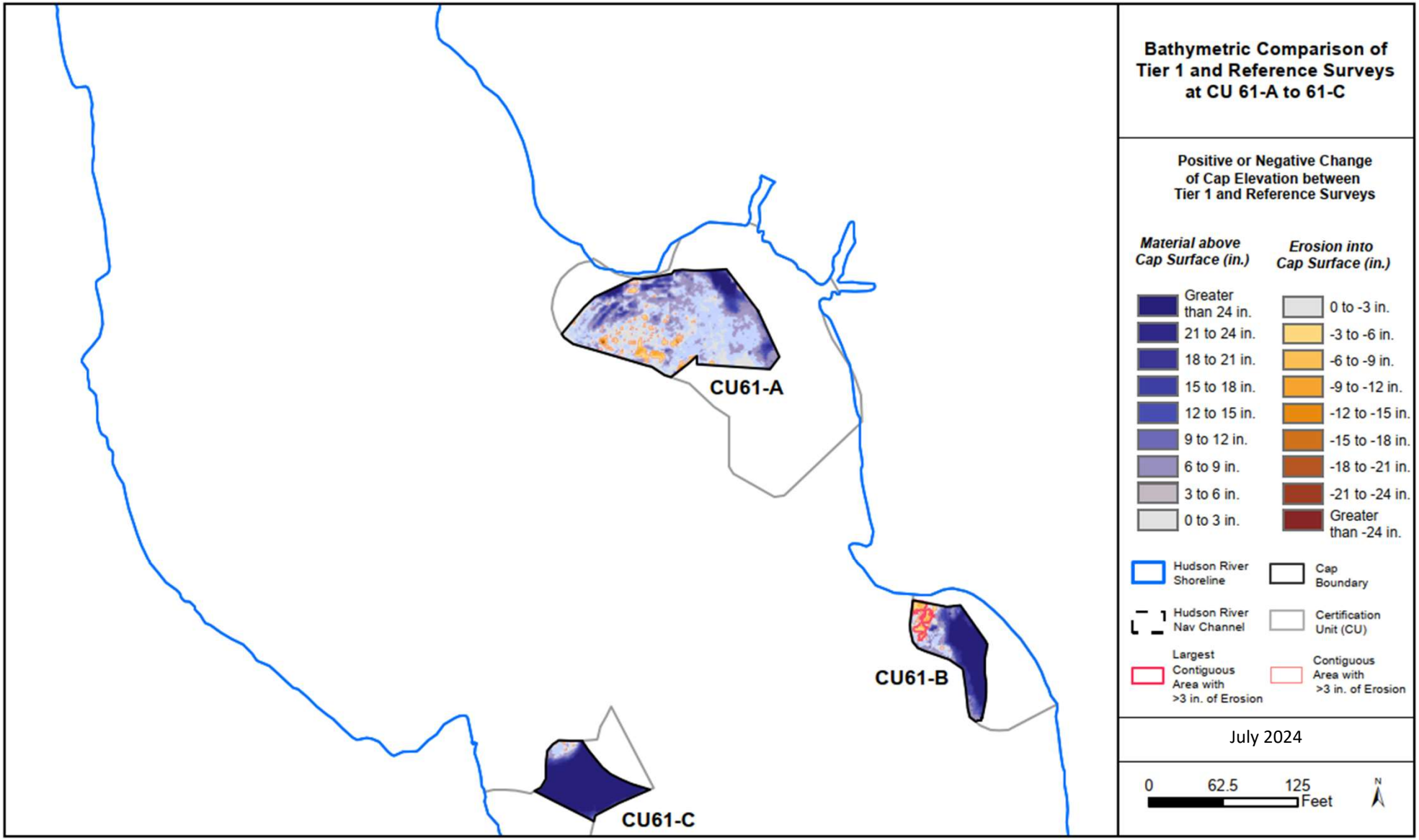
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 36-A and 36-B

Figure A4-3

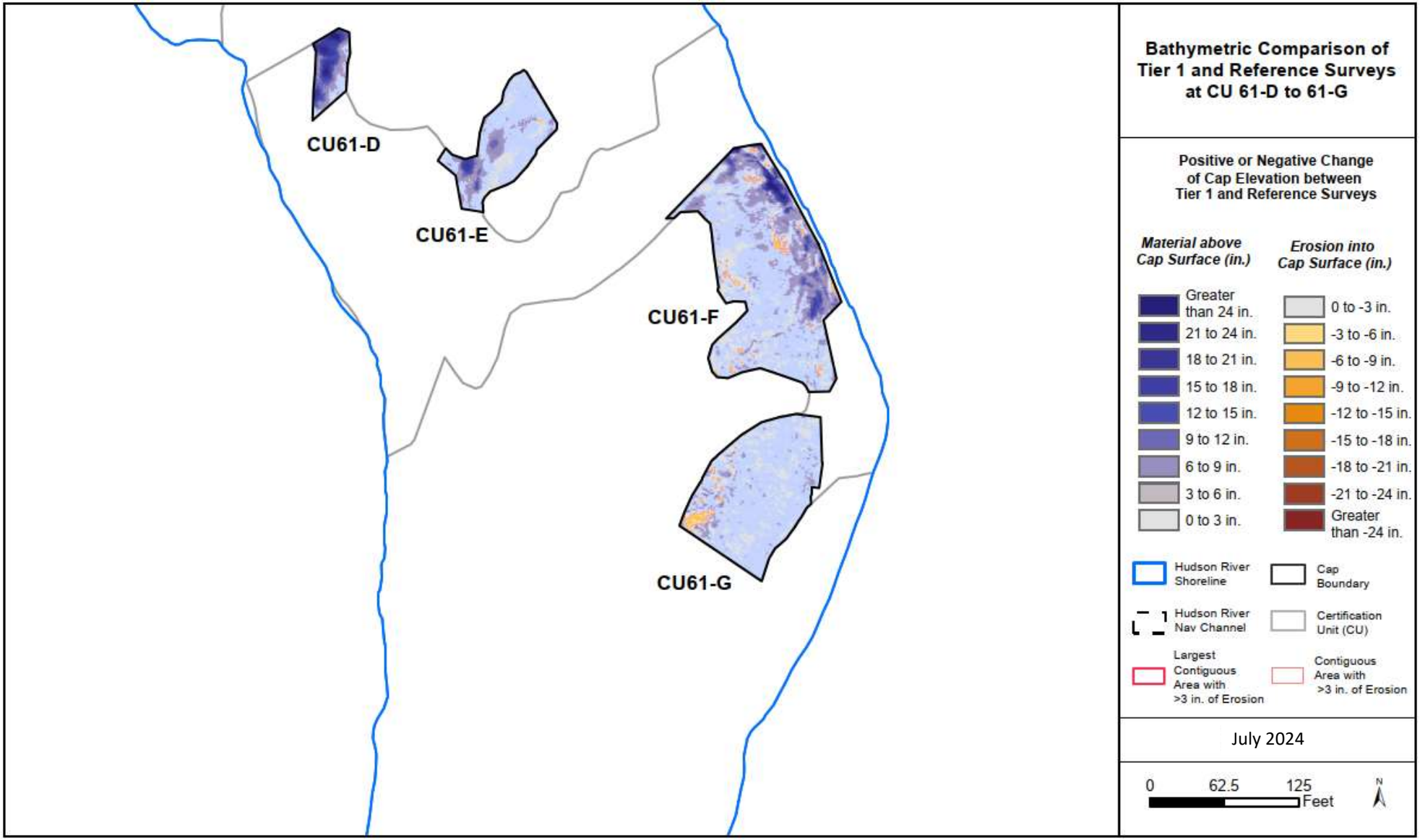
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 61-A to 61-C

Figure A4-4a

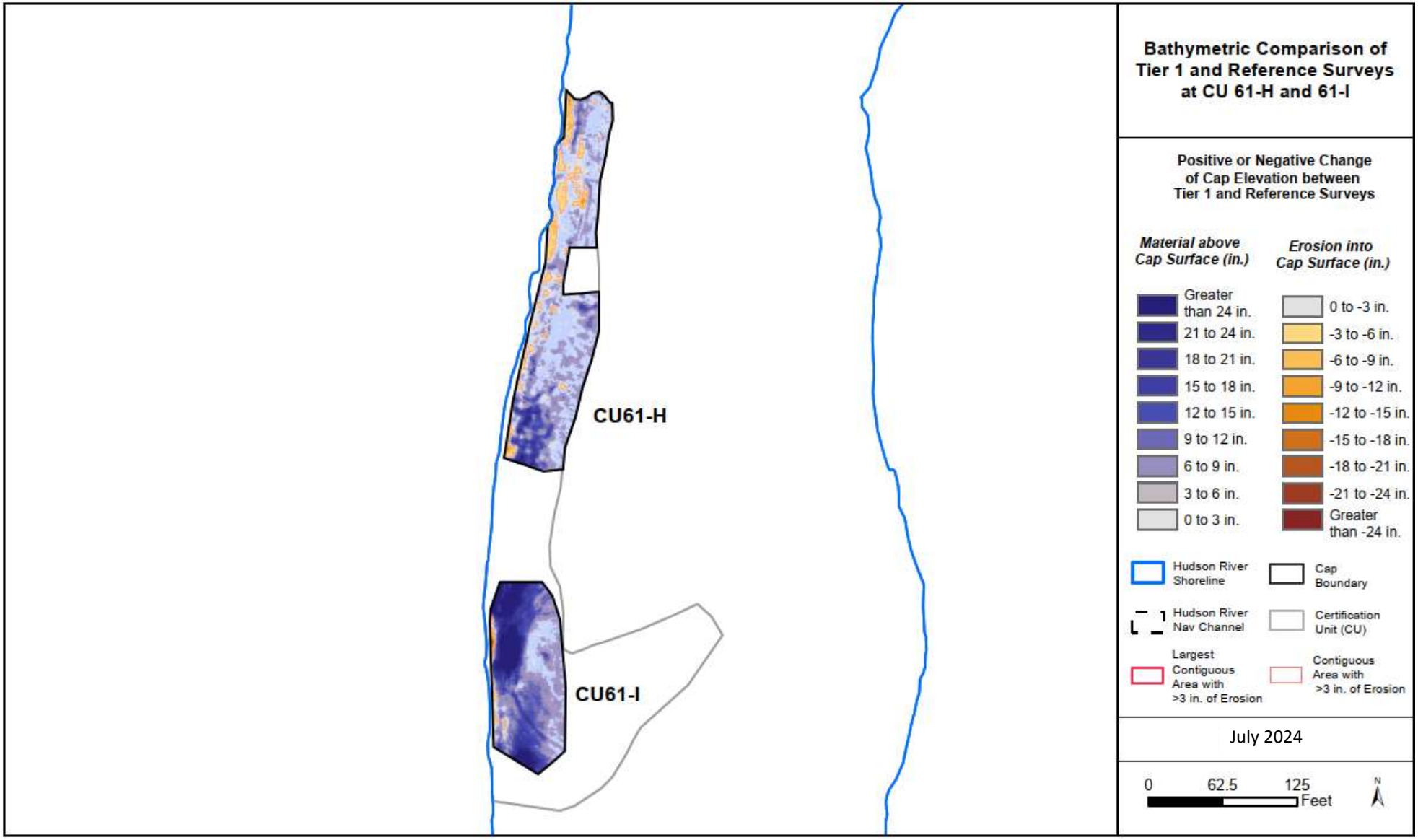
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 61-D to 61-G

Figure A4-4b

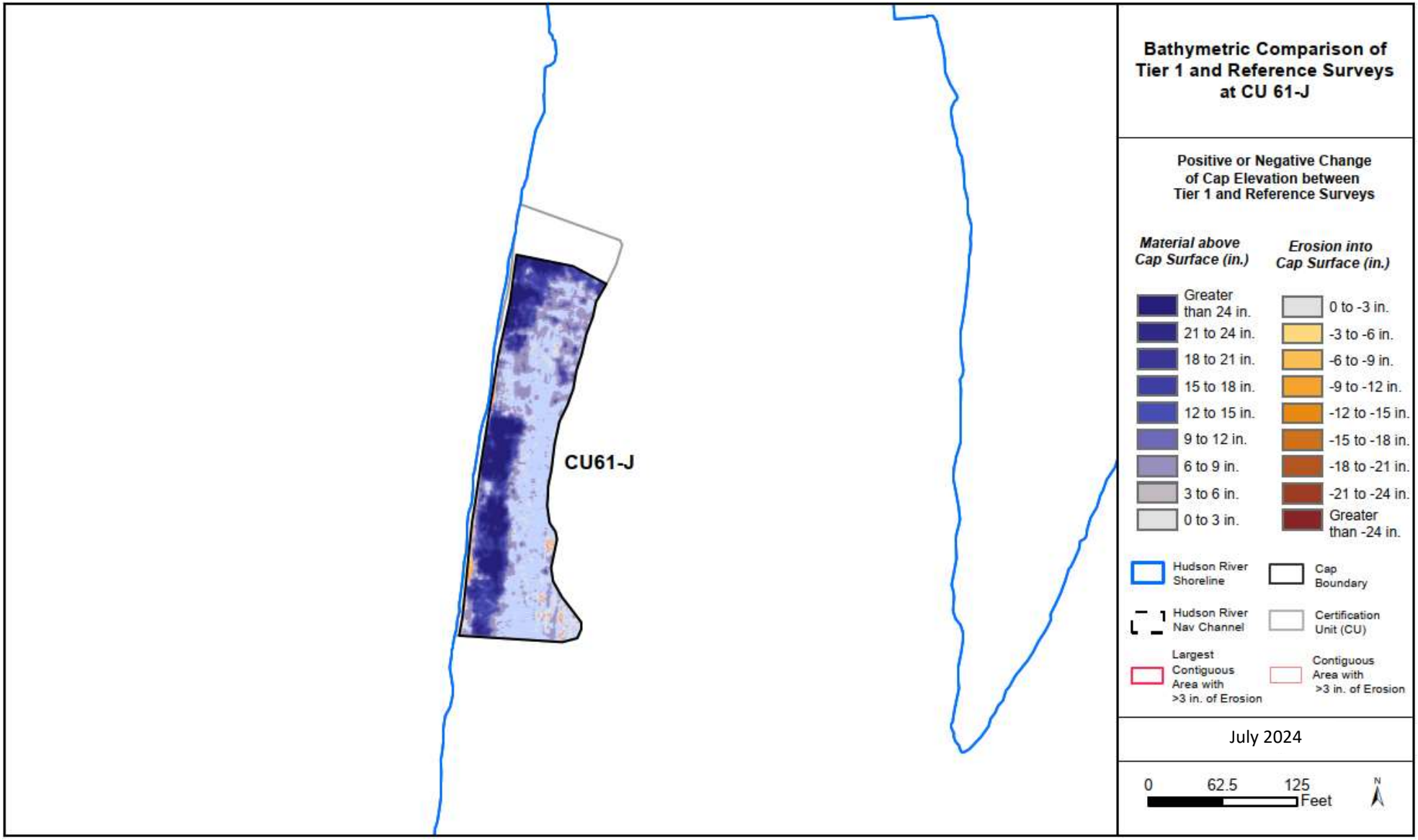
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 61-H and 61-I

Figure A4-4c

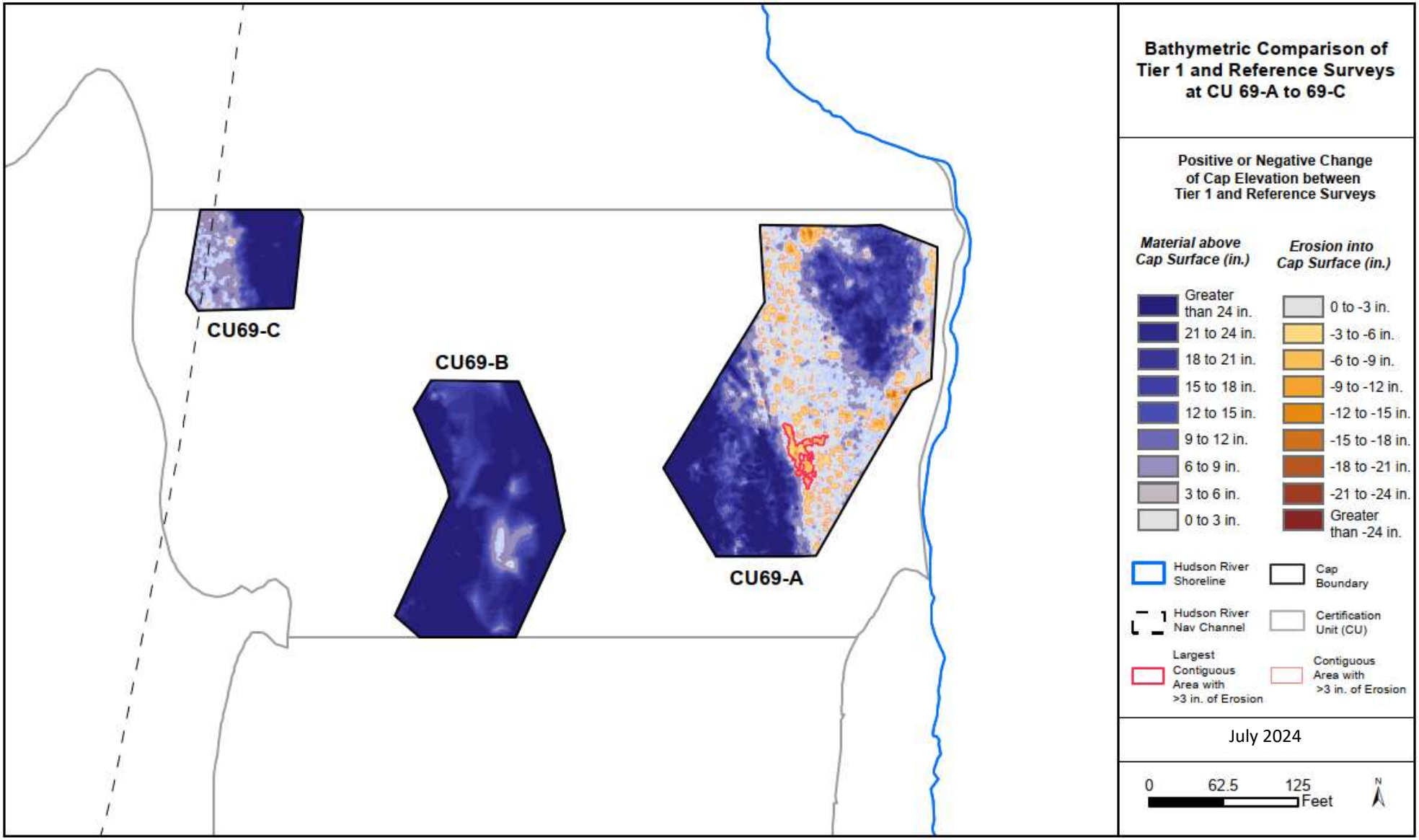
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 61-J

Figure A4-4d

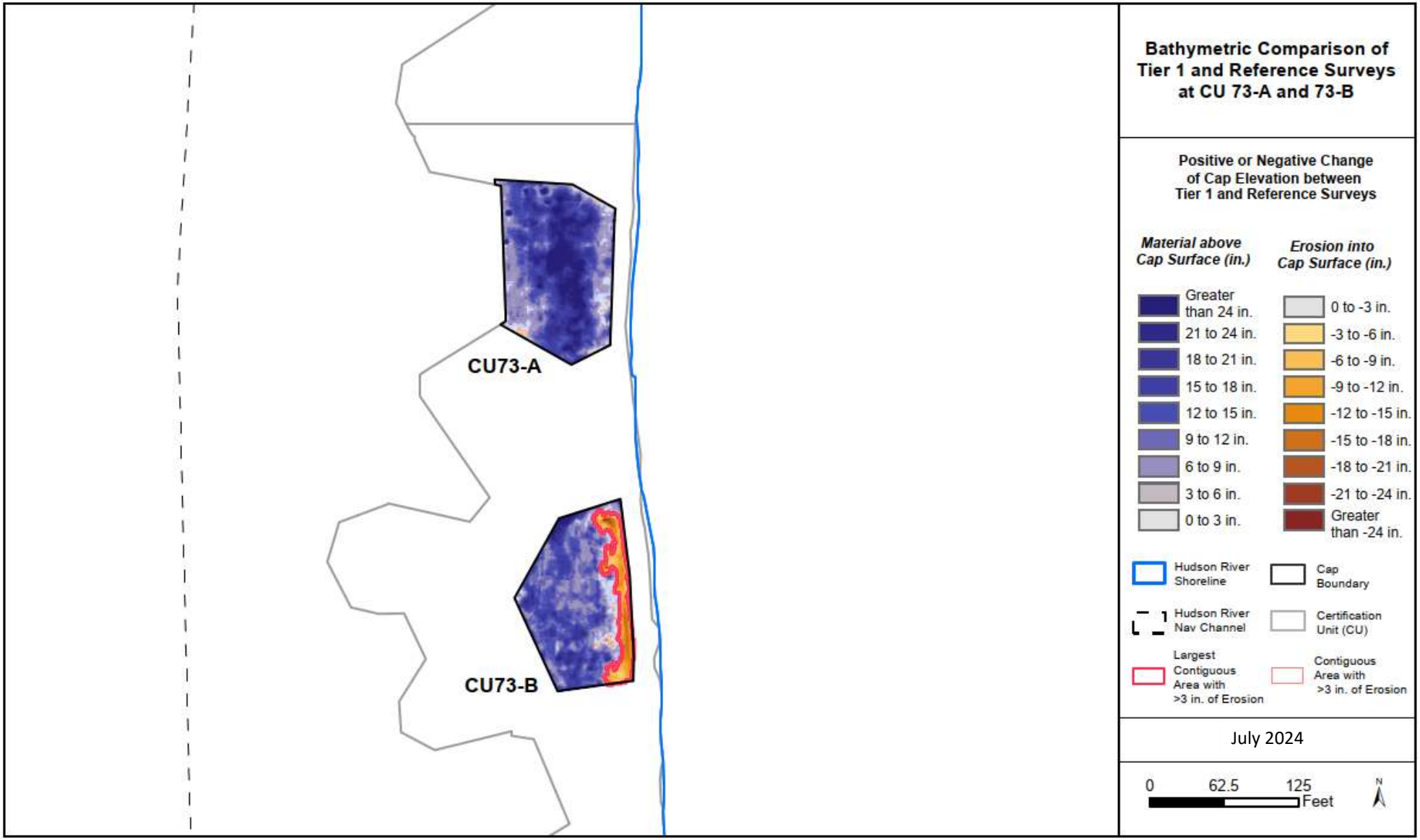
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 69-A to 69-C

Figure A4-5

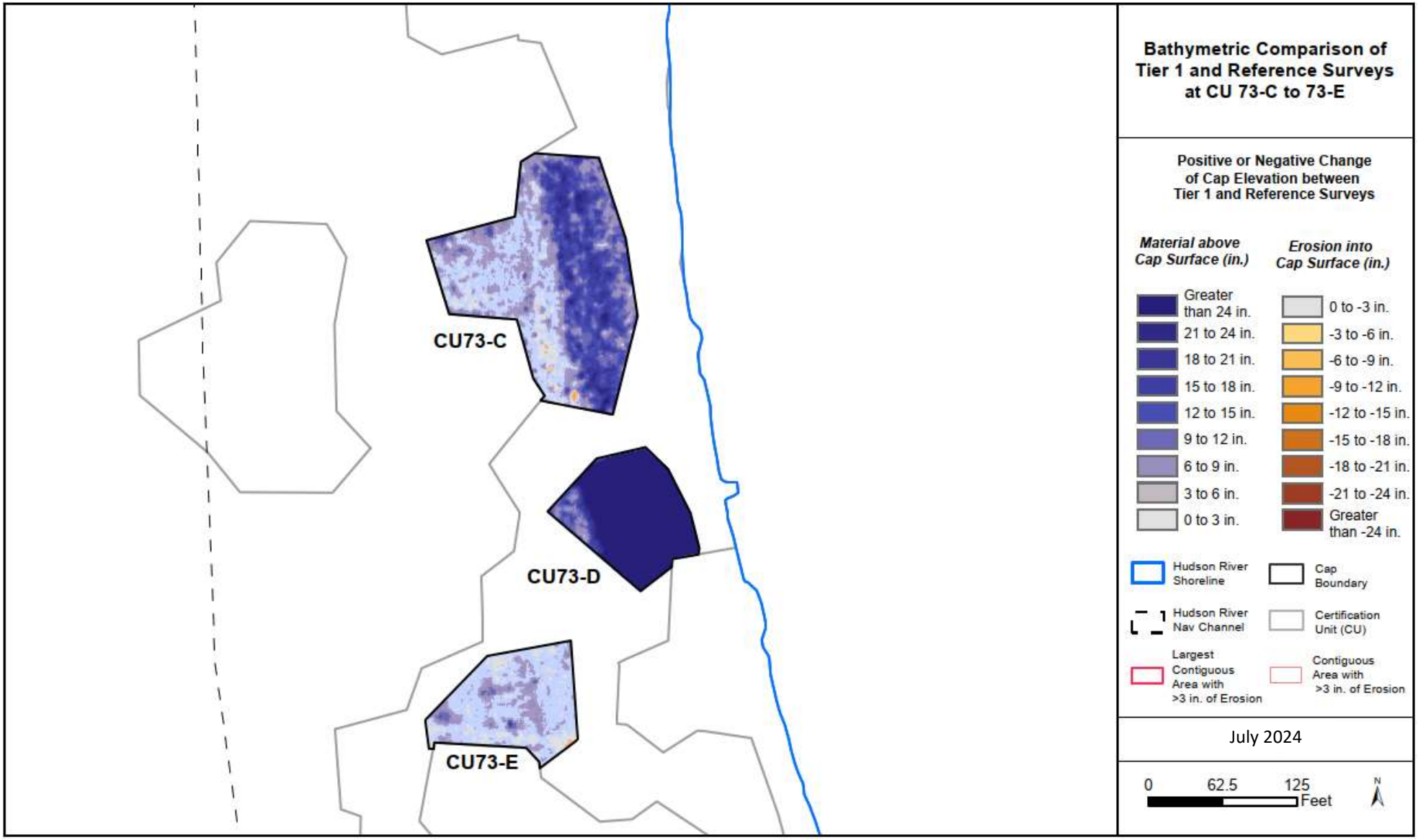
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 73-A and 73-B

Figure A4-6a

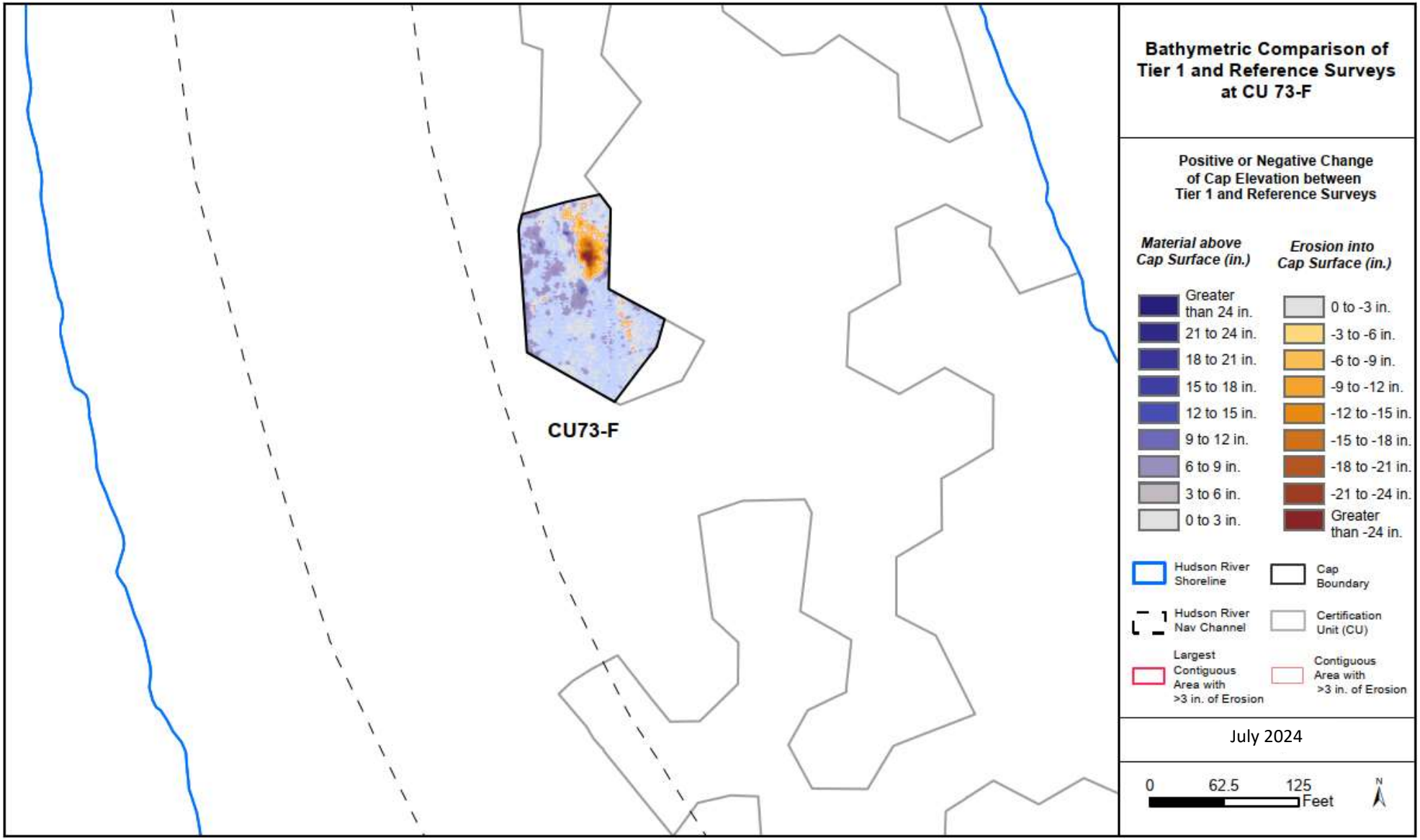
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 73-C to 73-E

Figure A4-6b

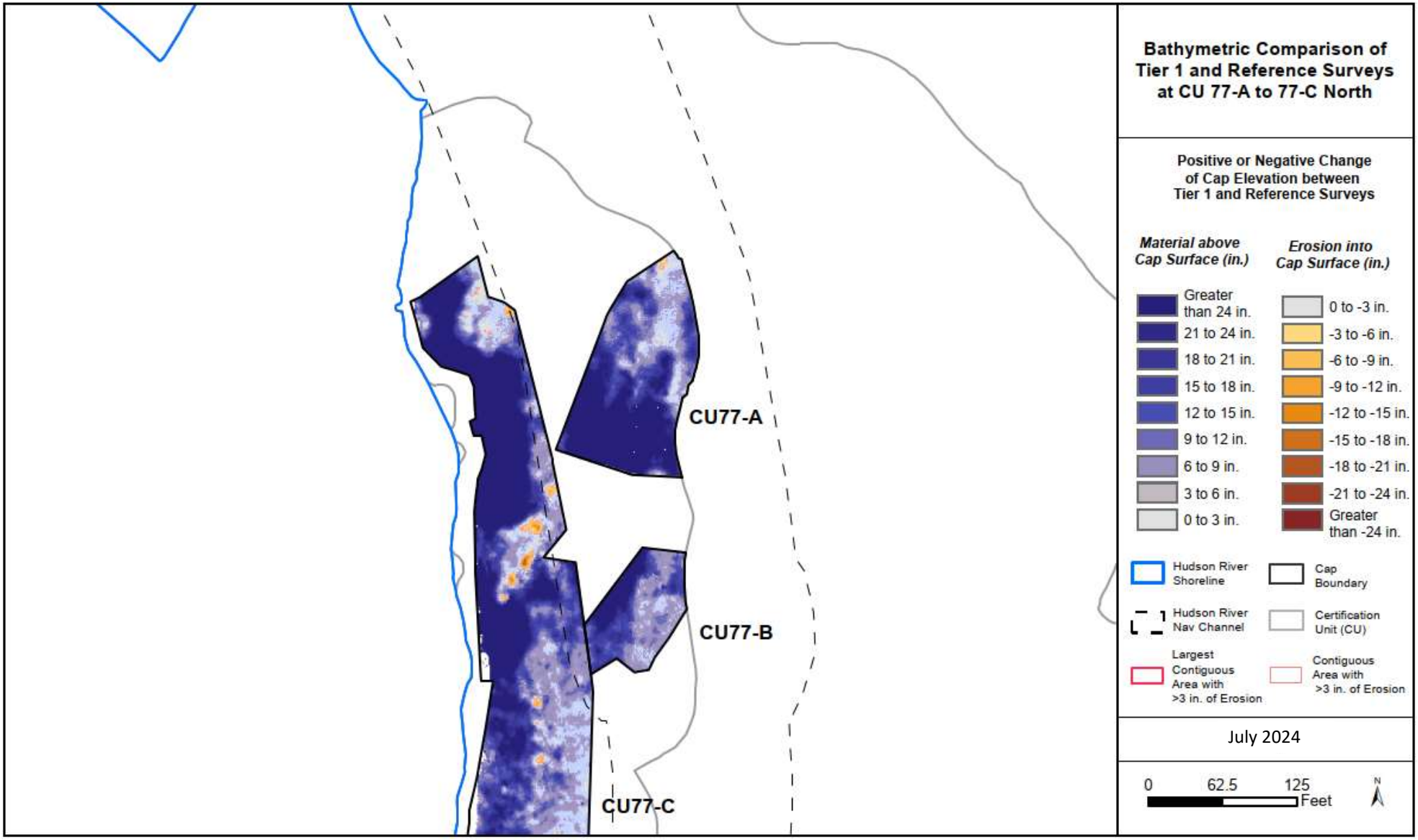
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 73-F

Figure A4-6c

July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 77-A to 77-C

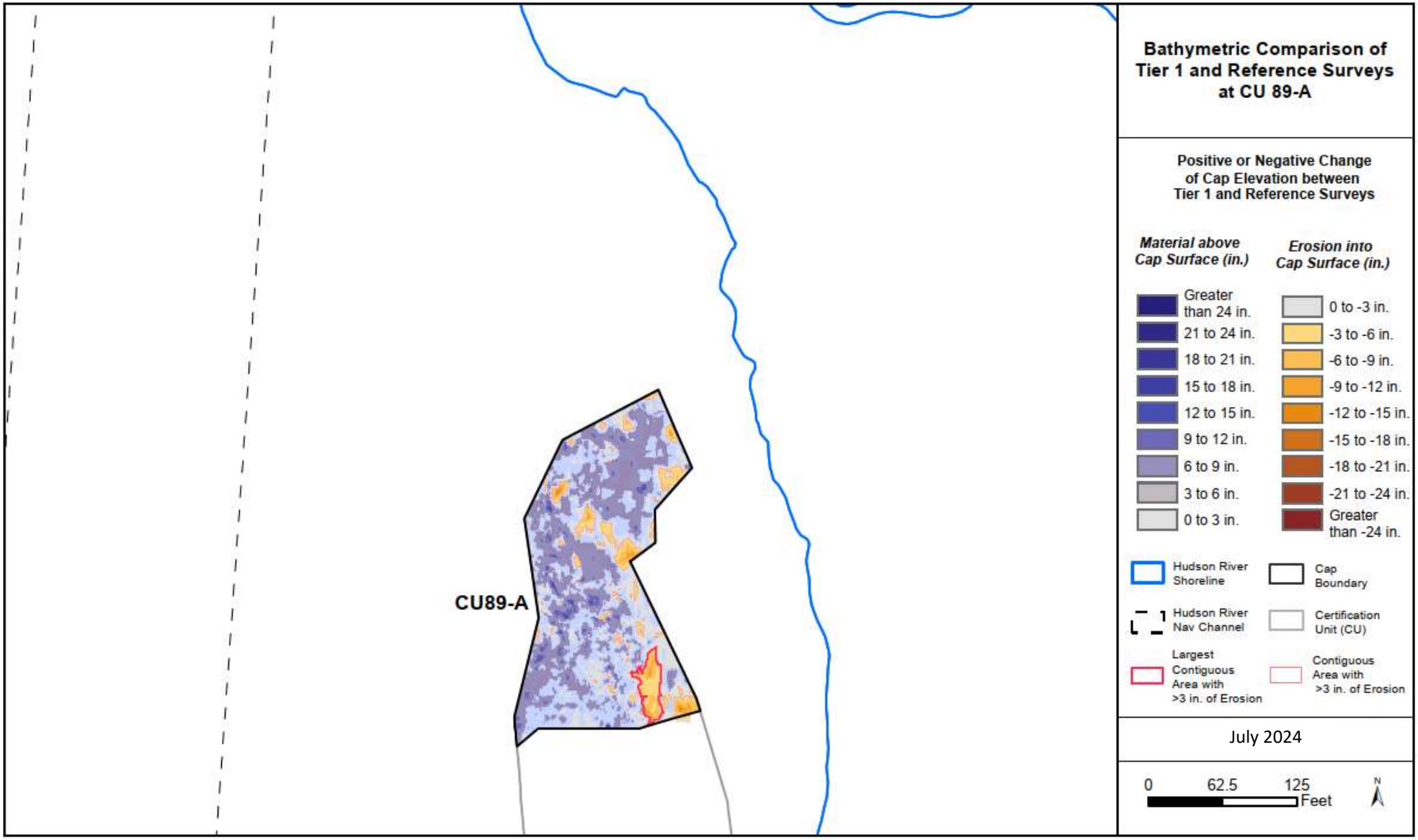
Figure A4-7a

July 2024

Bathymetric Comparison of Tier 1 and Reference Surveys at CU 77-C South

Figure A4-7b

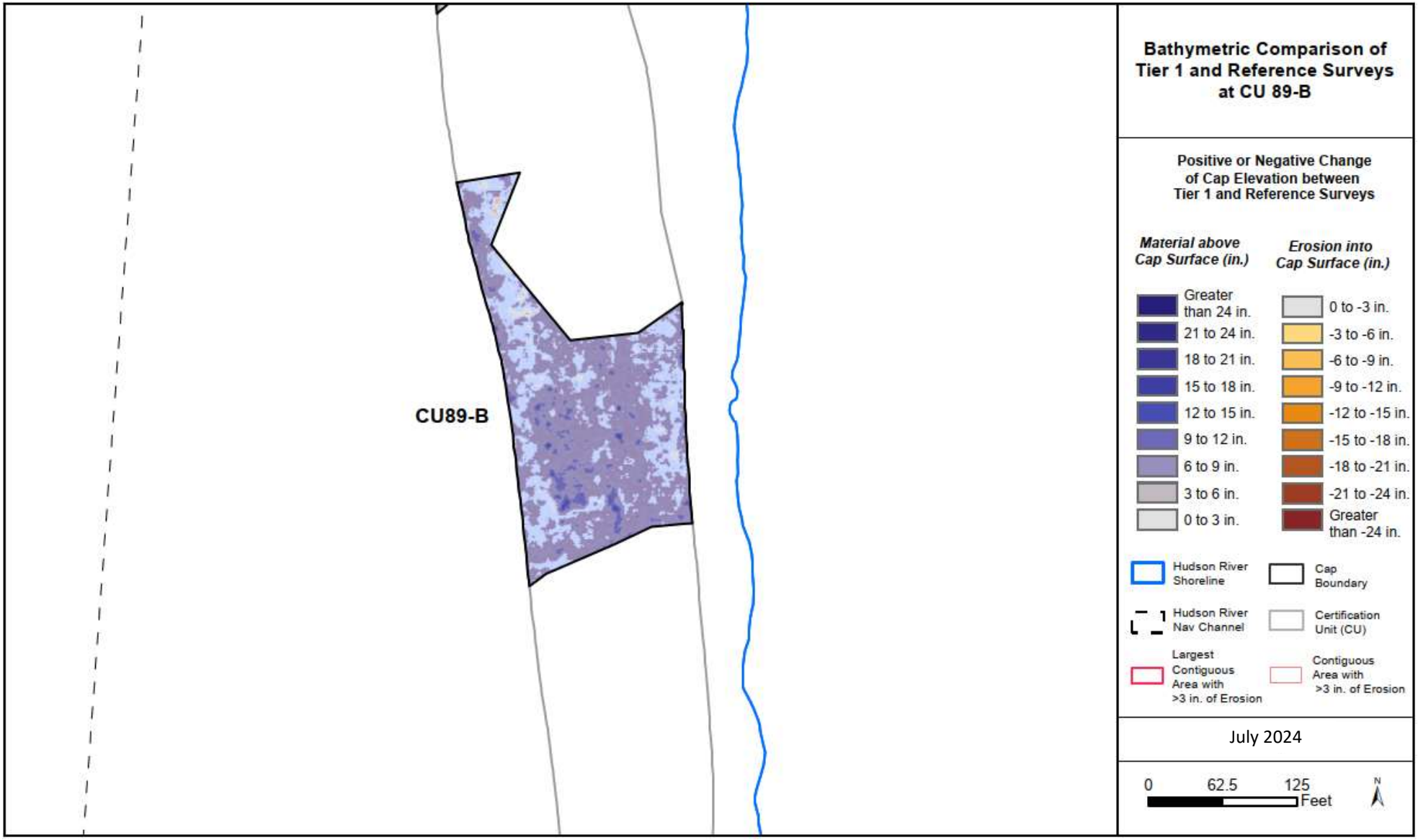
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 89-A

Figure A4-8a

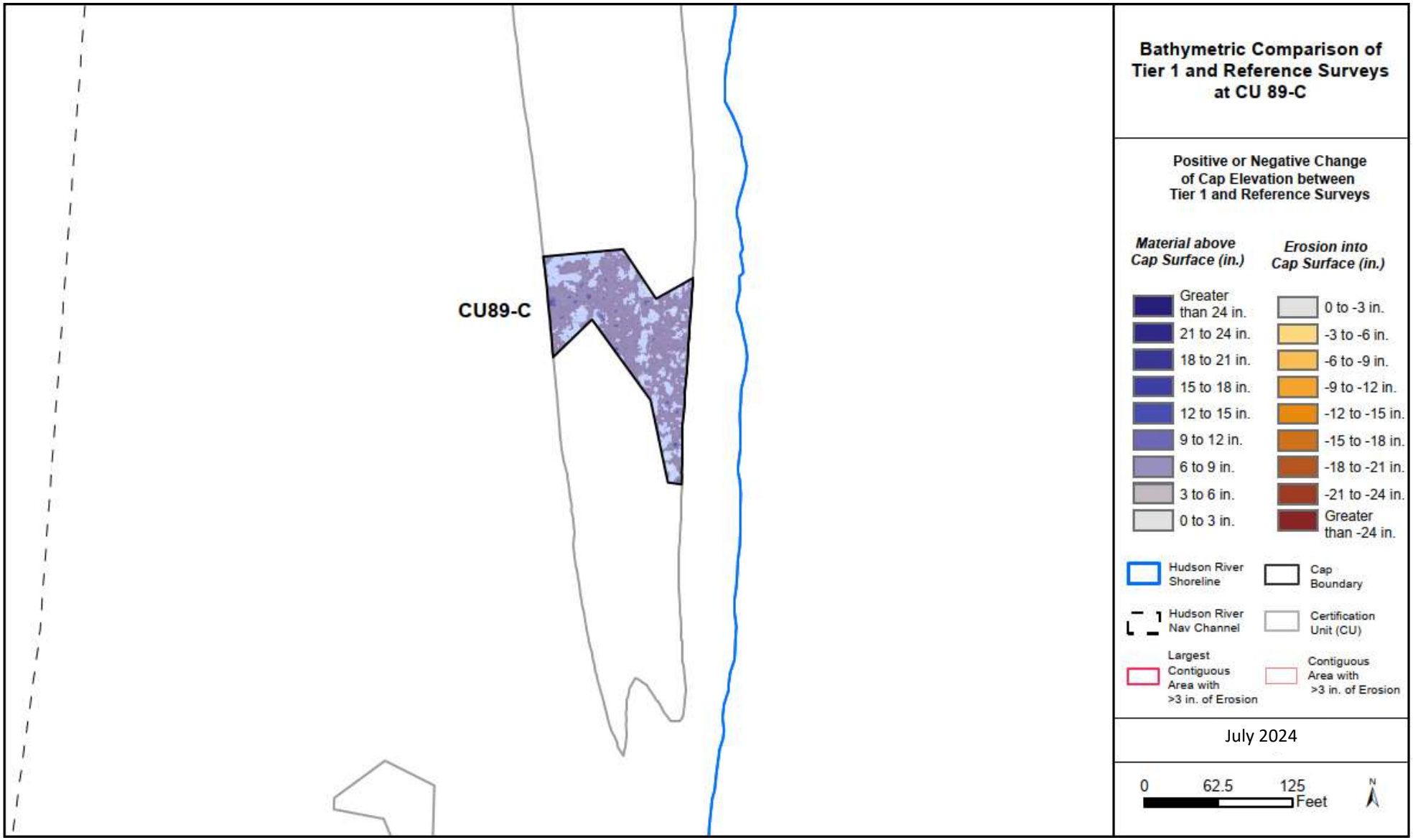
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 89-B

Figure A4-8b

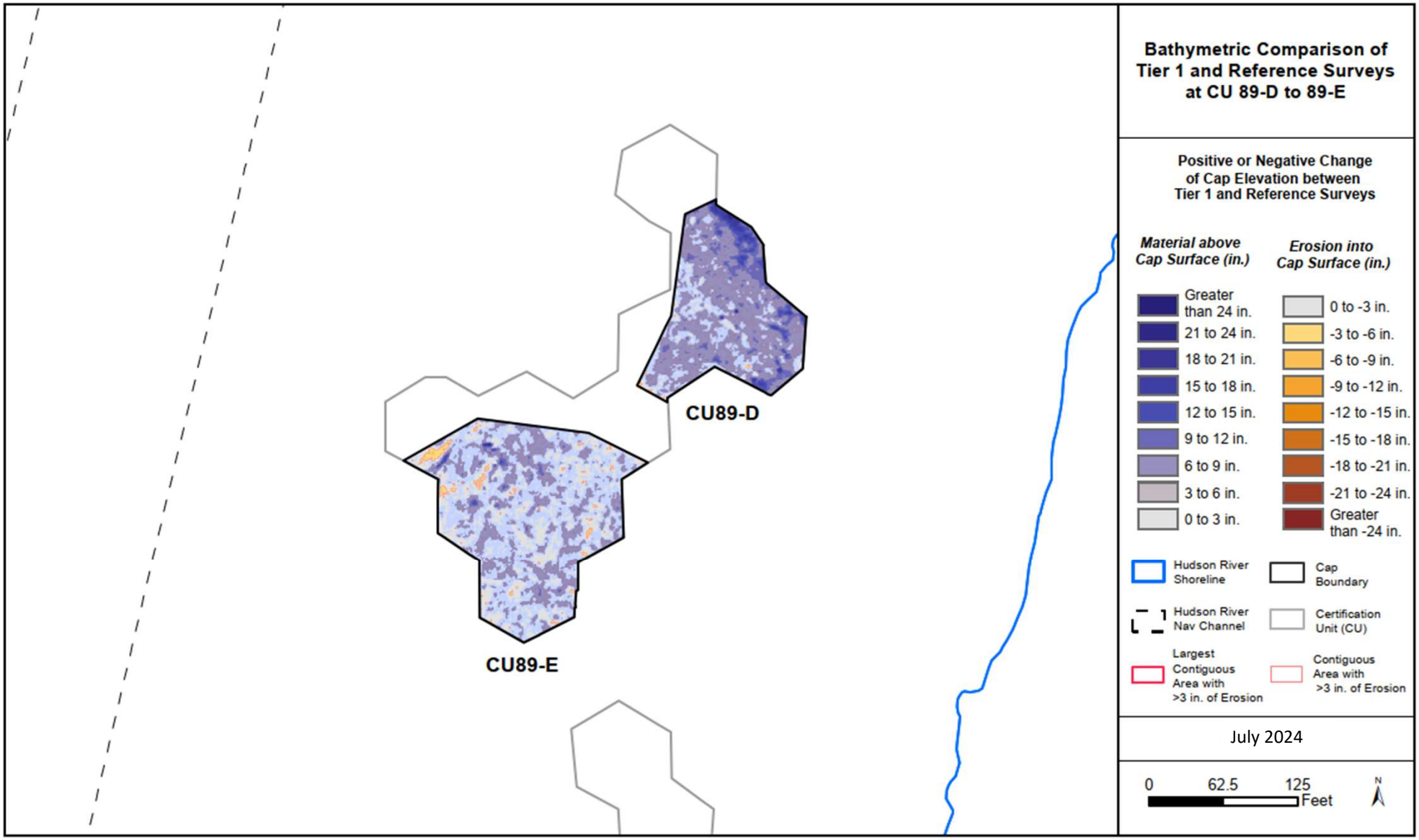
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 89-C

Figure A4-8c

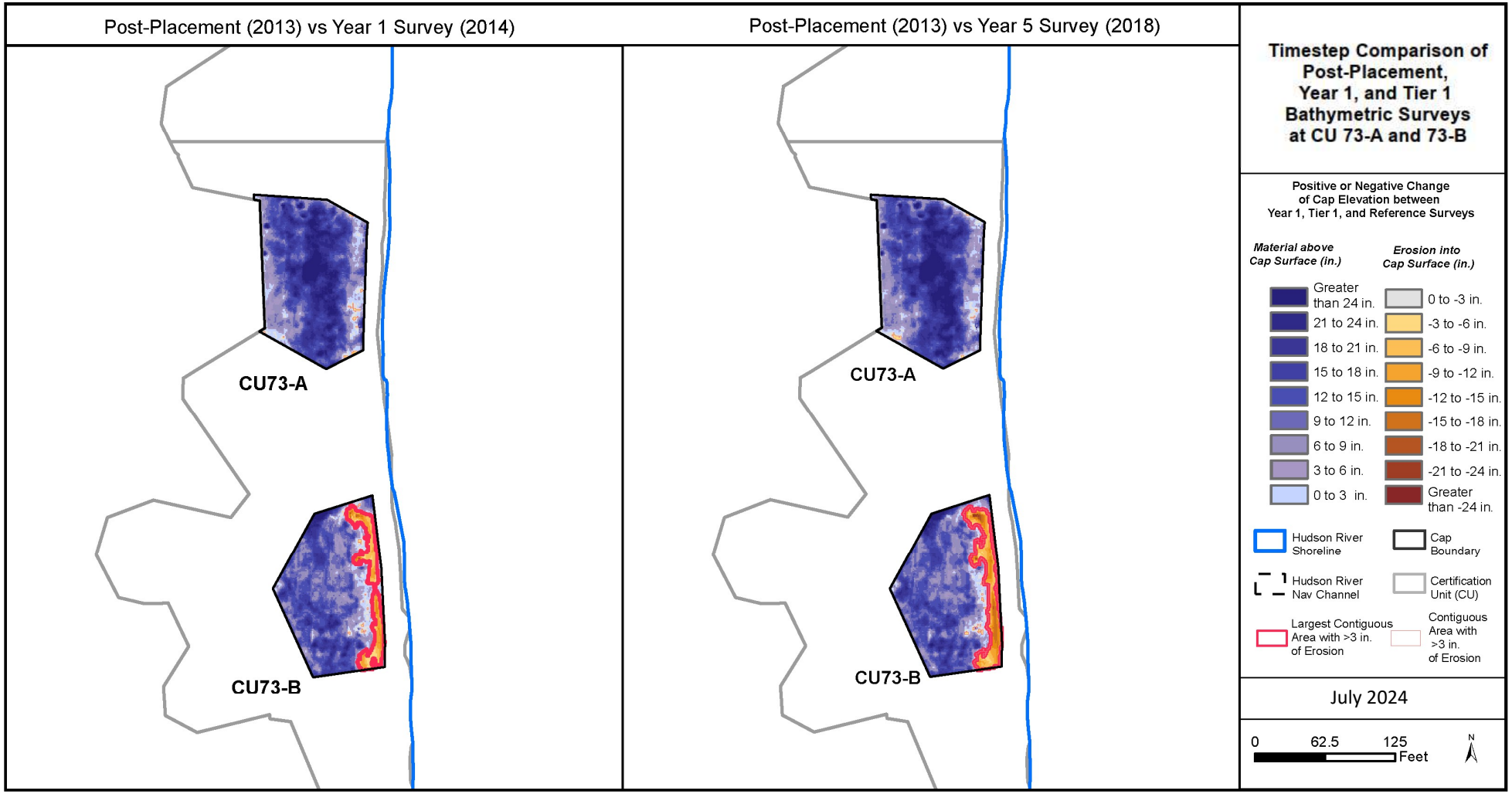
July 2024



Bathymetric Comparison of Tier 1 and Reference Surveys at CU 89-D and 89-E

Figure A4-8d

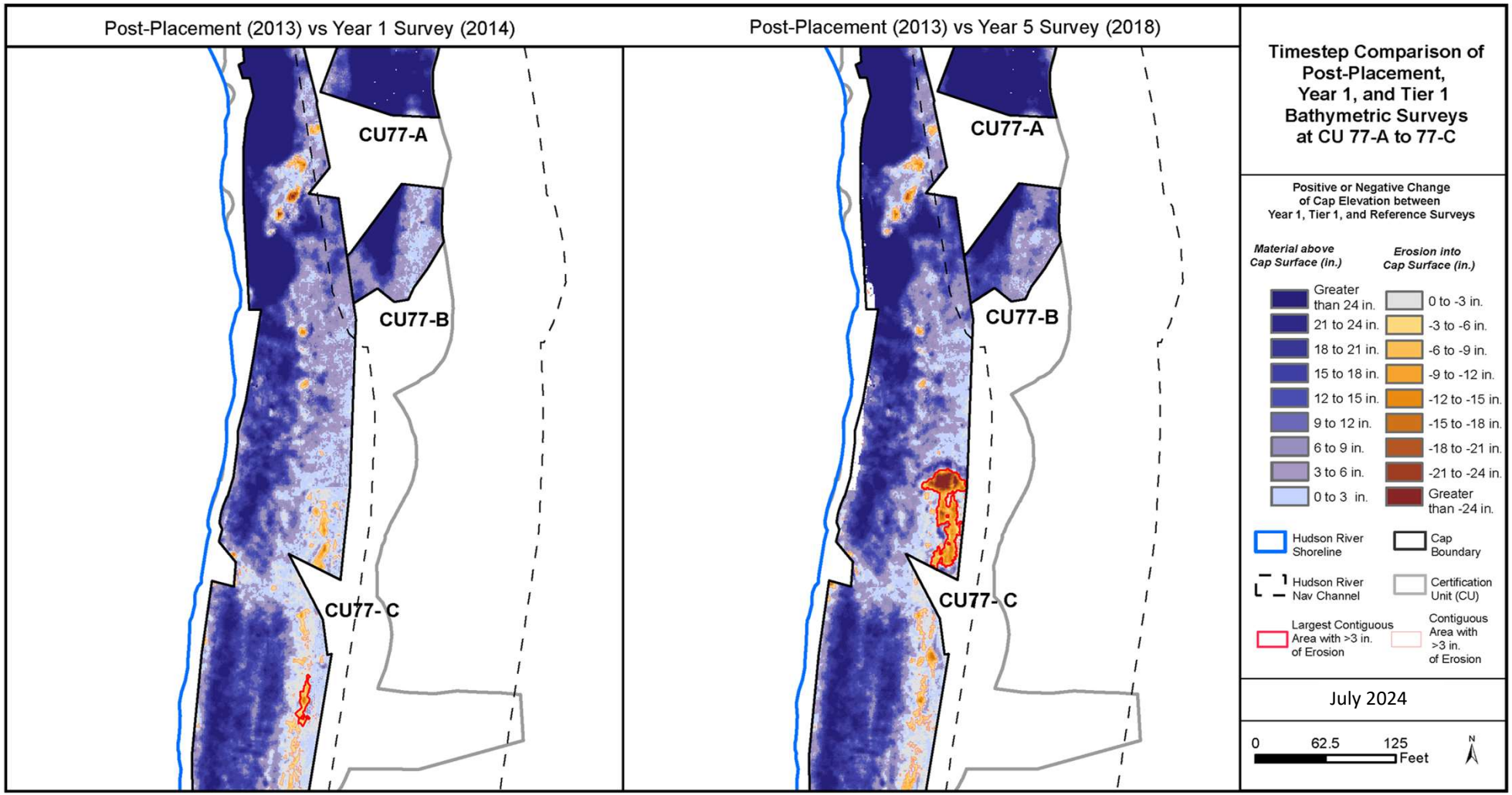
July 2024



Timestep Comparison of Post-Placement, Year 1, and Tier 1 Bathymetric Surveys at CU 73

Figure A4-9

July 2024



Timestep Comparison of Post-Placement, Year 1, and Tier 1 Bathymetric Surveys at CU 77

Figure A4-10

July 2024