Appendix 7-C: Suspended Sediment Monitoring During Pre-Installation Trials for the Champlain Hudson Power Express Project, Hudson River Reports

This Appendix contains the following two reports:

Suspended Sediment Monitoring during Pre-Installation Trials for the Champlain Hudson Power Express Project: Final Hudson River Report March 2024

Suspended Sediment Monitoring during Pre-Installation Trials for the Champlain Hudson Power Express Project: Hudson River Report April 2023

Suspended Sediment Monitoring during Pre-Installation Trials for the Champlain Hudson Power Express Project

Final Hudson River Report

NYSPSC Certificate Case 10-T-0139

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Normandeau Project No. 24711.001

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Acronyms and Abbreviations

ABS	Acoustic backscatter
ADCP	Acoustic Doppler current profiler
Alpha	Alpha Analytical, Inc.
APHA	American Public Health Association
ASSO	Asso.subsea Single Member SA, Asso Group, Inc.
BDL	Below the method detection limit
C	Celsius
Certificate	Certificate of Environmental Compatibility and Public Need
CHPE	Champlain Hudson Power Express
COC	Chain of custody
CTD	Conductivity-temperature-depth sensors
ft	feet
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HVDC	High voltage direct current
µg	Microgram
mL	Milliliters
The Monitoring Plan	Suspended Sediment / Water Quality Monitoring Plan for CHPE (2020 revision)
NKT	NKT, Inc.
Normandeau	Normandeau Associates, Inc.
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDPS	New York State Department of Public Service
NYSPSC	New York State Public Service Commission
OBS	Optical backscatter
PCBs	Polychlorinated biphenyls
PSU	Practical Salinity Units
QAPP	Quality Assurance Project Plan
QC	Quality control
SM	Standard Method
SOP	Standard operating procedure
TRDI	Teledyne RD Instruments
Trencher	AssoTrencher V Mk3
TSS	Total suspended solids
USGS	United States Geological Survey
VMT	Velocity Mapping Toolbox
WQC	Water Quality Certification pursuant to Section 401 of the Federal Water Pollution Control Act, 33 U.S.C § 1341, and Article VII of the New York Public Service Law

Executive Summary

CHPE LLC contracted Normandeau Associates, Inc. ("Normandeau") to conduct suspended sediment and water chemistry monitoring to assess the levels of sediment resuspension from the remote submersible jetting trencher AssoTrencher V Mk3 ("the trencher" or "jetting trencher") operations during the pre-installation trial in the Hudson River. Additionally, a secondary objective of the pre-installation trial monitoring was to describe quantitative relationships (if any) among the acoustic and optical backscatter data with the laboratory-derived total suspended solids ("TSS") data in attempt to calibrate remote sensing methods for near real-time TSS monitoring during the submarine cable installation activities anticipated to occur from 2024 through 2025. The intent of the TSS sampling during the trials was to monitor sediment plumes from the trencher operations for potential exceedance of TSS standards set forth in CHPE LLC's Section 401 Water Quality Certificate ("WQC"). This report documents the activities and results from TSS monitoring during the pre-installation trial in the Hudson River.

A pre-installation jet plow trial occurred along a 2,640-foot route in Hudson River on September 9, 2022. This same trial was conducted for a remotely operated submersible trencher on December 22, 2023. Laboratory analysis of TSS from water samples collected during the trencher trial showed low to slightly elevated levels of TSS above background levels, but none approached exceeding ambient concentrations by 200 mg/L as per the condition described in the WQC, and all but three samples showed increases in TSS of 10 mg/L or less. An increase of 23 mg/L was the maximum observed value above background for TSS levels during the trencher trial and TSS levels were generally within 10 mg/L of ambient levels. It appears likely that any sediments that are resuspended due to the jetting trencher operations would only be observed as TSS at the 500-foot distance from the barge within a small width of cross-sectional area (estimated from a few feet ["ft"] to 30-35 ft wide, depending on conditions, when observable) and primarily during the times surrounding peak tidal currents within the tidal cycle.

The survey operation included an acoustic Doppler current profiler ("ADCP") to collect vertical profile measurements of current velocity and relative acoustic backscatter ("ABS"); a multi-parameter sonde to collect vertical profile measurements of conductivity (salinity), temperature, and depth ("CTD"); and an optical backscatter ("OBS") sensor to measure turbidity. Water samples for TSS analysis were collected concurrently with the OBS and ABS data before, during, and after the trial. These concurrent and co-located TSS, OBS, and ABS data were used to develop calibration curves to attempt to estimate TSS from both OBS and ABS data.

A statistically significant and well-correlated calibration relationship was established for TSS to OBS, but the TSS data were not correlated with ABS for all data collected. However, correlations for TSS to ABS were explored by modelling each sampling day separately (i.e. not combining the ABS and TSS sample data across survey days), which did show statistically significant and moderately correlated relationships. The strength of the OBS-TSS regression indicates that OBS is likely a better predictor of TSS values between the two methods, corroborating results from the 2022 jet plow trial in the Hudson River. The ABS data from ADCP provide a remote profiling instrument capable of sampling the entire water column (i.e., without being physically lowered from a vessel at a point), which is useful for locating potential sediment plumes. It is apparent that different hydrological conditions or background sediment characteristics can result in variability in the calibrations, particularly for the TSS to ABS correlations. Based on the results from the Hudson River jetting trencher trial, and primarily due to the apparent variability and scale of the observable suspended sediment plume induced by the trencher, the ABS data are helpful in determining if a potential plume is present at 500 ft down-current from the trencher in real-time and for monitoring purposes to determine where to sample for CTD-OBS and confirmatory TSS from water samples. The ABS contour plots demonstrate that the sediment plume is observable remotely, and based on these observations, the presence and spatial variability of the plume across conditions and

tides can be confirmed. While the ABS could provide an additional estimate of near real-time TSS levels during future monitoring activities, the ABS-TSS correlations from the trencher trial surveys were only significant if correlated for each day (as opposed to combining the datasets). As such, for conditions encountered in this region of the Hudson River, the OBS sensor is likely more appropriate for guiding compliance determinations during active construction.

In summary, the pre-installation jetting trencher trial in the Hudson River demonstrated that (1) trencher activities produced either no observable plume or a small area of slightly elevated TSS levels within a cross-sectional transect that were well below the TSS standards identified in the WQC (at most approximately 11.5% of the standard for elevation above background levels); (2) the presence and location of a suspended sediment plume at 500 ft down-current of the trencher was able to be detected in the ABS data, although one was not always observed during the trial; and (3) the OBS calibration to TSS exhibited high predictive power, whereas the ABS calibration was either not statistically significant, or too sensitive to variability in conditions to be useful for long-term active construction monitoring. While these calibration relationships are subject to modification during the installation phase of the Project to reflect hydrological and sediment conditions that may not have been encountered during the trials, the regression results suggest that the use of the calibration curves developed as part of the trials, particularly the OBS-TSS calibration, would be appropriate for the start of the installation phase in the Hudson River.

1 Introduction

1.1 Background

The Champlain Hudson Power Express ("CHPE") transmission project ("Project") in Lake Champlain and the Hudson River will install a high-voltage direct current ("HVDC") electric transmission line capable of delivering up to 1,250 megawatts of clean renewable energy from hydroelectric generation facilities in Canada to New York City. The electric transmission line will consist of two HVDC cables buried underwater or underground. The submarine segment of CHPE transmission route is approximately 192 miles, where 97 miles are in Lake Champlain and 95 miles are in the Hudson, Harlem, and East Rivers. Prior to commencing submarine installation activities, pre-installation trials are required to be conducted to test operational conditions of the equipment to be used during cable burial activities. In September of 2022, a trial was conducted in the Hudson River to test the jet plow equipment to be used during the installation process in portions of the Hudson River. The same trial was conducted in December of 2023 for a remotely operated jetting submersible AssoTrencher V Mk3 ("the trencher"), owned and operated by Asso.subsea Single Member SA, Asso Group ("ASSO"). This report provides the results of the December 2023 pre-installation trial in the Hudson River.

1.2 Regulatory Overview

A Certificate of Environmental Compatibility and Public Need ("Certificate") for the Project was issued effective by the New York State Public Service Commission ("NYSPSC") on April 18, 2013. The Certificate contains several conditions for installation of the submarine portion of the CHPE route, including certain studies, which were adopted from the Joint Proposal of Settlement for Case 10-T-0139. One of these requirements was monitoring of suspended sediment and water quality chemical parameters in the water column during pre-installation trials of the equipment to be used during cable installation. On October 18, 2013, CHPE submitted a monitoring plan titled *Suspended Sediment / Water Quality Monitoring Plan* (i.e., "the Monitoring Plan"). The Monitoring Plan was developed in conjunction with the Project's Water Quality Certification pursuant to Section 401 of the Federal Water Pollution Control Act, 33 U.S.C § 1341, and Article VII of the New York Public Service Law Section 401 ("the WQC"), as well as comments received from the New York State Department of Environmental Conservation ("NYSDEC") and the New York State Department of Public Service ("NYSDPS").

1.3 Objectives

The Monitoring Plan outlined the requirements for the suspended sediment and water quality monitoring during pre-installation trials of the jet plow and jetting trencher equipment, specifically the monitoring of total suspended solids ("TSS") and chemical parameters in the water column during the pre-installation trials. The objectives of the TSS monitoring program were to assess the amount of sediment resuspension in the water column during operation of the jetting trencher, and to make potential recommendations (if any) for modifications to the trencher operation or monitoring procedures based on the results of the pre-installation trials.

CHPE LLC contracted Normandeau Associates, Inc. ("Normandeau") to conduct the TSS and water quality monitoring during the pre-installation trials which included, but was not limited to, collection of site-specific measurements of TSS from water samples, concurrently with measurements of acoustic and optical backscatter to assess the levels of sediment resuspension from the jet and shear plow operations during the pre-installation trials in Lake Champlain and the Hudson River in 2022, and during the Hudson River trial for the trencher in 2023. During the 2023 Hudson River trial, a second survey vessel and crew performed water quality sampling for chemical parameters identified in the WQC and the Monitoring Plan (Table 1-1).

Additionally, a secondary objective of the pre-installation trial monitoring was to attempt to describe quantitative relationships (if any) among the acoustic and optical backscatter and laboratory derived TSS data for potential development of remote sensing methods for near real-time TSS monitoring during the submarine cable installation activities anticipated to occur from 2024 through 2025. The intent of the TSS monitoring during the trials was to assess the potential observable impact from the trencher operations, with respect to the standards set forth in the WQC. This report documents the activities associated with the monitoring of TSS and water quality chemical parameters during the pre-installation trials in the Hudson River in December 2023.

Table 1-1. Water Quality Analytical Parameters for Laboratory Analysis of Samples collected for Chemical Analysis during Pre-Installation Trials (22-Dec-2023) in the Hudson River for CHPE.

Parameter	SW-846 Method[1]	Standard	Units
Phenanthrene	EPA 8270D-SIM	45	µg/L
Total PCBs	EPA 8082A	0.09	µg/L
Total Mercury	EPA 1631E	0.7	µg/L
Dissolved/Total Cadmium	EPA 200.8	5	µg/L
Dissolved/Total Copper	EPA 200.8	200	µg/L
Dissolved/Total Lead	EPA 200.8	50	µg/L
Total Suspended Solids	SM 2540D	N/A	mg/L
Hardness	EPA 6010D	N/A	mg/L

[1]United States Environmental Protection Agency ("USEPA") Hazard Waste Test Methods (USEPA 2015).

1.4 Project Location

The pre-installation trial documented in this report occurred on December 22, 2023, in the Hudson River, north of the Newburgh-Beacon Bridge near Chelsea, NY. This was the same location the pre-installation jet plow trial was performed in September 2022, with the route offset slightly from the 2022 trial. Figure 1-1 presents an overview map of the site location for the 2023 trencher trial, with the coordinates provided by CHPE's marine construction contractors, NKT, Inc. ("NKT") and ASSO. The trial route was planned to be approximately 2,640 feet ("ft") in length.

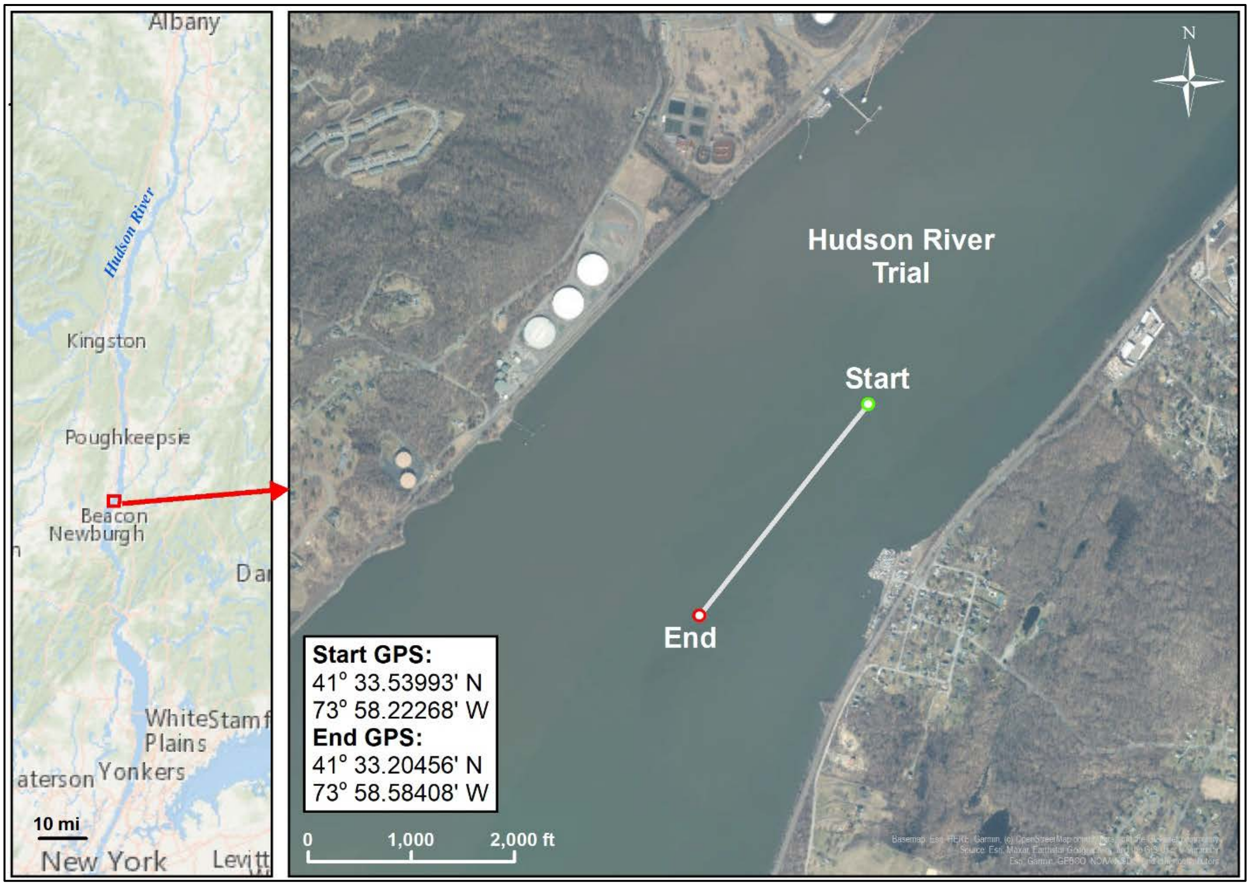

Figure 1-1. Overview of the Project site location for the Pre-Installation trial in the Hudson River, in the vicinity of Chelsea, NY. The planned start and end points of the jetting trencher trial route are presented.

2 Methods

2.1 Field Sampling

The survey operation included an acoustic Doppler current profiler ("ADCP") to collect vertical profile measurement of current velocity and relative acoustic backscatter ("ABS"); a multi-parameter sonde to collect vertical profile measurements of conductivity (salinity), temperature, and depth ("CTD"); an optical backscatter ("OBS") sensor to measure turbidity, a stainless steel Kemmerer water bottle sampler to collect samples for subsequent laboratory measurements of TSS, and an acrylic Kemmerer water bottle sampler to collect samples for chemical analyses. Data were georeferenced by the Global Positioning System ("GPS").

For the trial, the procedures outlined in the Monitoring Plan were applied for each "TSS sampling event", which consisted of the following sampling activities:

1. ADCP measurements collected at the up- and down-current side of the trencher, to confirm current direction, and to potentially estimate the location of a potential suspended sediment plume for down-current sampling;

2. Stationary collection of CTD-OBS measurements and water sampling to collect concurrent and co-located water samples for TSS at near-surface, mid-depth, and near-bottom depths in the water column; and
3. Concurrent ADCP measurement at the same near-surface, mid-depth, and near-bottom depths in the water column during the CTD-OBS and water sampling, to provide simultaneous ABS data.

These measurements were performed at approximately 500 ft up- and down-current of the trencher as was practicable and safely navigable to achieve. The 500 ft up- and down-current distance was specified in the Monitoring Plan after the requirements in the WQC. The sampling locations on either side of the trencher/barge were to be sampled as often as possible given the conditions during the duration each trial, with ADCP transects and discrete sampling conducted as outlined above and described further below. During preparation for the trial monitoring, it was determined that consistently sampling from the north-to-south side of the trencher and barge would be more efficient logistically, and enable more samples to be collected, as opposed to switching the up/down-current sample collection order based on the tidal currents (which were predicted to potentially switch directions twice during the trial period). This was done to improve communication with the other sampling teams on the water, not directly connected to the pre-installation trials monitoring.

During the Hudson River trial, a second survey vessel collected water quality samples for the chemical parameters identified in the Monitoring Plan and WQC for Class A waters, alongside of the TSS monitoring (Table 1-1). As outlined in the Monitoring Plan and WQC, a chemical sampling event was performed for each change in trencher speed: the trencher traversed the route at speeds of 5 ft/min in the first 660 ft of route, 10 ft/min for the middle 1,320 ft of the route, and 5 ft/min for the last 660 ft of route, with a chemical sampling event for each speed segment. The second vessel and crew conducting the chemistry sampling worked alongside the primary survey vessel conducting the remote sensing and TSS monitoring, following the same protocol above in sequence with the ADCP, CTD-OBS, and TSS sampling, but only collected discrete water samples at each station for the lab analysis of the chemical parameters outlined in the Monitoring Plan and WQC (Table 1-1). During the respective trial sampling events (3 events for water chemistry, 10 events for TSS monitoring), the water chemistry samples were collected at each up-current and down-current station location immediately following collection of the ADCP, CTD-OBS, and TSS samples.

2.1.1 Equipment

Current velocity and ABS measurements were collected with a Teledyne RD Instruments (“TRDI”) 600 kHz Workhorse Sentinel ADCP, attached to an aluminum pole mount deployed from the starboard side of Normandeau’s 24-foot survey vessel and submerged 0.67 m below the water surface as measured to the ADCP transducer faces. A Hemisphere Vector V500 Global Navigation Satellite System (“GNSS”) receiver and antenna was mounted on the top of the pole 2.33 m directly above the ADCP and was used to collect GPS coordinates for georeferencing the ADCP data and survey navigation. A weatherproof laptop computer was used on the vessel to acquire data for the surveys. The GPS signal was configured to supply positional data to HYPACK navigation software (HYPACK, version 21.0.2.0) for real-time positioning of the vessel, and to TRDI’s WinRiver II (WinRiver II, version 2.23) data acquisition software for ADCP calibration, testing, and measurements. WinRiver II allowed configuration and saving of the ADCP sampling parameters for the survey, confirmation of the GPS signal integration with the ADCP data, and the ability to review the raw data in real-time while the survey was underway. The ADCP, V500 GNSS antenna, survey laptop, and additional computer monitor were powered from a sine wave power inverter onboard the vessel. A Garmin® handheld laser rangefinder was used in the field to assess distance from the barge/trencher in real-time for setting the location of the ADCP transects and CTD-OBS sampling stations, as practicable and safely navigable.

Prior to each day's survey activities, the ADCP system passed all internal system and sensor tests performed with WinRiver II. ADCP compass calibrations were also conducted at the Project area each day with the ADCP in the deployed configuration per the manufacturer recommendations (TRDI 2020, 2021; Mueller et al. 2013). The ADCP was configured such that the acoustic signal would adequately profile the entire water column under the anticipated water quality conditions and expected site depths (up to 18 m [59 ft]). The ADCP was configured to collect data in 0.5-m depth layers with respect to vertical range from the ADCP (referred to herein as "bins"), with transmit acoustic pulses ("pings") set to sample fast as possible, which yielded a raw profile sampling rate of approximately two pings per second (2 Hz) for most profiles. This configuration was chosen to allow for the transects to be sampled at as high a resolution as possible with respect to the vertical axis while ensuring an acoustic profile range that extended to the river bottom and allowed for maximum data retention for analysis.

Water quality and turbidity measurements were collected with a YSI EXO2 multi-parameter sonde for CTD-OBS data collection and recorded digitally with the sonde's handheld controller during sample collection. The CTD-OBS was configured to sample at the fastest rate possible (2 Hz) to capture as much data per sample location as possible. The YSI sensors were calibrated prior to each survey per the manufacturer's recommendations and methods (YSI 2019).

Water samples for laboratory analysis of TSS were collected with a 2.2-liter Wildco® stainless-steel Kemmerer sampler. The Kemmerer sampler and CTD-OBS were mounted together with two bracket clamps such that the sampling depth of the water sample and CTD-OBS data would be co-located with respect to the water column, as practicable given the current flow. A diagram of the sampling equipment with respect to the vessel and deployment with depth is presented in Figure 2-1.

The second survey vessel (25-ft Parker) and crew mobilized to sample alongside the primary survey vessel (described above and in Section 2.1) to conduct the water chemistry monitoring and collected water samples sufficient for laboratory analysis of the chemical parameters identified in Table 1-1. These water samples were collected with an 8.2-liter Wildco® acrylic Kemmerer sampler, suitable for chemical and trace metal sampling.

All field data collection methods followed recommendations, guidelines, procedures, and methods outlined in the respective manuals for sampling equipment (i.e., ADCP, GPS, CTD-OBS, and Kemmerer samplers).

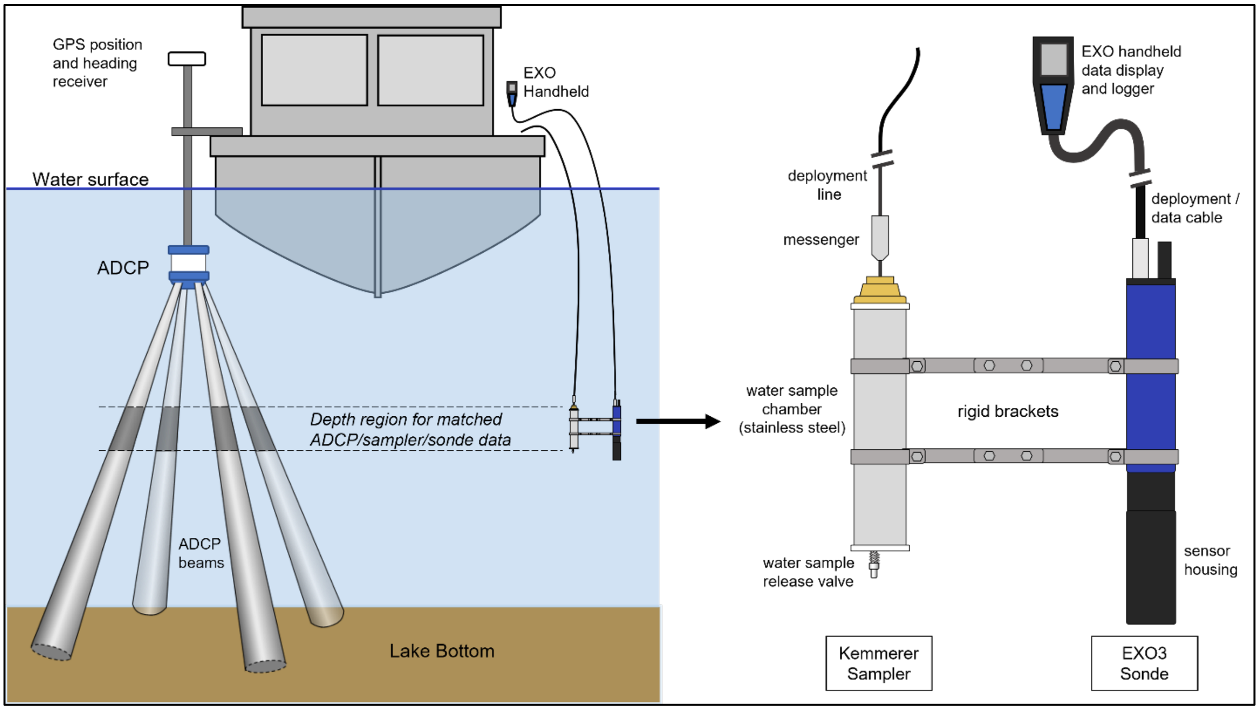

Figure 2-1. Sampling equipment schematic diagram showing the relative deployment positioning of the ADCP, CTD-OBS, and Kemmerer sampler with respect to the vessel and water column on the left-hand side. To the right is a zoomed diagram of the design of the CTD-OBS-Kemmerer mount used during TSS monitoring.

2.1.2 Sample Collection

During the Hudson River pre-installation trial, sampling occurred at approximately 500 ft up- and down-current of the trencher. Once notified by personnel from ASSO that the trencher had commenced the trial, the procedure for each "TSS sampling event" was performed until the approximately 2,640-ft long trial route was completed. For each TSS sampling event, the shipboard processing occurred iteratively as follows:

1. Survey vessel attempted to verify current direction by performing two ADCP transects to collect current velocity data and confirm which side of the trencher and barge were up- and down-current.
    a. Note: for the Hudson River trials, the tidal currents were predicted to reverse direction two times during the trial with predicted slack currents at 10:12 and 17:00 on December 22, 2023. Therefore, it was determined that the survey vessel would sample in a north-to-south pattern, to improve efficiency and logistics in the field at the start of the trial, and up- and down-current locations were assigned based on the tidal currents and presence/absence of a potential suspended sediment plume.
2. After collecting the ADCP transects, the vessel navigated to the north side of the trencher, approximately 500 ft distance from the trencher and in line with the route as best as possible, and recorded GPS coordinates and station metadata for the up-current sampling station (e.g., date/time, weather and sea state conditions, etc.).
3. A "stationary" ADCP measurement, as practicable given conditions, was started once on-station at the up-current sampling location to record concurrent ABS data with the CTD-OBS and water

samples for TSS. This station's file was used to collect ABS data during the entire up-current station's sampling for CTD-OBS and water samples.

4. After starting the ADCP measurement, the CTD-OBS and Kemmerer sampler were prepared for deployment, with samples collected from near-surface, mid-depth, and near-bottom levels in the water column (but within the valid measurement range of the ADCP's acoustic beams).
5. For each sampling depth, the CTD-OBS and coupled Kemmerer sampler were lowered to the depth being sampled based on the real-time readout from the CTD-OBS handheld controller. Once at depth (e.g., 10 ft), the equipment was held in position for approximately 10-20 seconds before triggering the Kemmerer sampler to close. The equipment was then held in position for another 10-20 seconds prior to recovery to provide a sufficient time for data collection of OBS and ABS data to assess for remote sensing correlation to TSS (described in Section 3.2).
6. When the Kemmerer sampler was at the required predetermined depth, a messenger weight was released down the connecting line to the sampler which triggered the sampling device to close. Upon retrieving the Kemmerer sampler, the first 10-20 mL of the collected sample was discharged to clear any potential contamination on the valve. The remaining sample was collected in lab-provided 950 mL containers which were labeled, secured, and stored on ice while on the survey vessel.
7. Steps 5 and 6 were repeated and reported for near-surface, mid-depth, and near-bottom at each sampling station.
8. After three samples were collected at the north side of the trencher, the survey vessel navigated to the south side of the trencher to repeat Steps 1 through 7. This process generally took from 10-15 minutes for each up/downriver side of the trencher, and 25-35 minutes per pair of up/downriver sampling stations (i.e., "Pass"), when including navigation time.
    a. While collecting ADCP transects on the down-current side of the trencher (north or south depending on tidal currents), the raw ABS data from the ADCP were reviewed in real-time to attempt to estimate the position of a suspended sediment plume, if there is one observed at 500 ft distance. When no potential plume was observed, then the down-current samples were also collected as close to in line with the trencher route as possible.
9. After the south station's sampling was completed, the vessel navigated back to the north side of the trencher and repeated the entire process.

For the water chemistry sampling, "chemistry sampling events" were conducted by the second survey vessel alongside of the TSS monitoring vessel, with only one chemistry sampling event for each change in trencher speed. The planned trial route was to be conducted at two speeds, 5 ft/min for the first 660 ft of the route and 10 ft/min for the remaining portion of the route. The original plan to conduct the middle 1,320 ft of the route at 600 ft/min and then slow back down to 5 ft/min was altered during the trial in the interest of completing the trial within one day due to daylight and logistical concerns with sample transfer to the laboratory. For the chemistry sampling events, the second vessel coordinated with the TSS monitoring vessel to collect the water chemistry samples in sequence with the ADCP, CTD-OBS, and TSS water samples at each up/downriver station location to complete a chemistry sampling event (i.e., the water chemistry samples were not collected on every TSS monitoring Pass).

After being notified by ASSO that the pre-installation trial was completed, an additional Pass of sampling was conducted with the up-current and down-current locations being collected at the mid-point of the trial route, and south of the trencher and barge, respectively, and one additional water chemistry station was sampled at the mid-point of the trial route. ADCP, CTD-OBS, and TSS sampling locations for each Pass are presented in Figure 2-2, Figure 2-3, and Figure 2-4.

After completion of the trencher trial, samples were transferred to Alpha Analytical, Inc. ("Alpha"), the laboratory used for the TSS and chemical analyses, as described in more detail in Section 2.1.3. In addition to the sampling steps described above, a full-water-column CTD-OBS profile was collected before the trial to provide initial background water column conditions.

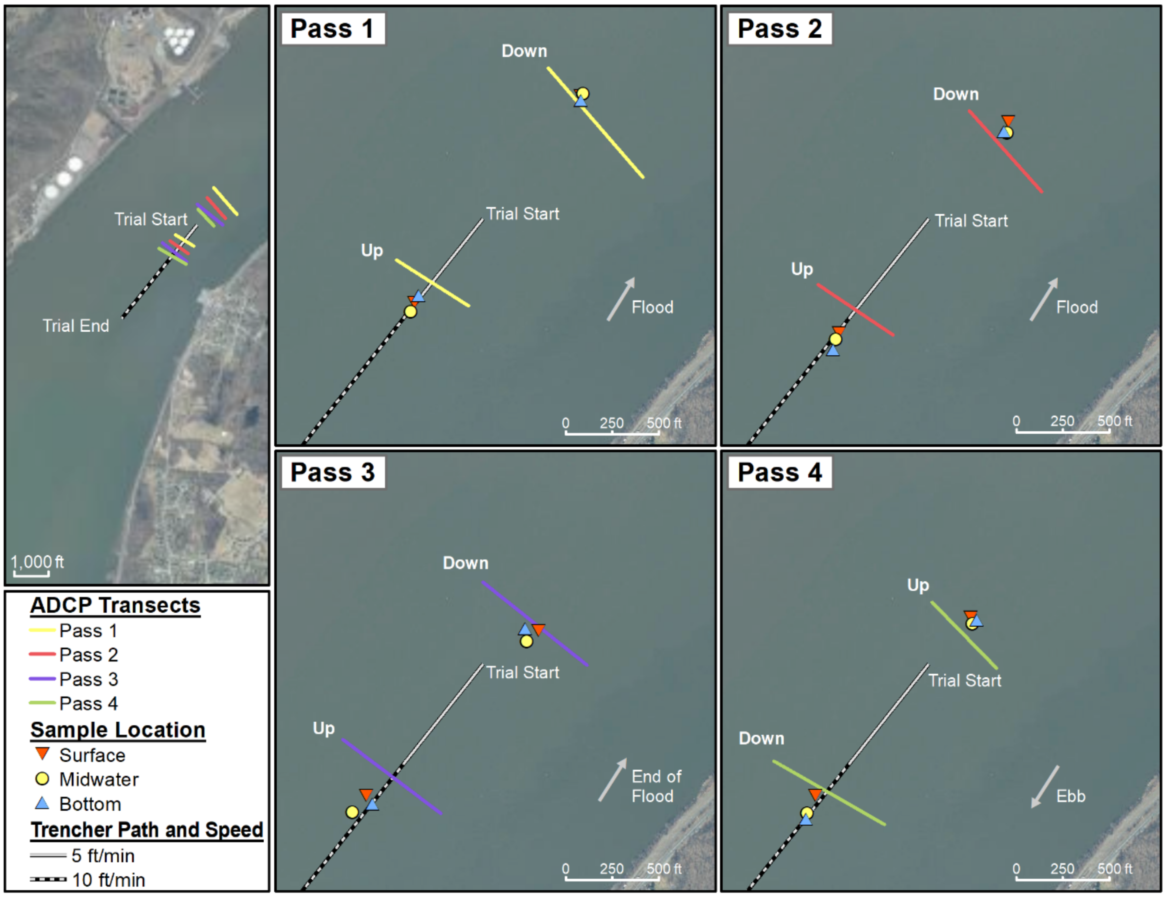

Figure 2-2. Summary of the sampling locations for Passes 1 through 4 before and during the pre-installation jetting trencher trial during 22-Dec-2023 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The trencher route for the trial is shown as white or dashed black line indicating the sections of the trial route that the jetting trencher was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.

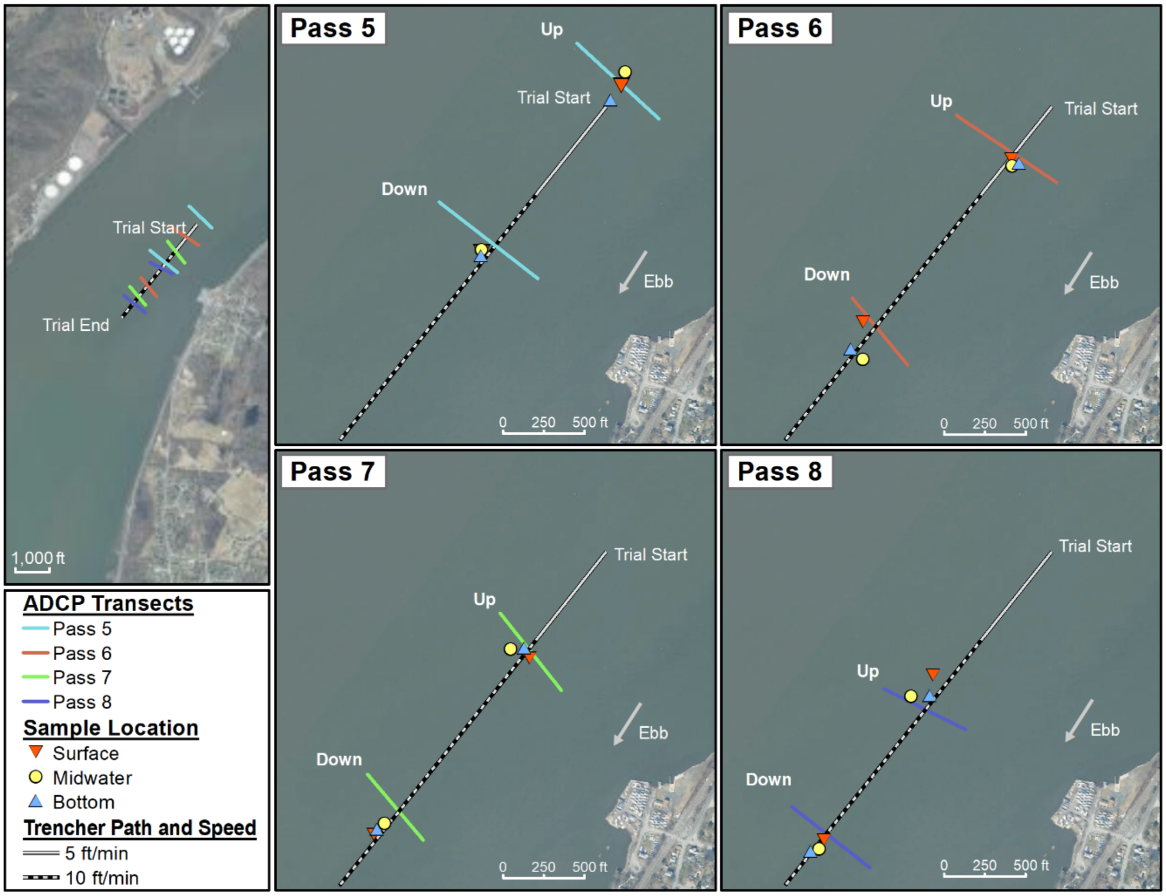

Figure 2-3. Summary of the sampling locations for Passes 5 through 8 before and during the pre-installation jetting trencher trial during 22-Dec-2023 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The trencher route for the trial is shown as white or dashed black line indicating the sections of the trial route that the jetting trencher was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.

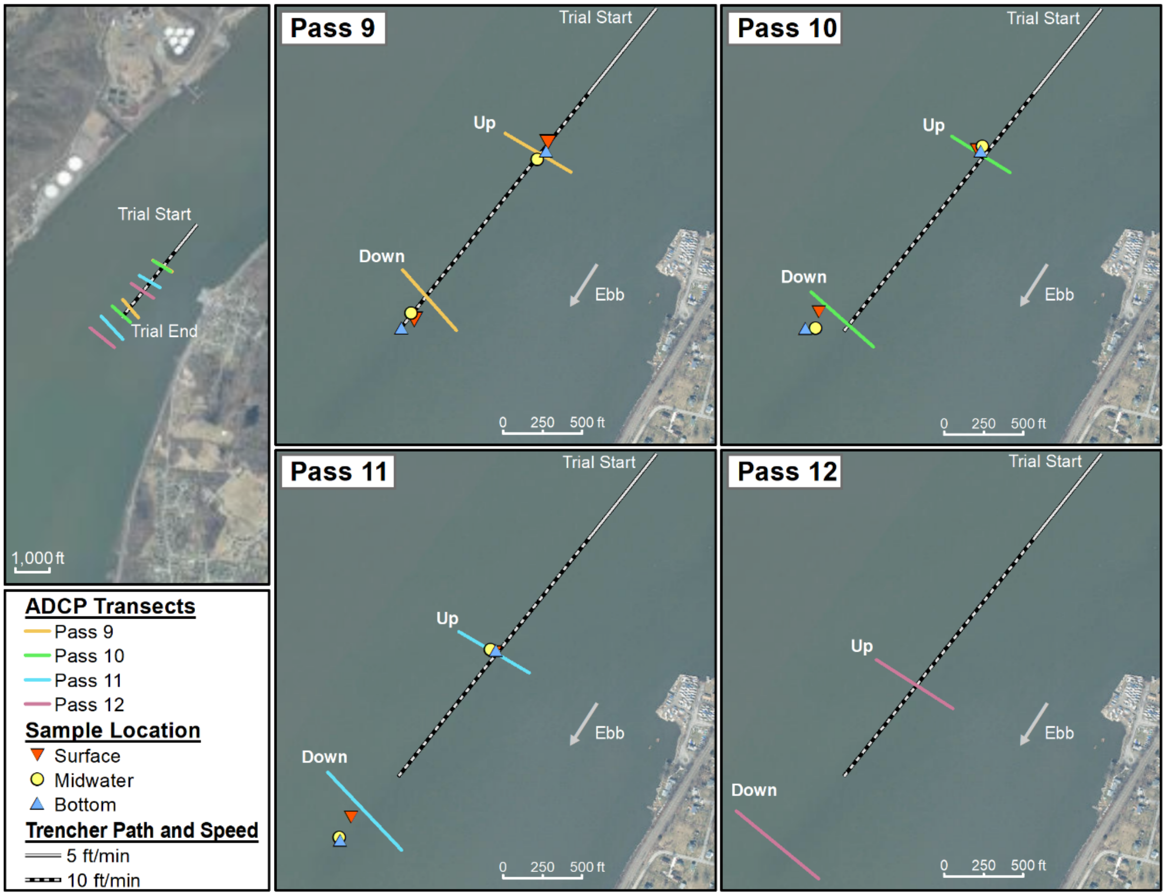

Figure 2-4. Summary of the sampling locations for Passes 9 through 12 before and during the pre-installation jetting trencher trial during 22-Dec-2023 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The trencher route for the trial is shown as white or dashed black line indicating the sections of the trial route that the jetting trencher was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.

2.1.3 Water Sample Handling for TSS and Chemical Analyses

After completion of the trial, the water samples (stored on ice in coolers) were processed onshore in preparation to be transferred to a courier for Alpha, per the specifications required by the lab. All sample jar labels were reviewed against the field notes to confirm sample locations and times, and this information was provided to Alpha in the Chain-of-Custody ("COC") forms. The water samples were packed with enough packing material to prevent movement during shipping, with care taken not to pack materials too tightly. Transfer of samples occurred via couriers provided by Alpha, and all samples were kept on ice in coolers during transport.

2.2 Analytical Methods

2.2.1 Water Quality and TSS

The CTD-OBS data were processed using a combination of the manufacturer's software (YSI) and Normandeau-developed post-processing routines in MATLAB® software (MathWorks; Natick, MA). Each CTD-OBS data file corresponded to a concurrent and co-located water sample, as described in Section 2.1, and was truncated to approximately 30 seconds coincidental to the water sample collection. For each measurement file, the parameters recorded at 2-Hz sampling intervals were averaged over the ~30-second water sampling interval to provide the concurrent CTD-OBS data (i.e., temperature [degrees Celsius, "°C"], depth [ft], salinity [Practical Salinity Units, "PSU"], turbidity/OBS [Nephelometric Turbidity Units, "NTU"]) with the TSS data from the water sample.

All water samples collected during the trials as part of the TSS monitoring were analyzed for TSS by Alpha utilizing the laboratory analysis of dry weight TSS following Standard Method ("SM") 2540D (APHA 2018). The CTD, OBS, and TSS data were then compiled into a data table in MATLAB® with paired up-current and down-current data for each TSS sampling event (i.e., Pass), to assess whether there were observable differences in TSS levels down-current of the trencher operation during the pre-installation trials. Additionally, the OBS data were compiled with the paired TSS data to develop a calibration relationship, if one existed, between OBS measured in the field and the lab-analyzed TSS data, using the OBS (predictor) with the TSS concentration (response). Linear modeling tools in MATLAB® software ("fitlm" function) were used to assess the relationship between OBS and TSS, detailed below in Sections 2.2.3 and 3.2.1.

The water chemistry data were also compiled separately into a data table in MATLAB® with paired up-current (i.e., for background) and down-current (i.e., for potential sediment plume) data for each chemistry sampling event, to assess whether there were any levels that exceeded the standards defined in the WQC (Table 1-1).

2.2.2 ADCP Data

2.2.2.1 <u>Relative Acoustic Backscatter</u>

The ABS was processed from the stationary ADCP profile measurements recorded at each up/down-current station collected concurrently with the CTD-OBS and water samples described above. The raw ADCP data were processed using a combination of manufacturer's software (TRDI) and Normandeau-developed post-processing routines in MATLAB® software. All raw ADCP data were first reviewed in the manufacturer's software which included checks on all acoustic parameters provided by the ADCP, verification of sampling configuration (e.g., compass and transducer depth offsets), and confirmation of the start and end times for each transect. During preliminary review, the raw ADCP data were pre-processed in WinRiver II using the quality control ("QC") parameters set based on the configuration settings in the field and each data file was examined for potential interference, bottom detection signal issues, and/or impacts from vessel wakes or sea state conditions (Mueller et al. 2013; Engel and Jackson 2017). The pre-processed data were then exported from WinRiver II as ASCII text files and imported into MATLAB for additional post-processing.

The ABS data were collected and post-processed to attempt to calibrate the ABS to the lab-analyzed TSS from the concurrent water samples to develop a predictive relationship for estimating TSS in the field (*in situ*), following an established approach from numerous studies. The raw echo signal intensity is measured by the ADCP, which is proportional to the concentration of particles (i.e., suspended sediment, plankton, detritus), but to properly calibrate the ABS to TSS, it requires accounting for the losses due to acoustic beam spreading and acoustic absorption by water. A full derivation of the calculation of ABS is excluded here but is well-documented in recent literature (Deines 1999; Gartner 2004; Wall et al 2006; Gostiaux and van Haren 2010; Wood and Gartner 2010; Mullison 2017). The approach relies on a simplified version of the sonar equation to determine the ABS (in dB) for each ADCP bin per ping shown below:

$$ABS = 10Log_{10}\left[\left(\frac{\sum_{i=i}^{4}\left(10^{K_{ci}(E_i - E_{ri})/10}\right)}{4}\right) - 1\right] + 20Log_{10}(R\gamma) + 2\alpha_w R \qquad \text{(Equation 1)}$$

where K_{ci} = beam-specific ADCP conversion factor from echo intensity counts to decibel (dB),
E_i = raw echo intensity, in counts, for each beam *i*,
E_{ri} = raw echo intensity noise floor, in counts, for each beam *i*,
R = range along the acoustic beams, in meters,
γ = near field correction factor for non-spherical spreading of energy close to the ADCP transducers (dimensionless), and
α_w = acoustic attenuation coefficient due to sound absorption by water, in dB/m.

After determining the ABS for each depth bin per ping, the ABS data were paired with the CTD-OBS and water sample data by first truncating the time series to the same ~30-second timeframe as deployed and recorded by the CTD-OBS for the field measurements, averaging the ABS for each depth bin over that truncated timeframe, and identifying the ADCP bin most closely aligned with the average depth of CTD-OBS (and TSS sample) data for each sample duration.

The ABS-to-TSS calibration approach then consists of performing a linear regression model of the paired ABS-TSS measurements collected concurrently before, during, and after the trial, with the ABS as the predictor variable and with $\log_{10}$-transformed TSS concentrations as the response variable. Linear modeling tools in MATLAB® software were used to assess the relationship between ABS and $\log_{10}$(TSS), as described in Sections 2.2.3 and 3.2.2.

2.2.2.2 <u>Current Velocity</u>

Current velocity data were primarily collected to assess the up/down-current classification of the samples collected during the TSS monitoring events. The ADCP velocity data were processed as described above and reviewed to verify the up/down-current classifications of the samples made in the field.

Current velocity measurements were reviewed in the Velocity Mapping Toolbox ("VMT") within MATLAB® software (developed by U.S. Geological Survey ["USGS"]; Engel and Jackson 2017). ADCP transect data were processed with VMT to produce transect-mean cross section current velocities and any measurements that exceeded QC parameter thresholds for the transects were excluded from the review from each file (Mueller et al. 2013; Engel and Jackson 2017). These spurious points were typically end-of-profile data, low signal-to-noise ratio of the velocities due to little-to-no current flow, bubbles near the transducer faces, and any raw data identified in the data acquisition software as below thresholds or potential fish echoes or interference from debris in the water column. For the purposes of data visualization, the transects' current velocity measurement data were averaged into ensembles of 5 acoustic pings to better represent the tidal flow characteristics during the trial measurements. This was applied to the data to reduce random errors from measurement noise and high-frequency variability to better resolve the velocity features at the Project site, while maintaining a relatively high sampling interval (Parsons et al. 2013; Matte et al. 2014; Engel and Jackson 2017).

2.2.3 Remote Sensing Calibrations to TSS

Linear modeling tools in MATLAB® software ("fitlm" function) were used to assess the relationship between both remote sensing parameters (OBS and ABS [predictors]) and TSS (response). TSS, OBS, and ABS data were initially assessed for statistical outliers by several outlier influence metrics, including but not limited to, three times the scaled median absolute deviation ("MAD") via the "rmoutlier" function in MATLAB®, and review of several linear model diagnostics and residuals (e.g., Cook's distance, delete-1 scaled change in fitted values ["DFFITS"], and raw, standard, and studentized residuals). A linear fit of the log-log relationship (i.e., $\log_{10}$[TSS]-$\log_{10}$[OBS]) was also used to assess whether the model and calibration were improved (Rasmussen et al. 2009).

3 Results

This section presents the results of the TSS and water chemistry monitoring during the Hudson River pre-installation trial during December 22, 2023, and development of calibration relationships (if any) between the remote sensing data (i.e., OBS and ABS) and TSS.

3.1 AssoTrencher V Mk3 Trial

Table 3-1 and Table 3-2 and Figure 2-2, Figure 2-3, Figure 2-4 summarize the field sampling activities completed for the Hudson River trencher trial. The results from these monitoring efforts are presented below.

3.1.1 TSS Monitoring

The pre-installation jetting trencher trial at the Hudson River site occurred on December 22, 2023 during 0900-1717 EST. Conditions during the trial were fair with partly cloudy skies and light/variable northeast winds at 0-5 knots. A pre-trial ambient condition CTD-OBS profile was collected at 0822 (Figure 3-1), approximately one hour prior to the trencher operation. The temperature profile showed a mostly mixed water column with temperature ranging from ~3.5-4.5 °C (colder temperatures in the upper part of the water column due to the cold air temperatures in the preceding days and morning of the trial [~19°F air temperature]. The salinity profile was well-mixed (freshwater at 0.1PSU) and turbidity profile was somewhat elevated ranging from 80-100 NTU. Two ADCP transects were performed before the trial started to assess the ambient current velocity and indicated that river current was flooding prior to the start of the trial, flowing northeast. Pre-trial TSS samples were collected during Pass 1, and then the monitoring crews waited for the trencher trial to begin before collecting additional sampling. Plots of data from all ADCP transects collected during the Hudson River trials are included in Appendix A. Representative pairs of the up-/down-current ADCP transects are shown in Figure 3-2 (for flood currents) and Figure 3-3 (for ebb currents) for reference and perspective on the conditions.

While the jetting trencher was operating during the trial, a total of 10 Passes were completed, which consisted of TSS monitoring at the up- and down-current side of the trencher, resulting in 60 total CTD-OBS-TSS samples and 40 ADCP transects during trencher operation (Table 3-1). A summary of all sample measurements collected during the trial is presented in Table 3-3. To assess whether the trencher operations increased TSS levels in the water column, the change in TSS ("delta-TSS") over "background" was calculated as the difference in TSS level measured down-current from the trencher (down-current of potential sediment plume) compared to the up-current station (control) at the same depth layer. Table 3-4 presents the results of those calculations. In addition to near-surface, mid-depth, and near-bottom delta-TSS, a depth-averaged calculation was also performed for each Pass, presented in Table 3-4. The highest TSS measurement from water samples collected during the Hudson River trial was 190 mg/L, in the near-bottom layer from Pass 8 during the trial. This sample represented an increase of 20 mg/L delta-TSS compared to the up-current samples from the same Pass and depth. The highest observed increase in TSS (i.e., delta-TSS) during the trial was 23 mg/L, from 87 mg/L to 110 mg/L, observed in the mid-depth depth layer during Pass 7. This observed increase in TSS was well below the exceedance threshold of 200 mg/L delta-TSS defined in the WQC and the Monitoring Plan.

In addition to the samples collected during the trial, 36 co-located TSS, OBS, and ABS samples were collected three days before the trial during mobilization on the afternoon of December 19, 2023, 6 samples were collected approximately one hour before the trial began and 6 samples were collected within 0.5 hours of the end of the trial. In total, 108 water samples for TSS analysis were collected at the Hudson River trencher trial site, and paired with co-located OBS and ABS data, presented in Table 3-5. The additional samples from before and after the trial were included in the remote sensing calibration analyses, detailed below in Section 3.2. Overall, only three of the samples exhibited an increase in TSS over background TSS (for the same depth layer) greater than 10 mg/L.

3.1.2 Water Chemistry Monitoring

Table 3-2 presents a summary of the field sampling for the water chemistry monitoring activities conducted for the Hudson River jetting trencher trial. Water chemistry sampling events were conducted for each planned trencher speed during the trials. The trial route was planned to be conducted in three segments of different trencher speeds: 5 ft/min over the first and last 660 ft of the route and at 10 ft/min over the middle 1,320 ft (1/4 mile); however, due to limited daylight and logistical concerns with transfer of samples to the laboratory courier, the final 660 ft of the route was also travelled at 10 ft/min, but chemistry samples were still collected for the final 660 ft segment of the route. Samples were coincidental with TSS monitoring Passes 2, 7, and 11 (Figure 2-2, Figure 2-3, and Figure 2-4). Samples were collected as described in Section 2.1.2, and water chemistry results from the laboratory analyses are presented in Table 3-6. Total polychlorinated biphenyls (“PCBs”), dissolved lead, and dissolved and total cadmium were all below the laboratory’s method detection limits (“BDL”) for the respective analyses. All chemical parameters assessed for the water chemistry monitoring were substantially below the standards identified by the WQC and Monitoring Plan (Table 1-1).

Table 3-1. Achieved sampling design of TSS Monitoring during the monitoring effort for the CHPE Hudson River Pre-Installation Trial, including periods before and after the trial, on December 19 and 22, 2023.

Date	Survey Type[1]	Pass Number[2]	Location[3]	Sample Time[4] (EST) Start	End	N Depth Layers	Total Samples	Tide Stage
19-Dec-2023	Pre-trial (Ambient)	1	Up	1126	1136	3	3	Ebb
			Down	1155	1203	3	3	
		2	Up	1248	1255	3	3	Ebb
			Down	1310	1316	3	3	
		3	Up	1339	1345	3	3	Ebb
			Down	1400	1405	3	3	
		4	Up	1421	1426	3	3	Ebb[6]
			Down	1443	1449	3	3	
		5	Up	1508	1513	3	3	Ebb[6]
			Down	1530	1536	3	3	
		6	Up	1554	1559	3	3	Ebb[6]
			Down	1617	1622	3	3	
9-Sep-2022	Pre-trial (Ambient)	1	Down	0823	0828	3	3	Flood
			Up	0838	0843	3	3	
	Trial[5]	2	Down	0912	0917	3	3	Flood
			Up	0932	0936	3	3	
		3	Down	0950	0956	3	3	End of Flood
			Up	1008	1013	3	3	
		4	Up	1025	1029	3	3	Ebb
			Down	1042	1047	3	3	
		5	Up	1103	1108	3	3	Ebb
			Down	1120	1125	3	3	
		6	Up	1152	1157	3	3	Ebb
			Down	1210	1215	3	3	
		7	Up	1234	1239	3	3	Ebb
			Down	1248	1254	3	3	
		8	Up	1310	1317	3	3	Ebb
			Down	1327	1333	3	3	
		9[7]	Up	1453	1458	3	3	Ebb
			Down	1543	1547	3	3	
		10	Up	1558	1602	3	3	Ebb
			Down	1614	1619	3	3	
		11	Up	1635	1639	3	3	Ebb
			Down	1652	1656	3	3	
	Post-trial (Ambient)	12	Up	1707	1711	3	3	End of Ebb
			Down[8]	1723	1727	3	3	

[1]Pre-Trial and Post-Trial "ambient" conditions were assessed primarily to acquire additional data that may support the remote sensing calibrations to TSS.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Location refers to the sampling position Up/Down-current of the trencher.

[4]Sample times presented are the CTD-OBS and TSS water sample times. The time performing the ADCP transects for each Pass and Location are not included in this table, but typically took between 4-8 minutes prior to the sample start of each Pass in the table.

[5]Notification from ASSO during the trial indicated that the trencher started at 0900 and ended at 1717.

[6]The current was ebbing for Passes 4-6 during the Pre-Trial Survey on 19-Dec-2023 when tidal currents were predicted to be flooding at the site. Due to heavy rain and flooding the day before, flood currents did not occur during this survey due to freshwater runoff.

[7]During Pass 9, the trencher and barge paused for anchor relocation following the Up station samples.

[8]The Down-current samples collected following the trencher trial were collected south of the southern end of the route.

Table 3-2. Achieved sampling design of water chemistry sample collection during the monitoring effort for the CHPE Hudson River Pre-Installation Trial, on December 22, 2023.

Date	Survey Type	Chemistry Event Number[1]	Event Description	TSS Pass Number[2]	Location[3]	Sample Time[4] (EDT)		N Depth Layers	N Total Samples
						Start	End		
22-Dec-2023	Trial	1	Start trial, trencher speed 5 ft/min.	2	Down	0925	0935	3	3
					Up	0943	0952	3	3
		2	Trencher speed increased to 10 ft/min.	7	Up	1245	1255	3	3
					Down	1303	1310	3	3
		3	Trencher ramped back up 10 ft/ min.	11	Up	1645	1651	3	3
					Down	1702	1708	3	3

[1]Event number is sequential count for the paired Up/Down-current sampling positions for each sampling event (planned trencher speed).
[2]TSS Pass is the co-located sampling event for the TSS (and CTD-OBS-ABS) monitoring.
[3]Location refers to the sampling position Up/Down-current of the trencher.
[4]Sample times presented are the water sample times from start of surface sample until the end of the bottom sample collection.

Table 3-3. Hudson River sampling results for TSS monitoring events conducted up-current and down-current of the operating jetting trencher during the trial on December 22, 2023 for lab-analyzed total suspended solids ("TSS"), optical backscatter ("OBS"), and acoustic backscatter ("ABS").

		TSS (mg/L)			OBS (NTU)			ABS (dB)		
Pass	Location	Surface	Midwater	Bottom	Surface	Midwater	Bottom	Surface	Midwater	Bottom
Pass 2	Up	83.0	91.0	92.0	85.3	87.1	87.7	60.0	63.0	65.0
	Down	81.0	100.0	96.0	82.0	85.0	88.0	59.3	64.9	65.2
Pass 3	Up	81.0	84.0	92.0	78.9	83.6	91.2	57.5	59.9	62.9
	Down	83.0	83.0	94.0	83.5	85.0	87.3	60.0	61.8	63.2
Pass 4	Up	78.0	86.0	90.0	86.2	82.7	85.5	57.3	61.3	62.6
	Down	80.0	80.0	87.0	92.8	83.4	84.7	56.9	60.0	61.7
Pass 5	Up	84.0	86.0	93.0	87.6	84.7	84.2	57.2	60.5	62.1
	Down	80.0	81.0	94.0	81.5	83.3	95.7	74.2	58.9	60.9
Pass 6	Up	78.0	86.0	120.0	82.1	86.4	103.6	57.8	64.6	64.8
	Down	78.0	85.0	110.0	80.4	86.7	104.3	58.4	61.5	65.7
Pass 7	Up	77.0	87.0	170.0	95.8	85.2	122.5	54.3	63.5	68.8
	Down	83.0	110.0	170.0	99.3	109.9	111.3	66.4	68.3	70.3
Pass 8	Up	86.0	100.0	170.0	83.9	87.5	109.8	60.2	66.0	70.4
	Down	91.0	100.0	190.0	83.3	90.2	124.7	65.0	65.8	69.5
Pass 9	Up	110.0	120.0	180.0	95.2	105.1	132.5	61.4	70.2	72.6
	Down	100.0	120.0	160.0	97.2	100.7	121.2	64.9	67.1	71.3
Pass 10	Up	110.0	110.0	180.0	99.3	100.9	126.9	60.5	66.2	72.1
	Down	110.0	130.0	150.0	92.9	106.9	118.8	59.4	67.8	70.8
Pass 11	Up	110.0	110.0	140.0	99.2	100.0	113.8	76.5	67.0	70.1
	Down	100.0	120.0	140.0	99.0	101.2	115.1	57.6	66.0	68.7
Mean	Up	83.0	91.0	92.0	85.3	87.1	87.7	60.0	63.0	65.0
	Down	81.0	100.0	96.0	82.0	85.0	88.0	59.3	64.9	65.2

Table 3-4. Total suspended solids (TSS) measurements taken up-current and down-current of the operating jetting trencher for the Hudson River trial, with the change in TSS ("delta-TSS") relative to the up-current location for a given depth layer.

Pass	Layer	TSS (mg/L)		
		Down-current	Up-current	delta-TSS
2	Surface	81.0	83.0	-2.0
	Midwater	100.0	91.0	9.0
	Bottom	96.0	92.0	4.0
	Depth-Avg	92.3	88.7	3.7
3	Surface	83.0	81.0	2.0
	Midwater	83.0	84.0	-1.0
	Bottom	94.0	92.0	2.0
	Depth-Avg	86.7	85.7	1.0
4	Surface	80.0	78.0	2.0
	Midwater	80.0	86.0	-6.0
	Bottom	87.0	90.0	-3.0
	Depth-Avg	82.3	84.7	-2.3
5	Surface	80.0	84.0	-4.0
	Midwater	81.0	86.0	-5.0
	Bottom	94.0	93.0	1.0
	Depth-Avg	85.0	87.7	-2.7
6	Surface	78.0	78.0	0.0
	Midwater	85.0	86.0	-1.0
	Bottom	110.0	120.0	-10.0
	Depth-Avg	91.0	94.7	-3.7
7	Surface	83.0	77.0	6.0
	Midwater	110.0	87.0	23.0
	Bottom	170.0	170.0	0.0
	Depth-Avg	121.0	111.3	9.7
8	Surface	91.0	86.0	5.0
	Midwater	100.0	100.0	0.0
	Bottom	190.0	170.0	20.0
	Depth-Avg	127.0	118.7	8.3
9	Surface	100.0	110.0	-10.0
	Midwater	120.0	120.0	0.0
	Bottom	160.0	180.0	-20.0
	Depth-Avg	126.7	136.7	-10.0
10	Surface	110.0	110.0	0.0
	Midwater	130.0	110.0	20.0
	Bottom	150.0	180.0	-30.0
	Depth-Avg	130.0	133.3	-3.3
11	Surface	100.0	110.0	-10.0
	Midwater	120.0	110.0	10.0
	Bottom	140.0	140.0	0.0
	Depth-Avg	120.0	120.0	0.0
Mean	Surface	88.6	89.7	-1.1
	Midwater	100.9	96.0	4.9
	Bottom	129.1	132.7	-3.6
	Depth-Avg	106.2	106.1	0.1

Table 3-5. Hudson River sampling results for TSS monitoring events conducted up-current and down-current of the operating jetting trencher during the trial for lab-analyzed total suspended solids ("TSS"), optical backscatter ("OBS"), and acoustic backscatter ("ABS"). All data below were used in the regression analysis for developing relationships to attempt to calibrate OBS and ABS for estimating TSS.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
12/19/2023	11:26:43	41.56043	-73.96917	Pre-trial (ambient)	UP	1	SUR	6.8	32.47	41.0	65.2
12/19/2023	11:30:47	41.56009	-73.96956	Pre-trial (ambient)	UP	1	MID	25.8	42.14	50.0	69.3
12/19/2023	11:36:13	41.56016	-73.96888	Pre-trial (ambient)	UP	1	BOT	40.9	63.93	110.0	74.7
12/19/2023	11:55:28	41.55328	-73.97699	Pre-trial (ambient)	DOWN	1	SUR	7.5	33.48	43.0	64.9
12/19/2023	11:58:30	41.55281	-73.97725	Pre-trial (ambient)	DOWN	1	MID	27.8	52.28	80.0	71.3
12/19/2023	12:02:59	41.55334	-73.97693	Pre-trial (ambient)	DOWN	1	BOT	41.8	61.19	100.0	74.1
12/19/2023	12:48:30	41.56373	-73.96446	Pre-trial (ambient)	UP	2	SUR	6.7	31.39	35.0	67.8
12/19/2023	12:51:36	41.56349	-73.96478	Pre-trial (ambient)	UP	2	MID	26.6	39.54	49.0	70.5
12/19/2023	12:55:35	41.56328	-73.96527	Pre-trial (ambient)	UP	2	BOT	42.3	58.91	78.0	73.3
12/19/2023	13:10:48	41.55536	-73.97444	Pre-trial (ambient)	DOWN	2	SUR	8.0	32.52	39.0	69.5
12/19/2023	13:13:00	41.55491	-73.97463	Pre-trial (ambient)	DOWN	2	MID	27.9	35.50	45.0	68.7
12/19/2023	13:16:25	41.55479	-73.97493	Pre-trial (ambient)	DOWN	2	BOT	43.1	59.56	90.0	73.6
12/19/2023	13:39:35	41.56207	-73.96740	Pre-trial (ambient)	UP	3	SUR	8.0	30.86	34.0	63.6
12/19/2023	13:42:13	41.56168	-73.96746	Pre-trial (ambient)	UP	3	MID	28.7	36.01	50.0	68.2
12/19/2023	13:45:09	41.56180	-73.96775	Pre-trial (ambient)	UP	3	BOT	43.3	40.17	59.0	71.1
12/19/2023	14:00:23	41.55501	-73.97456	Pre-trial (ambient)	DOWN	3	SUR	8.2	36.92	38.0	65.3
12/19/2023	14:02:38	41.55469	-73.97477	Pre-trial (ambient)	DOWN	3	MID	26.7	33.72	37.0	66.6
12/19/2023	14:05:23	41.55487	-73.97500	Pre-trial (ambient)	DOWN	3	BOT	45.3	45.95	66.0	70.5
12/19/2023	14:20:57	41.56127	-73.96788	Pre-trial (ambient)	UP	4	SUR	7.1	26.70	29.0	60.2
12/19/2023	14:23:35	41.56152	-73.96819	Pre-trial (ambient)	UP	4	MID	27.8	32.82	39.0	68.5
12/19/2023	14:26:17	41.56113	-73.96833	Pre-trial (ambient)	UP	4	BOT	47.9	38.21	51.0	69.4
12/19/2023	14:43:28	41.55325	-73.97635	Pre-trial (ambient)	DOWN	4	SUR	7.8	27.72	32.0	61.9
12/19/2023	14:46:05	41.55327	-73.97666	Pre-trial (ambient)	DOWN	4	MID	26.9	29.68	35.0	64.9
12/19/2023	14:48:58	41.55300	-73.97688	Pre-trial (ambient)	DOWN	4	BOT	43.9	32.55	40.0	68.0
12/19/2023	15:07:56	41.56117	-73.96832	Pre-trial (ambient)	UP	5	SUR	7.3	27.91	30.0	62.7
12/19/2023	15:10:18	41.56114	-73.96860	Pre-trial (ambient)	UP	5	MID	28.4	30.73	35.0	66.7
12/19/2023	15:13:16	41.56129	-73.96856	Pre-trial (ambient)	UP	5	BOT	44.4	29.54	36.0	66.2
12/19/2023	15:30:48	41.55331	-73.97572	Pre-trial (ambient)	DOWN	5	SUR	7.1	27.12	33.0	60.2
12/19/2023	15:32:48	41.55306	-73.97574	Pre-trial (ambient)	DOWN	5	MID	28.9	28.15	32.0	62.7
12/19/2023	15:36:14	41.55278	-73.97607	Pre-trial (ambient)	DOWN	5	BOT	44.7	28.79	34.0	62.1
12/19/2023	15:54:42	41.56145	-73.96850	Pre-trial (ambient)	UP	6	SUR	8.0	27.75	32.0	72.3
12/19/2023	15:56:56	41.56127	-73.96860	Pre-trial (ambient)	UP	6	MID	28.1	27.66	33.0	63.0
12/19/2023	15:59:45	41.56111	-73.96841	Pre-trial (ambient)	UP	6	BOT	46.0	27.82	34.0	62.6
12/19/2023	16:17:14	41.55294	-73.97669	Pre-trial (ambient)	DOWN	6	SUR	7.7	24.02	28.0	59.8
12/19/2023	16:19:35	41.55272	-73.97683	Pre-trial (ambient)	DOWN	6	MID	28.6	24.38	27.0	71.4
12/19/2023	16:22:30	41.55229	-73.97691	Pre-trial (ambient)	DOWN	6	BOT	46.0	25.91	30.0	61.8
12/22/2023	8:23:18	41.56081	-73.96844	Pre-trial (ambient)	DOWN	1	SUR	7.5	91.33	82.0	59.4
12/22/2023	8:25:29	41.56084	-73.96840	Pre-trial (ambient)	DOWN	1	MID	29.6	90.86	99.0	63.7
12/22/2023	8:28:13	41.56073	-73.96844	Pre-trial (ambient)	DOWN	1	BOT	44.4	95.62	110.0	67.7
12/22/2023	8:38:15	41.55776	-73.97174	Pre-trial (ambient)	UP	1	SUR	7.6	84.62	86.0	60.0
12/22/2023	8:40:38	41.55763	-73.97181	Pre-trial (ambient)	UP	1	MID	26.4	89.60	94.0	64.5
12/22/2023	8:43:13	41.55787	-73.97165	Pre-trial (ambient)	UP	1	BOT	46.6	95.12	110.0	68.1

[1]For 12/19/2023, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents. For 12/22/2023, Location refers to the sampling position Up/Down-current of the trencher.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Depth Layer refers to sampled levels in the water column from near-surface ("SUR"), mid-depth ("MID"), and near-bottom ("BOT"), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

Table 3-5 continued.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
12/22/2023	9:12:50	41.56043	-73.96880	Trial	DOWN	2	SUR	7.4	82.01	81.0	59.3
12/22/2023	9:14:54	41.56026	-73.96882	Trial	DOWN	2	MID	29.4	85.01	100.0	64.9
12/22/2023	9:17:41	41.56028	-73.96889	Trial	DOWN	2	BOT	46.4	87.99	96.0	65.2
12/22/2023	9:32:26	41.55732	-73.97215	Trial	UP	2	SUR	7.5	85.32	83.0	60.0
12/22/2023	9:34:15	41.55722	-73.97222	Trial	UP	2	MID	28.2	87.05	91.0	63.0
12/22/2023	9:36:26	41.55707	-73.97227	Trial	UP	2	BOT	46.0	87.72	92.0	65.0
12/22/2023	9:50:50	41.55949	-73.96929	Trial	DOWN	3	SUR	8.1	83.49	83.0	60.0
12/22/2023	9:52:59	41.55933	-73.96952	Trial	DOWN	3	MID	27.9	85.01	83.0	61.8
12/22/2023	9:55:58	41.55952	-73.96955	Trial	DOWN	3	BOT	46.7	87.29	94.0	63.2
12/22/2023	10:08:26	41.55707	-73.97268	Trial	UP	3	SUR	7.9	78.87	81.0	57.5
12/22/2023	10:10:13	41.55682	-73.97297	Trial	UP	3	MID	26.0	83.60	84.0	59.9
12/22/2023	10:13:04	41.55694	-73.97257	Trial	UP	3	BOT	45.3	91.19	92.0	62.9
12/22/2023	10:24:55	41.55969	-73.96955	Trial	UP	4	SUR	7.4	86.18	78.0	57.3
12/22/2023	10:26:59	41.55959	-73.96951	Trial	UP	4	MID	26.1	82.73	86.0	61.3
12/22/2023	10:29:39	41.55964	-73.96942	Trial	UP	4	BOT	45.2	85.49	90.0	62.6
12/22/2023	10:42:46	41.55707	-73.97262	Trial	DOWN	4	SUR	8.1	92.75	80.0	56.9
12/22/2023	10:45:12	41.55681	-73.97278	Trial	DOWN	4	MID	27.2	83.40	80.0	60.0
12/22/2023	10:47:43	41.55672	-73.97280	Trial	DOWN	4	BOT	46.0	84.74	87.0	61.7
12/22/2023	11:02:56	41.55935	-73.97003	Trial	UP	5	SUR	7.9	87.64	84.0	57.2
12/22/2023	11:05:30	41.55958	-73.96994	Trial	UP	5	MID	25.5	84.68	86.0	60.5
12/22/2023	11:08:41	41.55911	-73.97028	Trial	UP	5	BOT	44.0	84.21	93.0	62.1
12/22/2023	11:20:04	41.55656	-73.97319	Trial	DOWN	5	SUR	8.0	81.49	80.0	74.2
12/22/2023	11:22:34	41.55660	-73.97319	Trial	DOWN	5	MID	25.1	83.33	81.0	58.9
12/22/2023	11:24:59	41.55650	-73.97320	Trial	DOWN	5	BOT	43.5	95.71	94.0	60.9
12/22/2023	11:52:19	41.55812	-73.97128	Trial	UP	6	SUR	7.3	82.06	78.0	57.8
12/22/2023	11:54:27	41.55801	-73.97127	Trial	UP	6	MID	25.3	86.43	86.0	64.6
12/22/2023	11:57:43	41.55805	-73.97112	Trial	UP	6	BOT	46.5	103.58	120.0	64.8
12/22/2023	12:09:59	41.55538	-73.97463	Trial	DOWN	6	SUR	7.9	80.37	78.0	58.4
12/22/2023	12:12:25	41.55476	-73.97465	Trial	DOWN	6	MID	26.3	86.72	85.0	61.5
12/22/2023	12:15:50	41.55493	-73.97492	Trial	DOWN	6	BOT	44.3	104.32	110.0	65.7
12/22/2023	12:34:06	41.55722	-73.97211	Trial	UP	7	SUR	7.8	95.82	77.0	54.3
12/22/2023	12:36:40	41.55737	-73.97253	Trial	UP	7	MID	26.6	85.18	87.0	63.5
12/22/2023	12:39:30	41.55739	-73.97224	Trial	UP	7	BOT	44.3	122.50	170.0	68.8
12/22/2023	12:47:53	41.55426	-73.97562	Trial	DOWN	7	SUR	7.3	99.32	83.0	66.4
12/22/2023	12:50:43	41.55445	-73.97539	Trial	DOWN	7	MID	25.5	109.91	110.0	68.3
12/22/2023	12:54:00	41.55435	-73.97555	Trial	DOWN	7	BOT	44.3	111.32	170.0	70.3
12/22/2023	13:10:03	41.55694	-73.97305	Trial	UP	8	SUR	7.4	83.90	86.0	60.2
12/22/2023	13:13:01	41.55658	-73.97355	Trial	UP	8	MID	25.7	87.48	100.0	66.0
12/22/2023	13:17:13	41.55659	-73.97313	Trial	UP	8	BOT	43.2	109.80	170.0	70.4
12/22/2023	13:27:03	41.55417	-73.97552	Trial	DOWN	8	SUR	7.4	83.32	91.0	65.0
12/22/2023	13:29:56	41.55402	-73.97563	Trial	DOWN	8	MID	25.3	90.21	100.0	65.8
12/22/2023	13:33:05	41.55397	-73.97582	Trial	DOWN	8	BOT	43.4	124.67	190.0	69.5

[1]For 12/19/2023, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents. For 12/22/2023, Location refers to the sampling position Up/Down-current of the trencher.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Depth Layer refers to sampled levels in the water column from near-surface (“SUR”), mid-depth (“MID”), and near-bottom (“BOT”), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

Table 3-5 continued.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
12/22/2023	14:53:49	41.55669	-73.97290	Trial	UP	9	SUR	8.0	95.23	110.0	61.4
12/22/2023	14:56:01	41.55639	-73.97316	Trial	UP	9	MID	25.0	105.06	120.0	70.2
12/22/2023	14:58:51	41.55652	-73.97295	Trial	UP	9	BOT	43.6	132.52	180.0	72.6
12/22/2023	15:43:04	41.55361	-73.97602	Trial	DOWN	9	SUR	7.2	97.20	100.0	64.9
12/22/2023	15:45:31	41.55372	-73.97610	Trial	DOWN	9	MID	24.9	100.70	120.0	67.1
12/22/2023	15:47:48	41.55346	-73.97632	Trial	DOWN	9	BOT	43.1	121.21	160.0	71.3
12/22/2023	15:58:36	41.55656	-73.97327	Trial	UP	10	SUR	7.3	99.27	110.0	60.5
12/22/2023	16:00:21	41.55662	-73.97316	Trial	UP	10	MID	24.8	100.88	110.0	66.2
12/22/2023	16:02:46	41.55652	-73.97319	Trial	UP	10	BOT	43.4	126.93	180.0	72.1
12/22/2023	16:14:28	41.55375	-73.97697	Trial	DOWN	10	SUR	7.9	92.89	110.0	59.4
12/22/2023	16:16:37	41.55346	-73.97705	Trial	DOWN	10	MID	24.9	106.92	130.0	67.8
12/22/2023	16:19:02	41.55346	-73.97728	Trial	DOWN	10	BOT	41.5	118.75	150.0	70.8
12/22/2023	16:35:10	41.55557	-73.97414	Trial	UP	11	SUR	7.5	99.24	110.0	76.5
12/22/2023	16:37:07	41.55561	-73.97424	Trial	UP	11	MID	24.6	100.02	110.0	67.0
12/22/2023	16:39:17	41.55559	-73.97412	Trial	UP	11	BOT	43.1	113.79	140.0	70.1
12/22/2023	16:51:57	41.55270	-73.97750	Trial	DOWN	11	SUR	7.5	99.04	100.0	57.6
12/22/2023	16:54:00	41.55236	-73.97777	Trial	DOWN	11	MID	24.9	101.24	120.0	66.0
12/22/2023	16:56:04	41.55230	-73.97775	Trial	DOWN	11	BOT	43.1	115.07	140.0	68.7
12/22/2023	17:07:10	41.55486	-73.97479	Post-trial (ambient)	UP	12	SUR	7.6	98.23	110.0	64.3
12/22/2023	17:09:17	41.55491	-73.97492	Post-trial (ambient)	UP	12	MID	25.8	101.19	120.0	65.4
12/22/2023	17:11:17	41.55465	-73.97501	Post-trial (ambient)	UP	12	BOT	42.3	111.72	140.0	67.6
12/22/2023	17:23:18	41.55182	-73.97791	Post-trial (ambient)	DOWN	12	SUR	7.2	99.73	100.0	60.5
12/22/2023	17:24:57	41.55159	-73.97816	Post-trial (ambient)	DOWN	12	MID	26.2	101.04	110.0	63.8
12/22/2023	17:27:21	41.55157	-73.97830	Post-trial (ambient)	DOWN	12	BOT	42.6	121.96	140.0	65.8

[1]For 12/19/2023, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents. For 12/22/2023, Location refers to the sampling position Up/Down-current of the trencher.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Depth Layer refers to sampled levels in the water column from near-surface (“SUR”), mid-depth (“MID”), and near-bottom (“BOT”), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

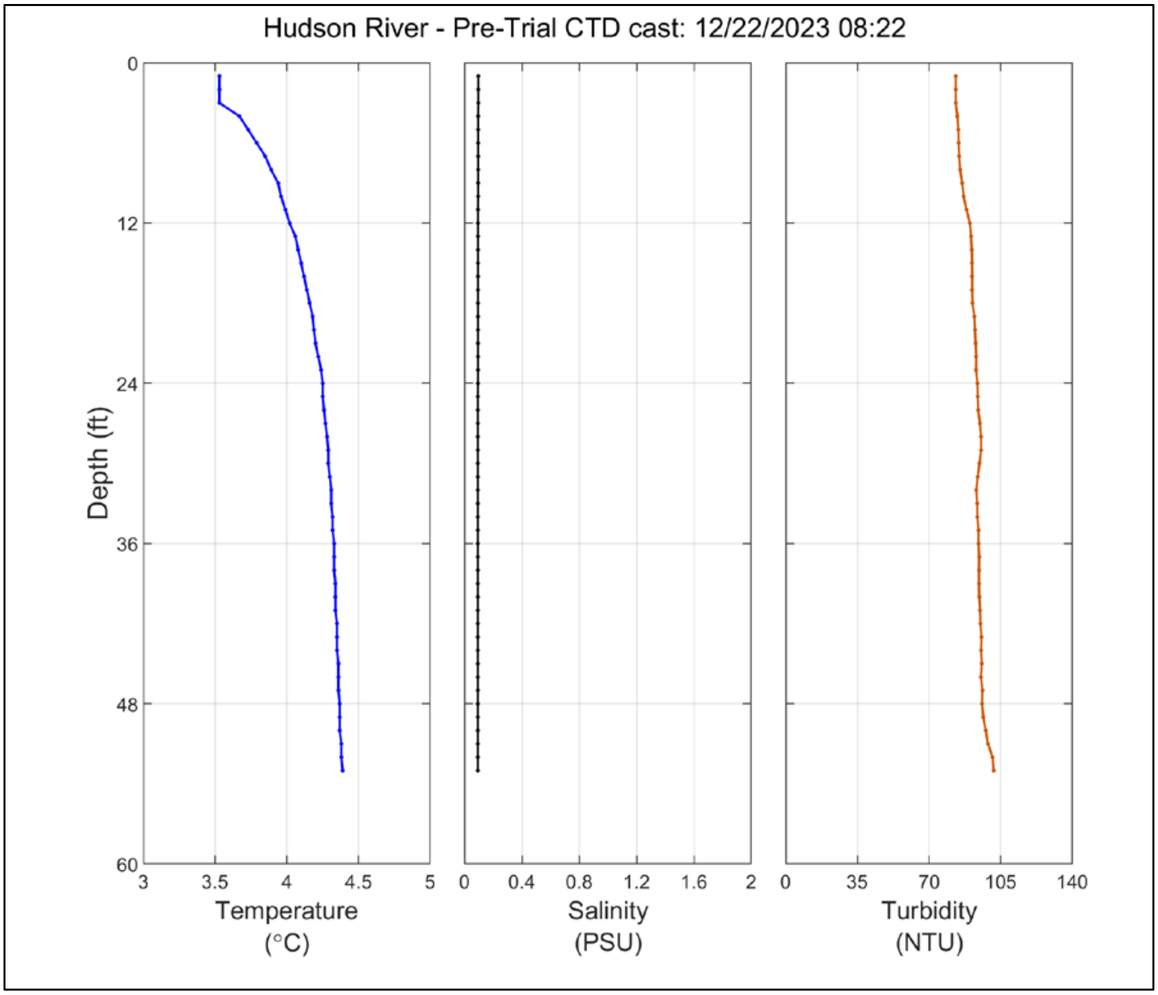

Figure 3-1. CTD-OBS profiles of temperature, salinity, and turbidity (OBS) from Hudson River site prior to of the trencher trial during flood tidal currents.

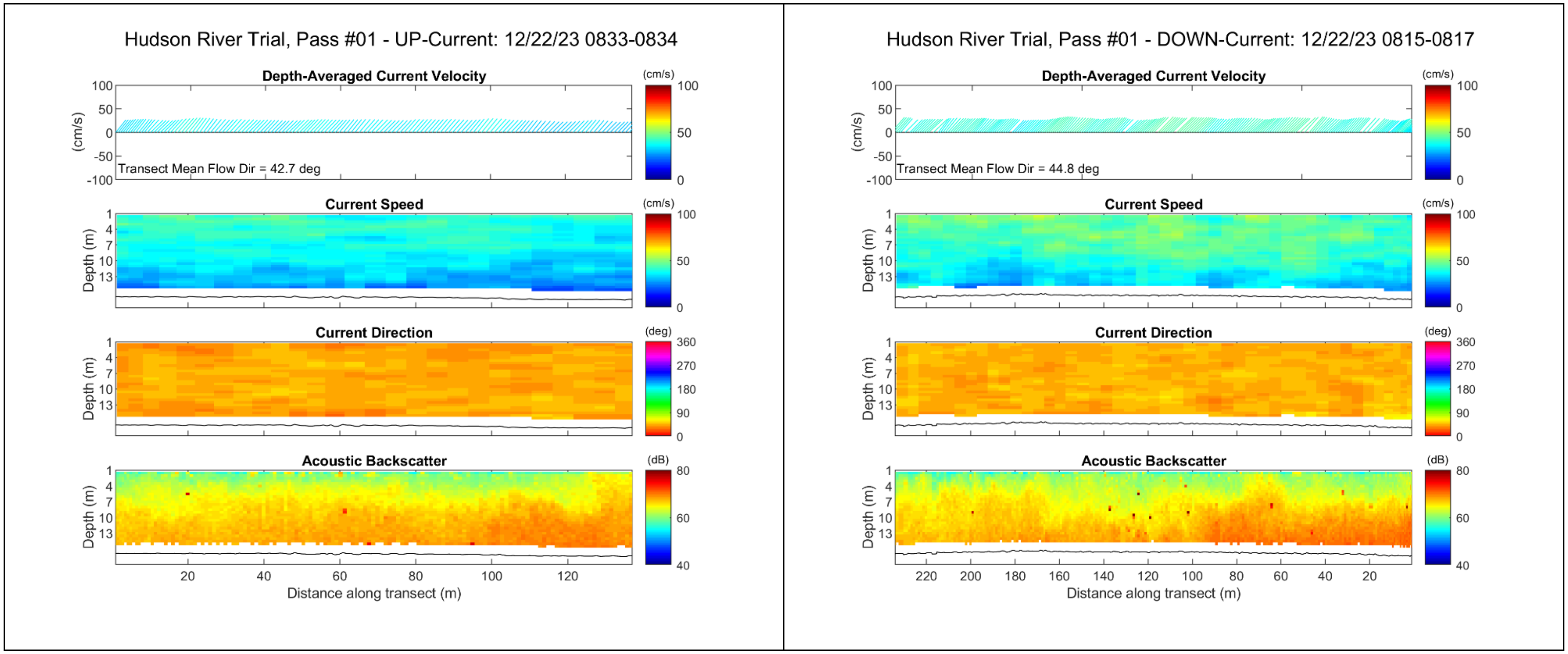

Figure 3-2. ADCP transect data from Pass 1 of the Hudson River trial TSS monitoring, during flood tidal current conditions: up-current (south side of the trencher) transect is shown on the left and the down-current transect (north) is shown on the right. The top panel in each is a current velocity vector stick plot, where the sticks point toward the direction of the depth-averaged current velocity and are colored relative to the current speed. The remaining three panels are cross-sectional contour plots of current speed, direction, and relative acoustic backscatter. The location of the Pass 1 ADCP transects is shown in Figure 2-2.

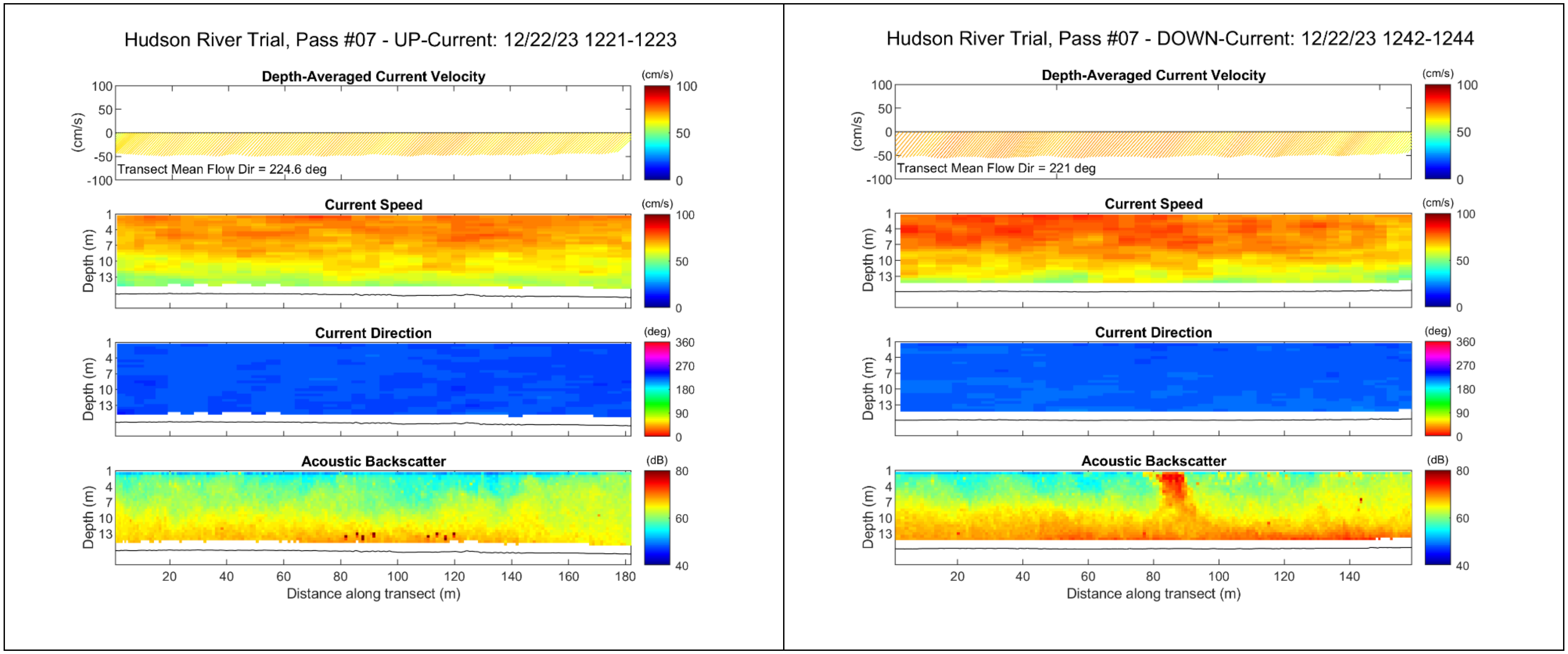

Figure 3-3. ADCP transect data from Pass 7 of the Hudson River trial TSS monitoring, during ebb tidal current conditions: up-current (north side of the trencher) transect is shown on the left and the down-current transect (south) is shown on the right. The top panel in each is a current velocity vector stick plot, where the sticks point toward the direction of the depth-averaged current velocity and are colored relative to the current speed. The remaining three panels are cross-sectional contour plots of current speed, direction, and relative acoustic backscatter. The location of the Pass 7 ADCP transects is shown in Figure 2-4.

Table 3-6. Hudson River monitoring results for water chemistry sampling events conducted up-current and down-current of the operating jetting trencher during the trial on December 22, 2023 for lab-analyzed chemical parameters presented in the table below and Table 1-1.

Depth Layer	Event Number	Location	TSS (mg/L)	Phenanthrene (ng/L)	PCBs (µg/L)	Mercury (µg/L)	Hardness (mg/L)		Copper (µg/L)		Lead (µg/L)		Cadmium (µg/L)	
							Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Surface	1	Up	83.0	4.71	BDL[a]	0.0118	66.7	76.4	1.773	5.214	BDL[b]	2.693	BDL[c]	BDL[c]
		Down	81.0	5.33	BDL	0.0127	64.8	74.5	1.631	4.924	0.3946	2.658	BDL	BDL
	2	Up	83.0	5.17	BDL	0.0134	63.0	77.0	1.239	4.551	BDL	2.699	BDL	BDL
		Down	78.0	4.91	BDL	0.0115	62.6	78.1	1.129	3.705	BDL	2.606	BDL	BDL
	3	Up	97.0	5.19	BDL	0.0163	67.0	78.8	1.710	4.389	0.5323	3.177	BDL	BDL
		Down	98.0	4.91	BDL	0.0137	68.2	79.3	1.639	4.675	0.4779	3.205	BDL	BDL
	Mean	Up	87.7	5.02	BDL	0.0138	65.6	77.4	1.574	4.718	0.2918[d]	2.856	BDL	BDL
		Down	85.7	5.05	BDL	0.0126	65.2	77.3	1.466	4.435	0.3480[d]	2.823	BDL	BDL
Midwater	1	Up	84.0	5.83	BDL	0.0132	68.5	75.6	1.441	4.290	BDL	2.708	BDL	BDL
		Down	91.0	4.57	BDL	0.0134	65.2	73.1	1.355	3.718	BDL	2.672	BDL	BDL
	2	Up	83.0	5.11	BDL	0.0055	68.4	74.9	1.237	3.854	BDL	2.649	BDL	BDL
		Down	98.0	4.32	BDL	0.0154	61.9	79.3	1.285	4.137	BDL	3.224	BDL	BDL
	3	Up	110.0	5.36	BDL	0.0168	67.1	77.4	1.852	4.919	0.6386	3.549	BDL	BDL
		Down	110.0	6.00	BDL	0.0176	67.4	80.2	1.322	4.513	BDL	3.467	BDL	BDL
	Mean	Up	92.3	5.43	BDL	0.0118	68.0	76.0	1.510	4.354	0.3272[d]	2.969	BDL	BDL
		Down	99.7	4.96	BDL	0.0155	64.8	77.5	1.321	4.123	BDL	3.121	BDL	BDL
Bottom	1	Up	93.0	5.60	BDL	0.0146	63.9	76.6	1.343	4.541	BDL	2.959	BDL	BDL
		Down	94.0	5.86	BDL	0.0146	65.1	74.5	1.493	4.120	BDL	2.885	BDL	BDL
	2	Up	130.0	5.31	BDL	0.0186	62.3	75.6	1.383	4.363	0.3742	3.928	BDL	0.0602
		Down	120.0	4.93	BDL	0.0204	62.8	80.4	1.265	4.956	BDL	4.008	BDL	BDL
	3	Up	130.0	6.32	BDL	0.0196	69.0	80.9	1.873	5.120	0.5527	3.844	BDL	BDL
		Down	150.0	6.10	BDL	0.0374	67.6	81.5	1.798	5.437	0.6789	5.190	BDL	BDL
	Mean	Up	117.7	5.74	BDL	0.0176	65.1	77.7	1.533	4.675	0.3661[d]	3.577	BDL	0.0400[d]
		Down	121.3	5.63	BDL	0.0241	65.2	78.8	1.519	4.838	0.3406[d]	4.028	BDL	BDL

[a] Below the Method Detection Limit ("BDL") for PCBs, Total = 0.007 µg/L
[b] Below the Method Detection Limit ("BDL") for Lead, Dissolved = 0.3430 µg/L
[c] Below the Method Detection Limit ("BDL") for Cadmium, Dissolved and Cadmium, Total = 0.0599 µg/L
[d] Mean was calculated using Method Detection Limit (MDL)/2 in place of BDL for cases having one or two measurements >MDL.

3.2 Remote Sensing Calibrations to TSS

The secondary objective of the TSS monitoring activities during the pre-installation trencher trials was to use the sample data collected to investigate the development of calibrations describing quantitative relationships (if any) between the remote sensing data and the laboratory measured TSS, to potentially use OBS and/or ABS as remote sensing methods for near real-time TSS estimates during monitoring of the submarine cable installation. All sample data collected on December 19 and 22, before the trial, during trencher operations, and after the trial, were used to extract paired remote sensing and TSS measurements for linear regression analysis and are presented in Table 3-5.

Of the 108 data pairs of both TSS-OBS and TSS-ABS, the outlier detection metrics described in Section 2.2.3 identified between zero and ten potentially influential outliers for the data pairs used in the regression analyses, depending on the specific metric. Due to the variability in identification of statistical outliers across the methods, and more importantly, the fact that none of the measurements were deemed egregious, faulty, or suitable for exclusion from the regression analysis based on observations from the field, all measurements of TSS, OBS, and ABS were retained for the calibrations described herein.

3.2.1 Optical Backscatter

The calibration equation and curve resulting from the linear regression analysis of TSS on OBS is shown in Figure 3-4. The relationship was highly correlated and statistically significant ($R^2 = 0.860$, $p<0.0001$; see statistical details in Appendix B).

3.2.2 Acoustic Backscatter

The calibration equation and curve resulting from the linear regression analysis of $\log_{10}$(TSS) on ABS is shown in Figure 3-5. The TSS-ABS relationship was not well-correlated and was not statistically significant ($R^2 = 0.024$, $p = 0.108$; see statistical details in Appendix B). It is likely that the apparent TSS-ABS relationship was impacted by potential changes in suspended sediment composition within the water column between the two survey days that data were collected, where a similar range of ABS data were observed during the two survey days, but the background TSS levels were higher on the day of the trial. Calibration curves assessed for the individual days' data provide significant moderately-correlated results, discussed further in Section 4.

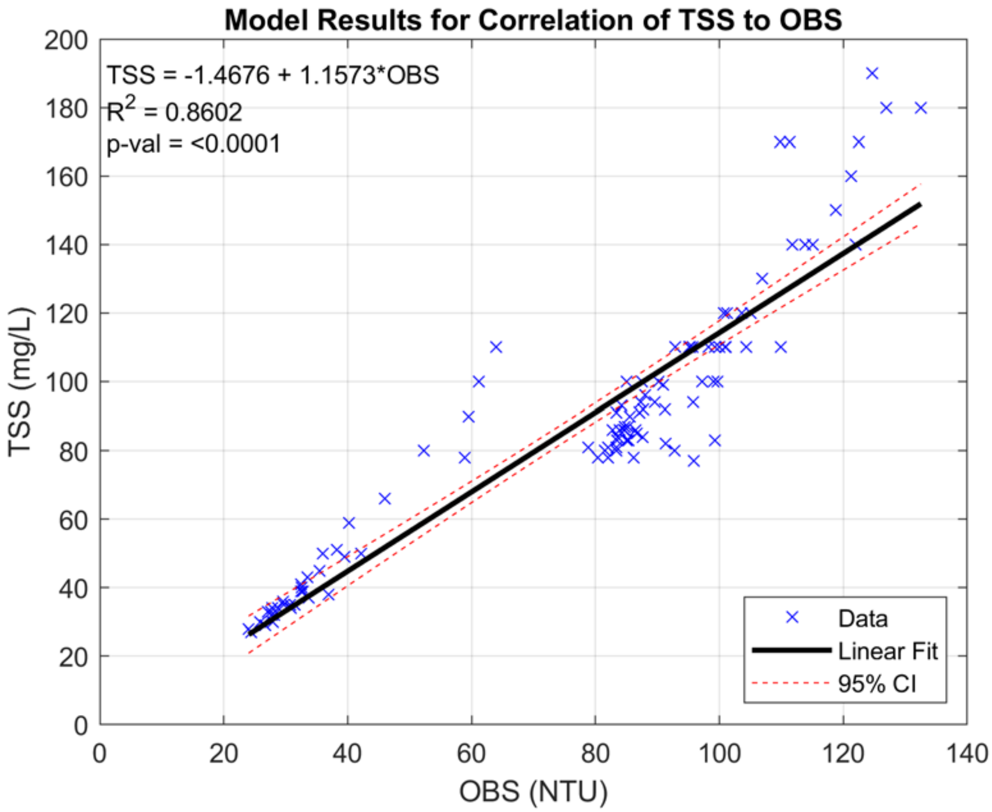

Figure 3-4. Calibration results for linear regression analysis of TSS to OBS for all paired sample data (N = 108) collected from the Hudson River trial (22-Dec-2023) and the ambient river survey (19-Dec-2023).

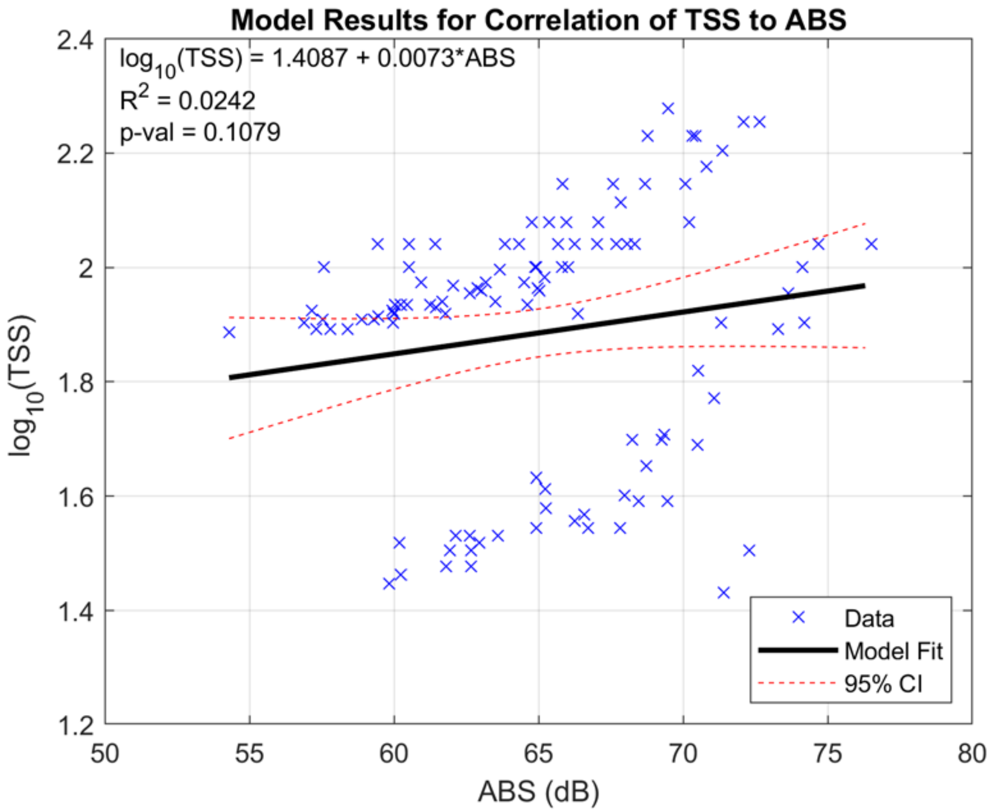

Figure 3-5. Calibration results for the linear regression analysis of log_{10}(TSS) to ABS for paired sample data (N = 108) collected from the Hudson River trial (22-Dec-2023) and the ambient river survey (22-Dec-2023).

4 Summary

4.1 Hudson River Jetting Trencher Trial

The standard in the WQC requires that TSS levels at 500 ft down-current from the installation equipment (jetting trencher or jet plow) do not increase by more than 200 mg/L greater than background TSS measured up-current of the trencher (i.e., the “delta-TSS” as presented herein). Monitoring during the pre-installation jetting trencher trials in the Hudson River for CHPE showed that TSS levels ranged from 29 mg/L in near-surface samples to 190 mg/L in a near-bottom sample, with the highest calculated increase during trencher operations (delta-TSS) being 23 mg/L, 88.5% lower than the exceedance threshold for delta-TSS in the Hudson River. Observations from the trial showed that, when measured at the prescribed 500 ft distance from the construction barge, changes in TSS levels were well below the permitted standards.

In addition, it is noted that a potential suspended sediment plume was observed in the ABS data in several ADCP down-current transects, specifically for Passes 6 through 8 which occurred during increasing and peak ebb tidal currents. Of interest is that the cross-sectional width of the potential plume was small, on the order of 10–30 ft wide, as seen in the ABS contour plots (Appendix A). This pattern was observed primarily during stronger ebb tidal currents in the middle portion of the trial, and the estimate width of the potential plume was similar to that observed during the 2022 jet plow trial in the Hudson River. The apparent suspended sediment plume was not always observable in the ABS data, and there were some transects that showed some elevated ABS levels in the up-current transects (e.g., Passes 5, 9, and 11), which was also observed the CTD-OBS and TSS data (Table 3-3).

Lastly, the water chemistry sampling showed that, where the parameters were detectable by the laboratory analysis methods, the levels observed for all parameters were significantly below the standards identified by the WQC and Monitoring Plan.

4.2 Optical and Acoustic Backscatter Calibrations

Results from the regression analyses indicated that the OBS exhibited a much stronger and statistically significant relationship with TSS concentrations ($R^2 = 0.860$) and, as such, likely provides better estimates of TSS for future monitoring in similar conditions. The TSS-ABS regression was not statistically significant ($R^2 = 0.024$, $p = 0.108$). Furthermore, inclusion of the ambient survey data and the trial data shows that the ABS data may not be sensitive to changes in hydrologic and sediment characteristics (i.e., that the water column conditions were different during the December 19 and 22, 2023 surveys, with higher background TSS levels on the 22nd, but the ABS signal did not necessarily represent that change). It is noted herein that performing the correlation analysis with the ABS data from the ambient survey and the trial survey separately yields statistically significant correlations for those conditions independently ($R^2 = 0.599$ and $R^2 = 0.539$ for the ambient and trial surveys, respectively). However, given the intent of the approach detailed in the Monitoring Plan, and as performed during the 2022 trials, a combined correlation for all the data collected the week of the trial was assessed.

The differences observed between the responses of the OBS and ABS is likely attributable to varying sensitivities to different particle sizes and sediment characteristics, for which the OBS sensors and ABS from ADCP have different responsiveness. The OBS sensor is typically more sensitive to smaller particle sizes than the ABS from the 600 kHz ADCP and therefore, the ABS may slightly underestimate suspended sediments in the smaller particle size ranges (e.g., particles in the silt and clay range <40-60 µm) (Gartner 2004; Jay et al. 2015). That may be the case with the data collected during the ambient survey and trial survey described above. At sites with different hydrologic or sediment characteristics, changes in estimated TSS concentrations from the OBS and ABS data could result from changes in suspended particle size distribution rather than changes in TSS, or both (Garter 2004; Wall et al. 2006; Landers 2010). Provided that sampling conducted during installation monitoring will provide confirmatory TSS data along with additional OBS and ABS these data, where appropriate, can be used to expand the calibrations, if necessary. However, it is apparent that development of a river-wide calibration for ABS to TSS will be an extensive scope item and it is not apparent how this calibration relationship would be utilized for monitoring efforts during active construction.

Additionally, the overall range of TSS levels observed for all samples collected was somewhat greater than the trials conducted in 2022, likely due to post-storm conditions in the river. Similar conditions could be expected to occur in the Hudson River during installation activities after storm events.

4.3 Conclusions

TSS levels observed during the pre-installation jetting trencher trial in the Hudson River were comparable to ambient TSS levels, which was evident in the sample data as only three of the samples exhibited an increase in TSS over background TSS for the same depth layer greater than 10 mg/L. This suggests that the trencher operations did not result in substantial increases in TSS in general and specifically that increases in TSS were well below the standards identified by the WQC and the Monitoring Plan. Based on the observations from the trencher trial, it appears likely that increases in TSS due to the trencher operations would only be observed at the 500 ft distance from the barge within a small width of cross-sectional area (estimated 10-30+ ft, and depth-dependent) and primarily during the times surrounding peak tidal currents within the tidal cycle.

Statistically significant and well-correlated calibration relationships were established for TSS to OBS, but only for ABS if correlated to each sampling day separately (i.e. not combining the sample data across days). The strength of the OBS-TSS regression indicates that OBS is likely a better predictor of TSS values between the two methods, corroborating results from the 2022 jet plow trial in the Hudson River. The ABS data from ADCP provide a remote profiling instrument capable of sampling the entire water column (i.e., without being physically lowered from a vessel at a point), which is useful for locating potential sediment plumes. Based on the results from the Hudson River trencher trial, and primarily due to the apparent variability and scale of the observable suspended sediment plume induced by the trencher, the ABS data are helpful in determining if a potential plume is present at 500 ft down-current from the trencher in real-time and for monitoring purposes to determine where to sample for CTD-OBS and confirmatory TSS from water samples. The ABS contour plots demonstrate that the sediment plume is observable remotely, and based on these observations, the presence and spatial variability of the plume across conditions and tides can be confirmed. While the ABS could provide an additional estimate of near real-time TSS levels during future monitoring activities, the ABS-TSS correlations from the trencher trial surveys were only significant if correlated for each day (as opposed to combining the datasets), and these relationships also exhibited a higher degree of uncertainty between sampling methods. As such, for conditions encountered in this region of the Hudson River, the OBS sensor is likely more appropriate for guiding compliance determinations during active construction.

In summary, the pre-installation trencher trial in the Hudson River demonstrated that (1) trencher activities produced either no observable plume or a small area of slightly elevated TSS levels within a cross-sectional transect that were well below the TSS standards identified in the WQC (at most approximately 11.5% of the standard for elevation above background levels); (2) the presence and location of a suspended sediment plume at 500 ft down-current of the trencher was able to be detected in the ABS data, although one was not always observed during the trial; and (3) the OBS calibration to TSS exhibited high predictive power, whereas the ABS calibration was either not statistically significant, or too sensitive to variability in conditions to be useful for long-term active construction monitoring. While these calibration relationships are subject to modification during the installation phase of the Project to reflect hydrological and sediment conditions that may not have been encountered during the trials, the regression results suggest that the use of the calibration curves developed as part of the trial, particularly the OBS-TSS calibration, would be appropriate for the start of the installation phase in the Hudson River.

5 References

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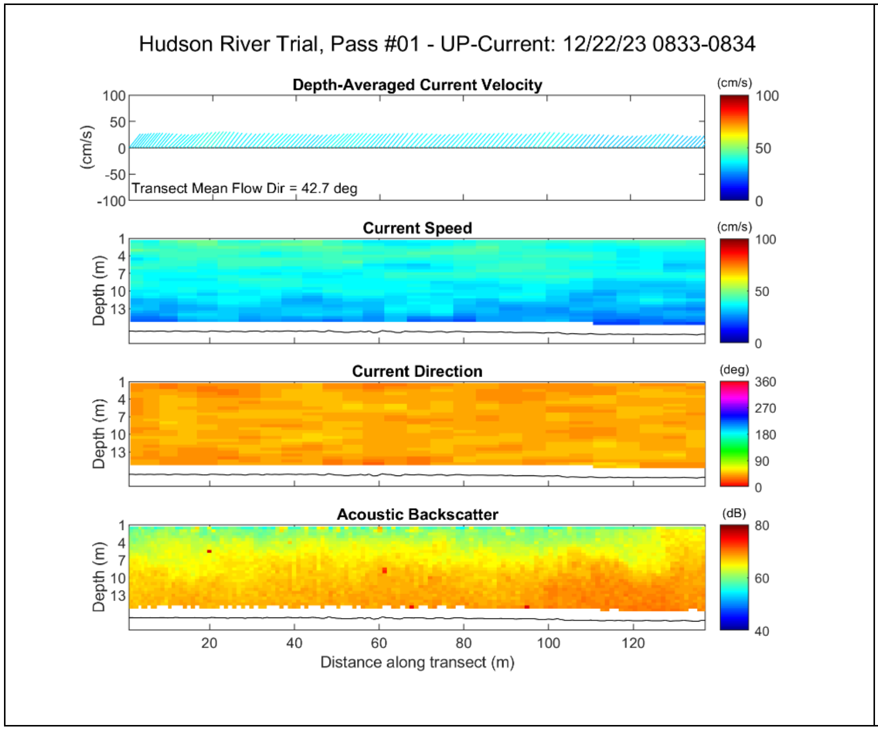
Appendix A. ADCP Velocity and ABS Transects from the Hudson River Trial


Hudson River Trial, Pass #01 - UP-Current: 12/22/23 0833-0834
Depth-Averaged Current Velocity
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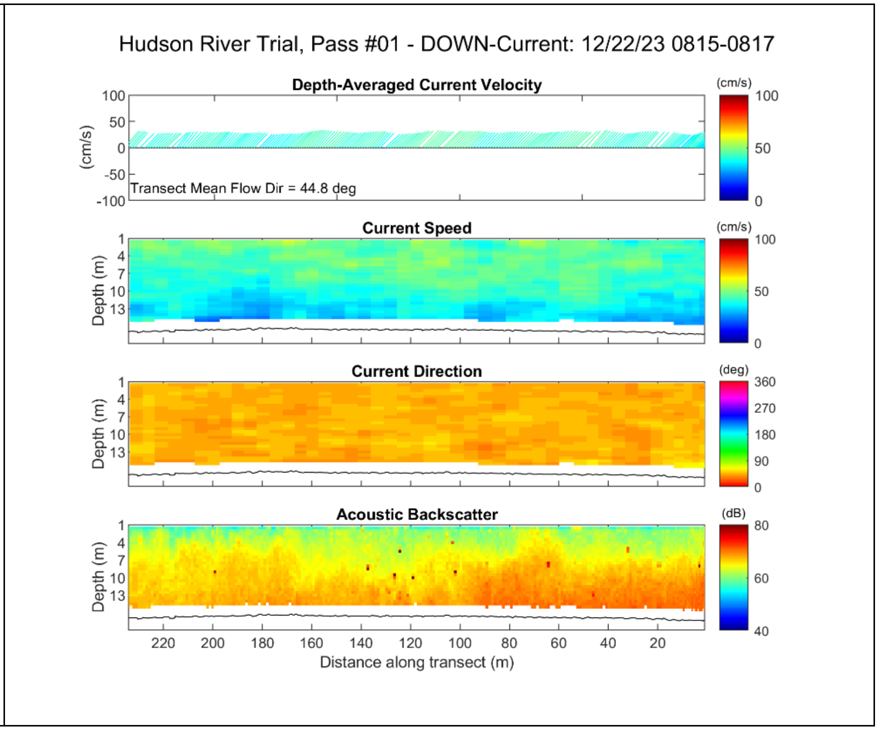
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Current Direction
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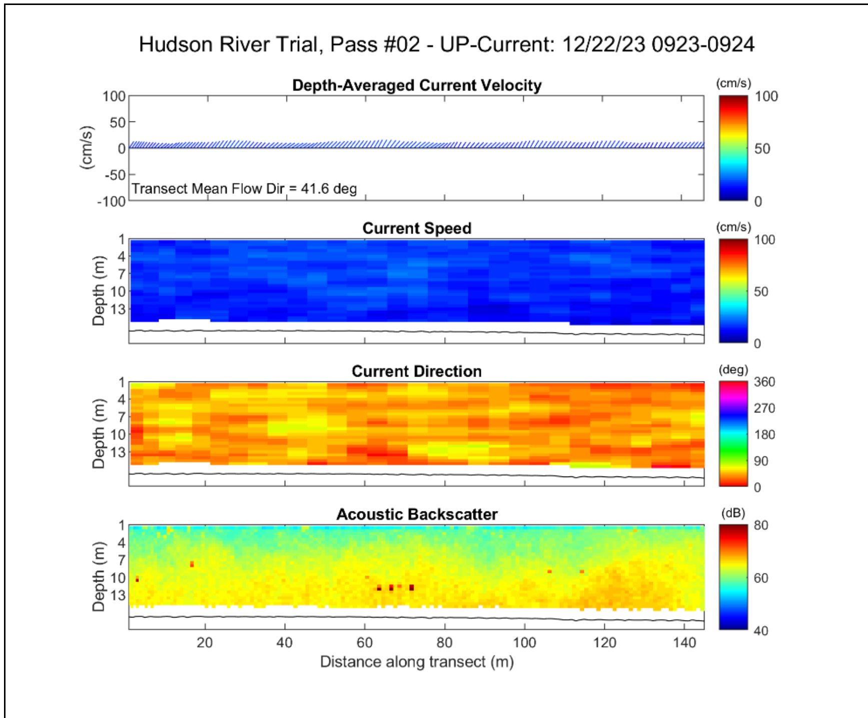
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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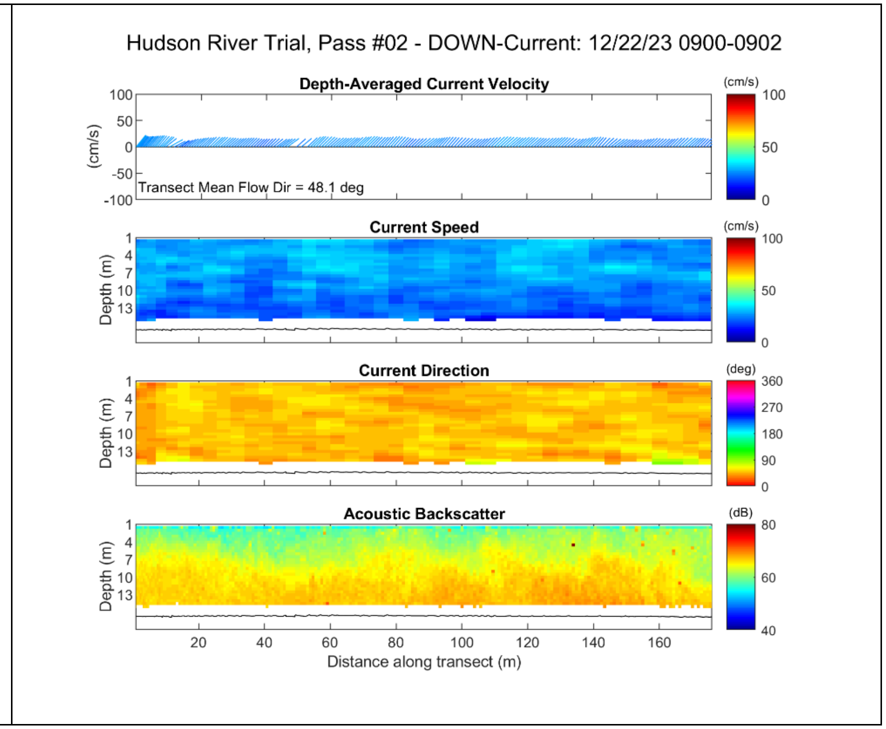
Current Speed
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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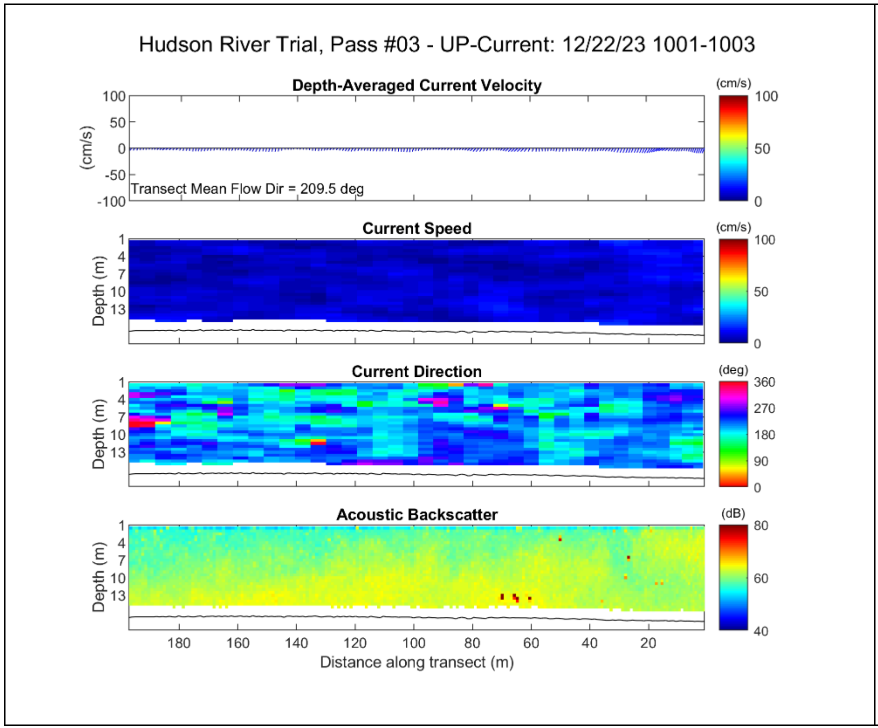
Current Speed
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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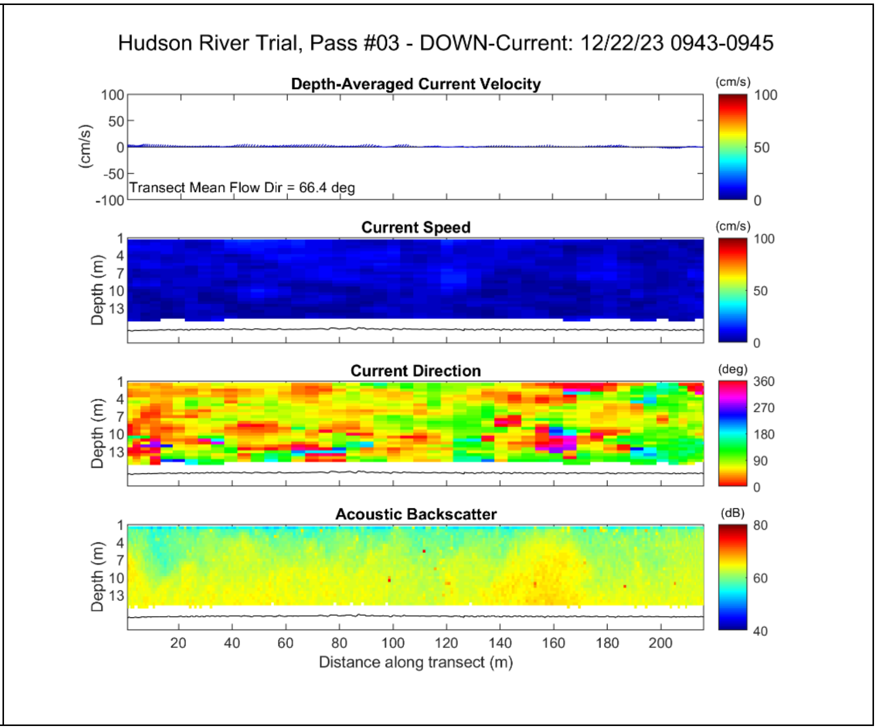
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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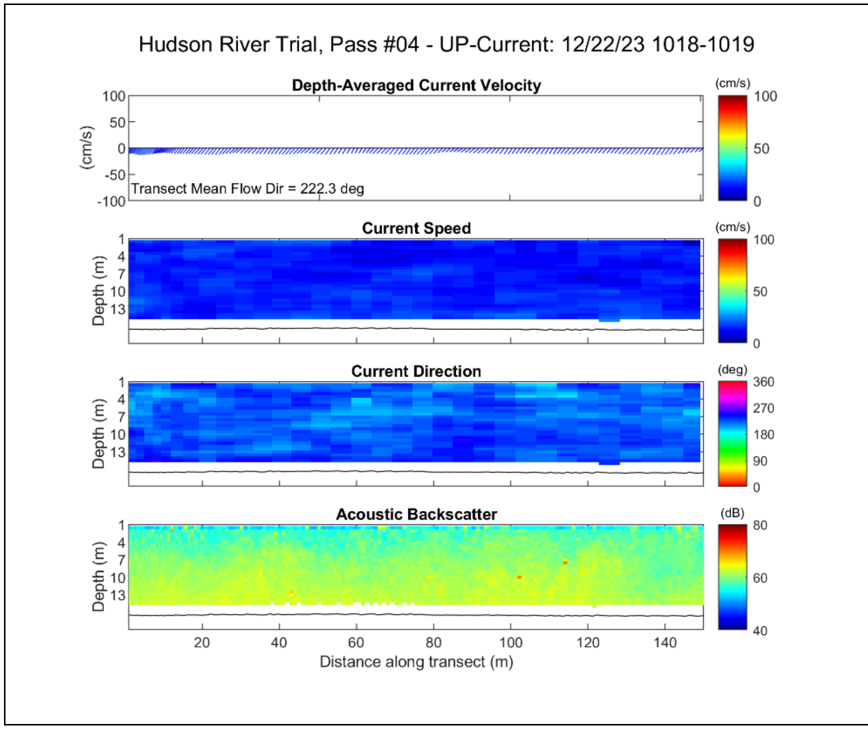
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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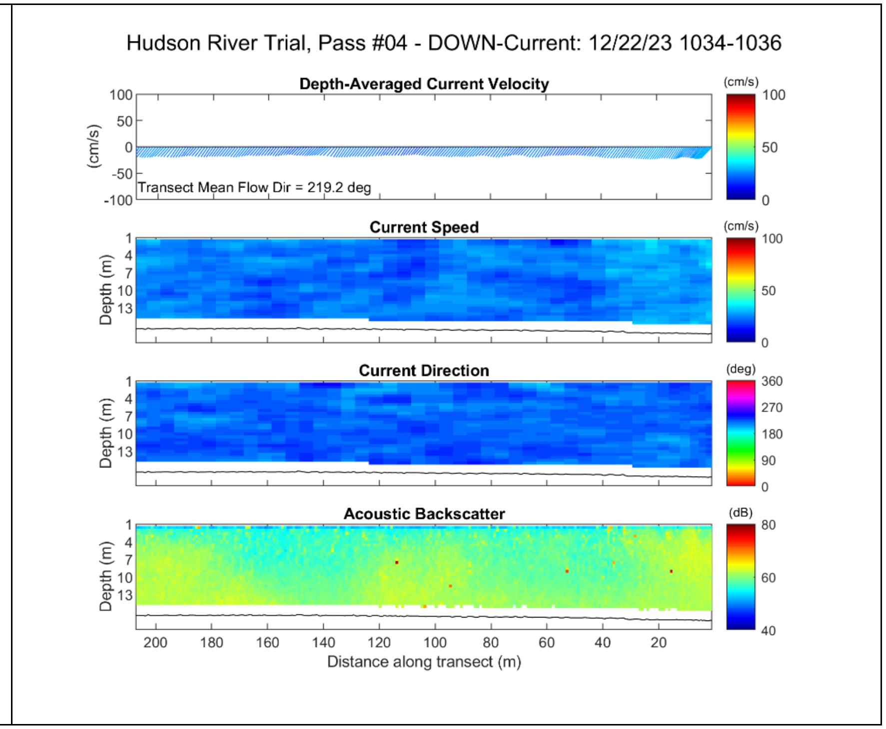
Depth-Averaged Current Velocity
Transect Mean Flow Dir = 222.3 deg
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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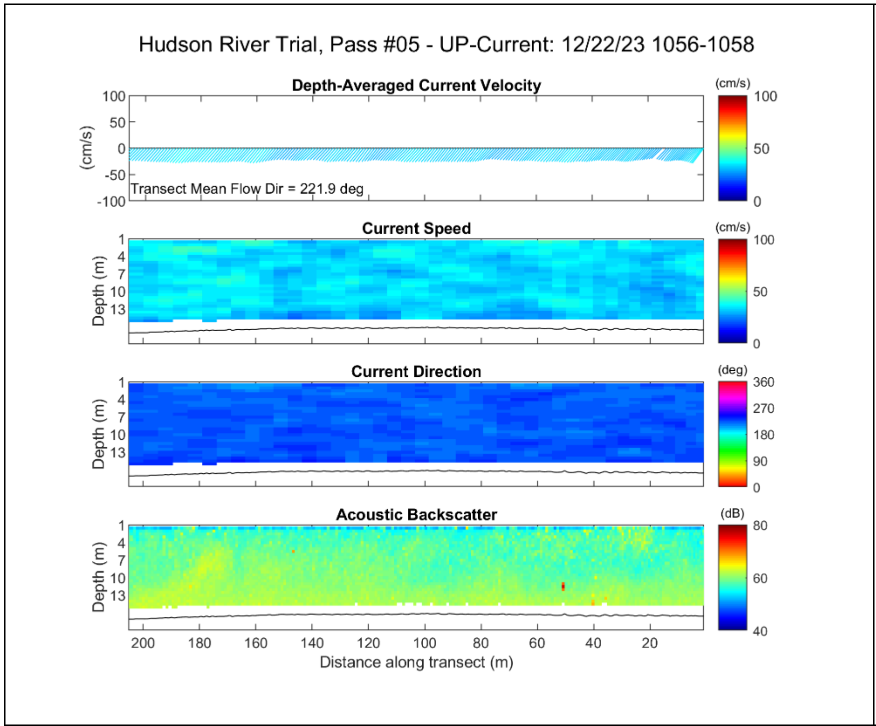
Depth-Averaged Current Velocity
Transect Mean Flow Dir = 219.2 deg
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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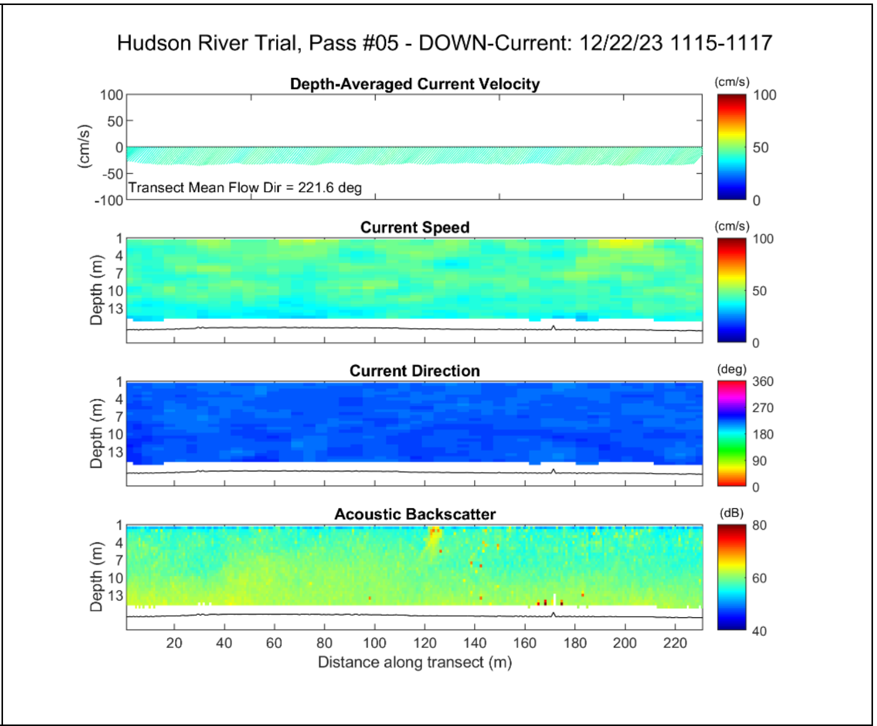
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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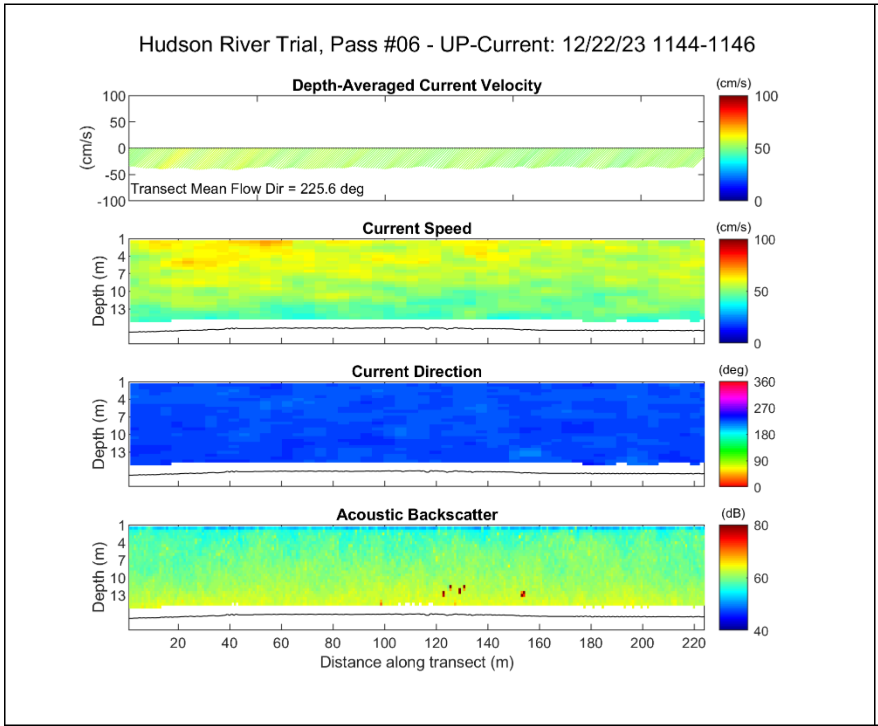
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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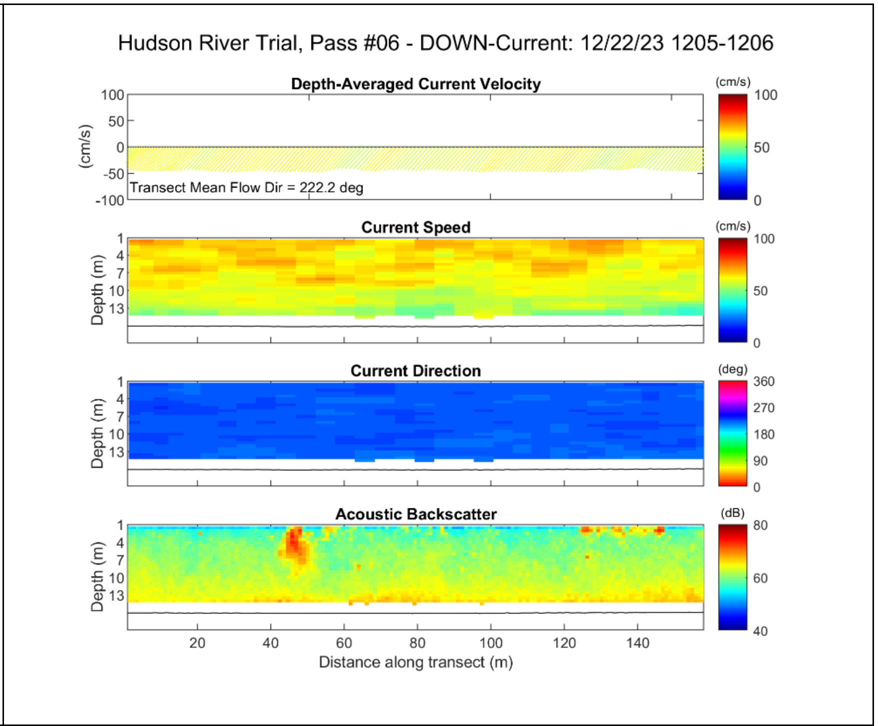
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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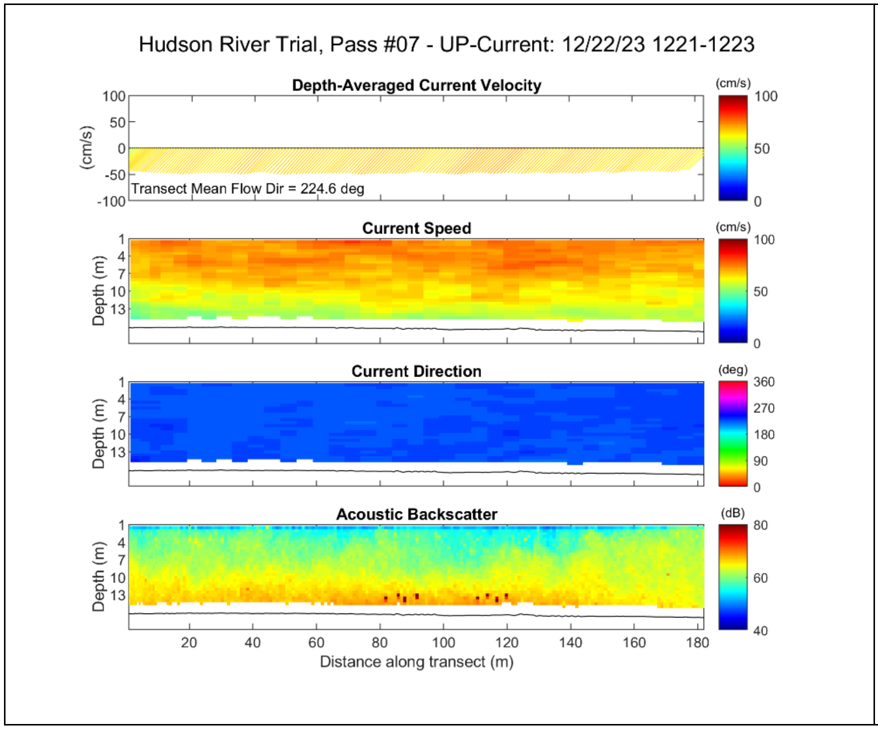
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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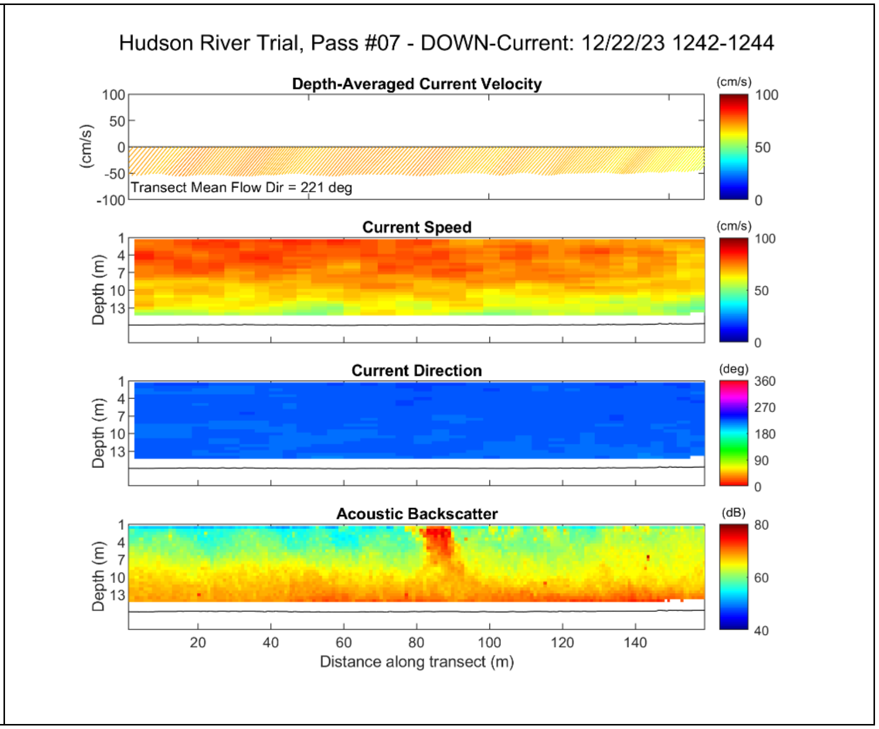
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Current Direction
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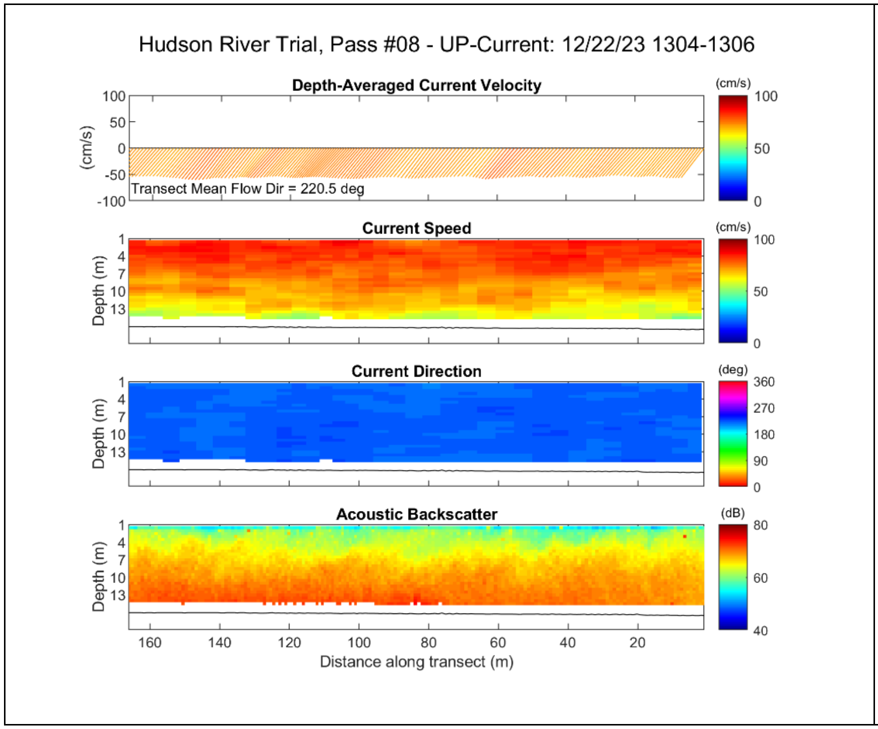
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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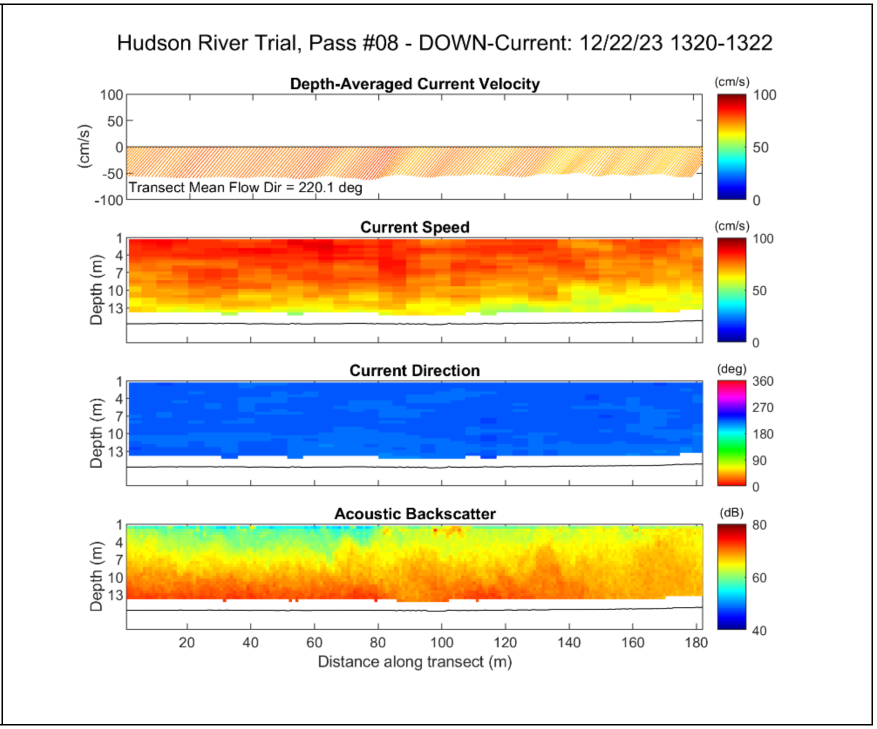
Current Speed
Current Direction
Acoustic Backscatter
Distance along transect (m)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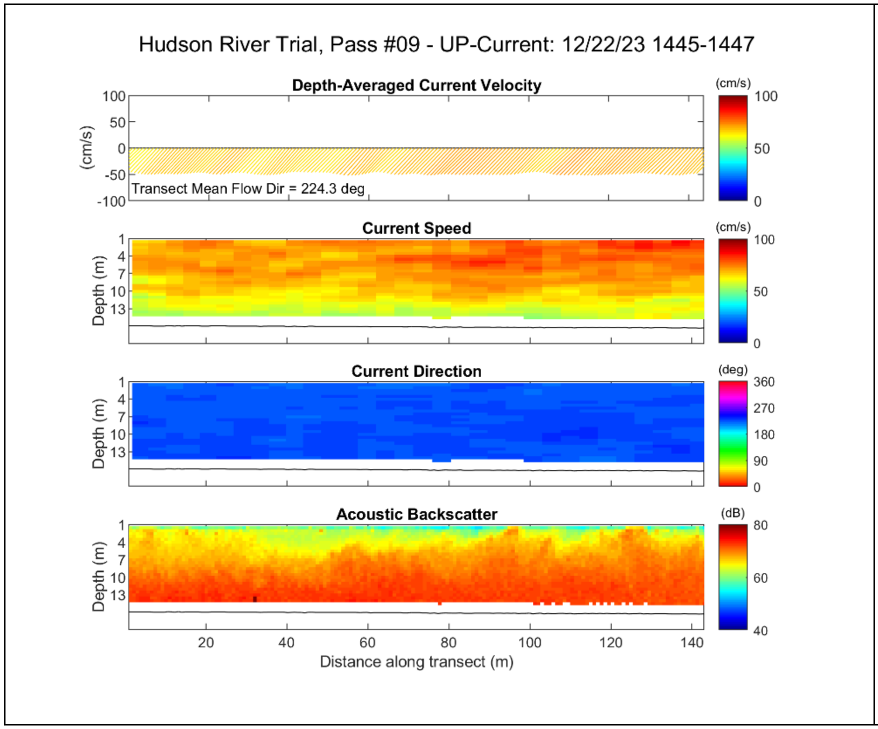
Current Direction
Acoustic Backscatter
Distance along transect (m)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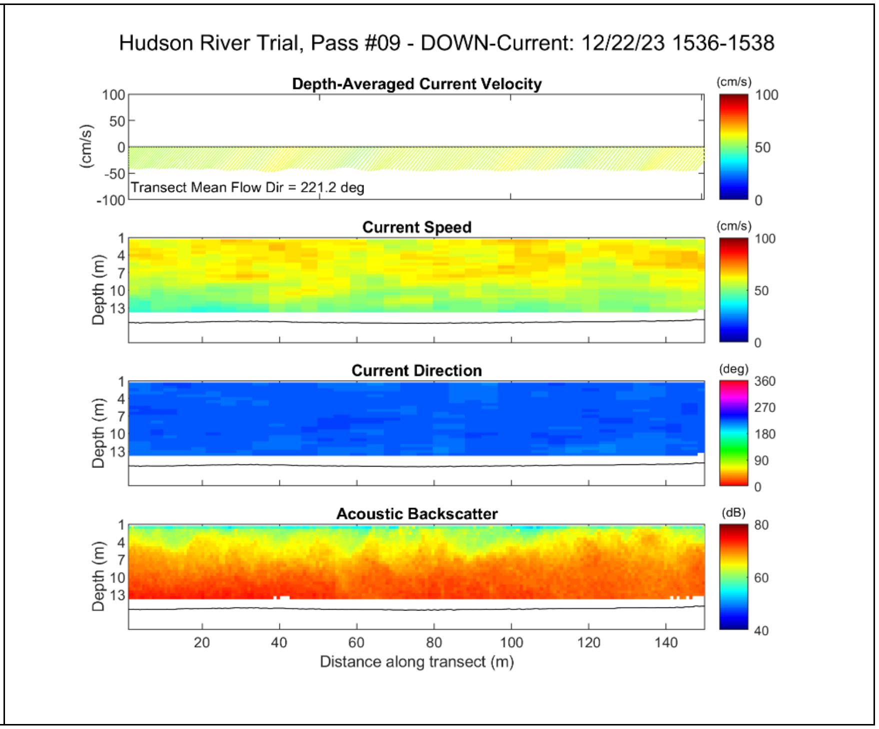
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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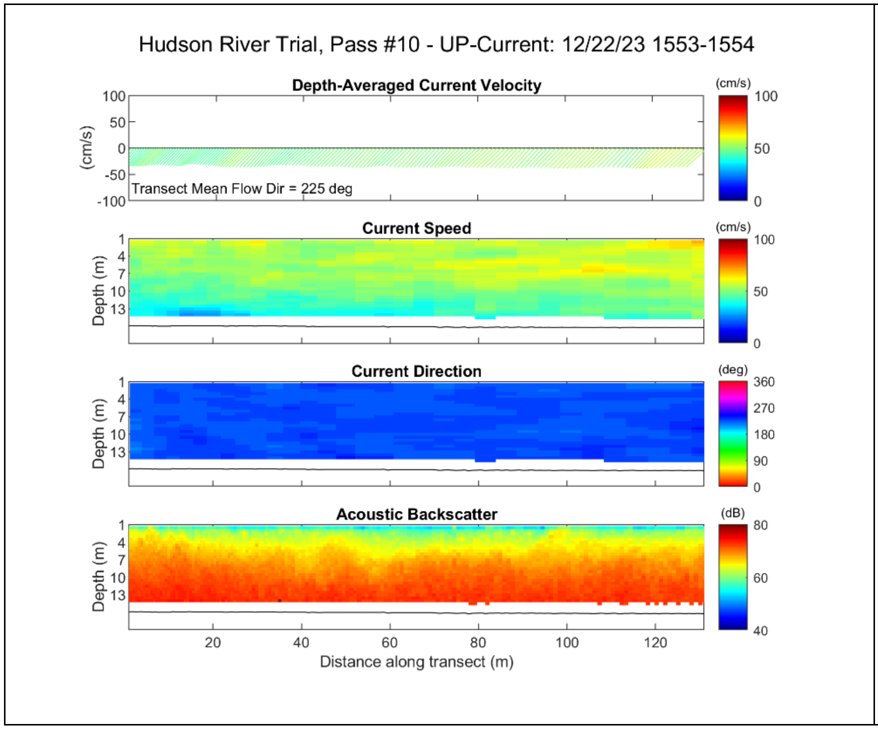
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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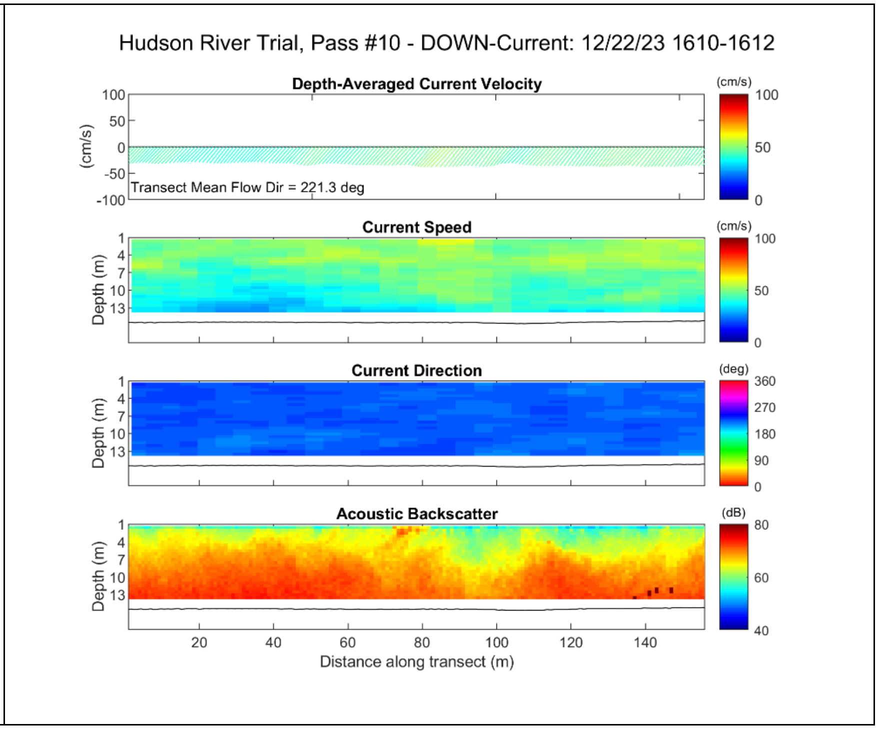
Transect Mean Flow Dir = 225 deg
Current Speed
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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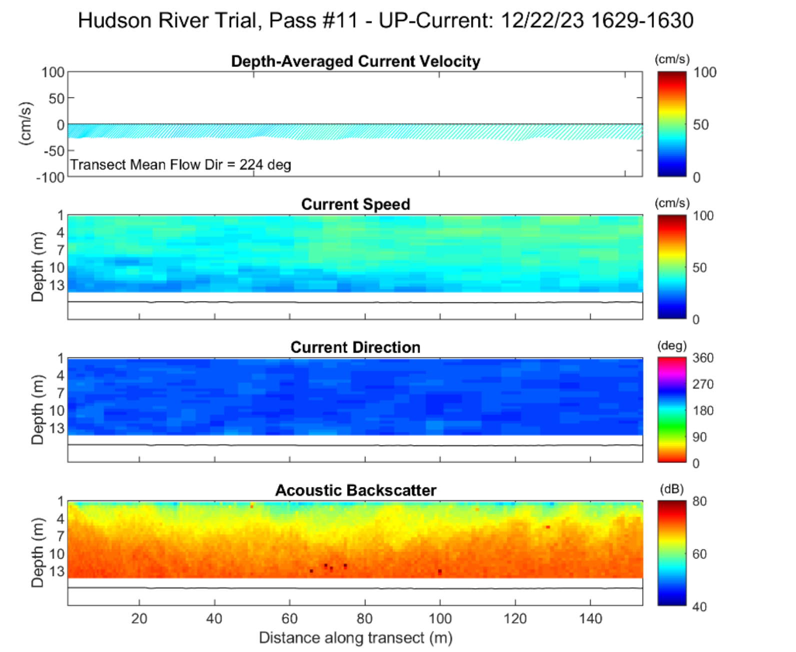
Depth-Averaged Current Velocity
(cm/s)
Transect Mean Flow Dir = 221.3 deg
Current Speed
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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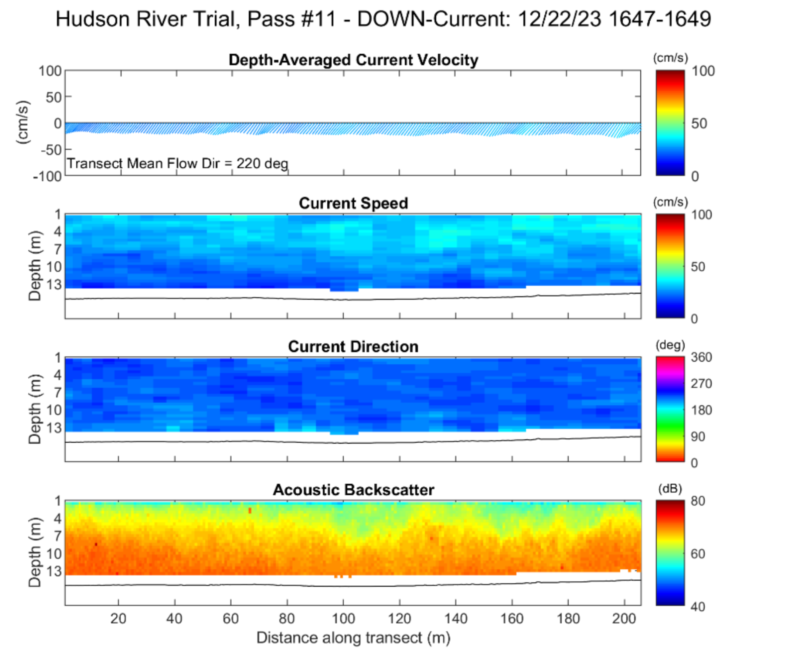
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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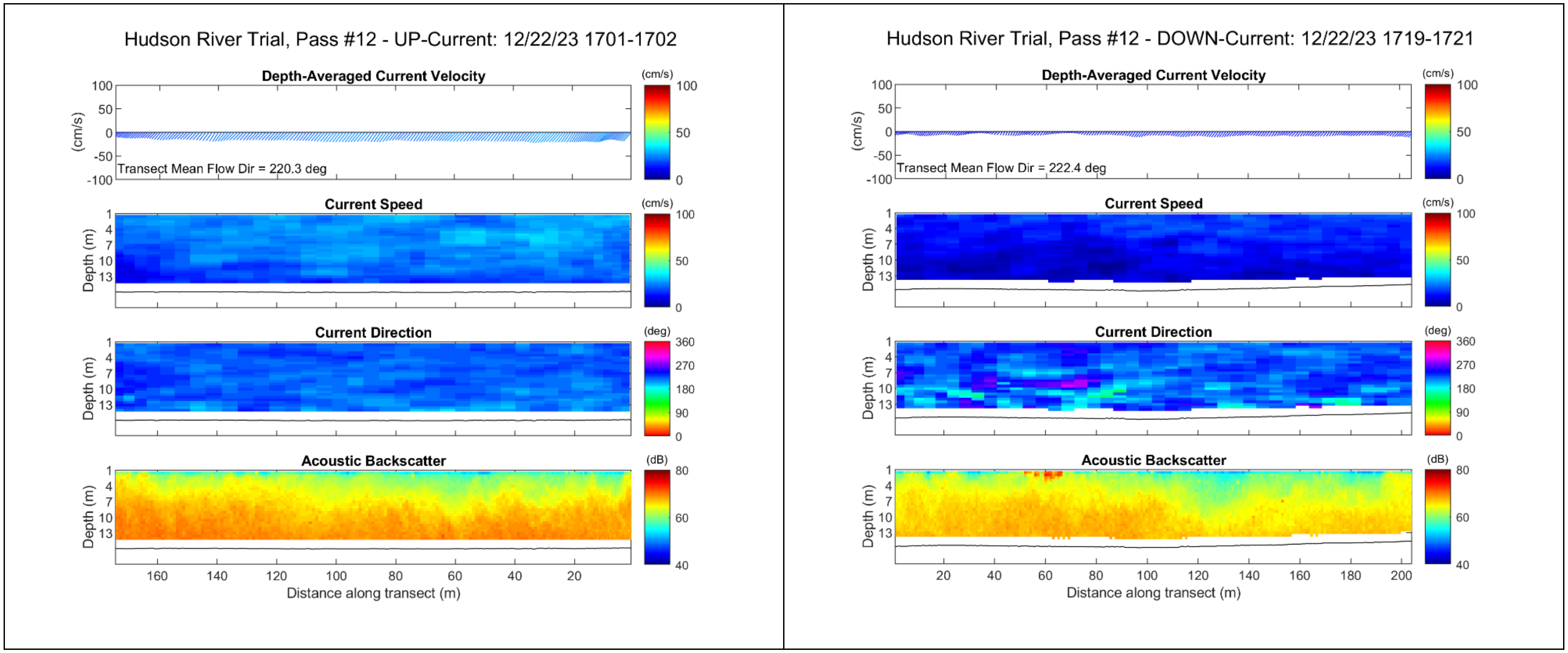
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)
Hudson River Trial, Pass #12 - DOWN-Current: 12/22/23 1719-1721
Depth-Averaged Current Velocity
Transect Mean Flow Dir = 222.4 deg
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)

Appendix B. Linear Regression Model Results from MATLAB® Output for TSS to OBS and TSS to ABS

```
---------------------------------------------------------------
*** SUMMARY of Linear Model for OBS-TSS:
---------------------------------------------------------------
 Model Information:

    TSS = -1.4676 + 1.1573*OBS

Linear regression model:
    y ~ 1 + x1

Estimated Coefficients:
                   Estimate       SE        tStat       pValue
                   ________    ________    ________    _________

    (Intercept)    -1.4676       3.7134    -0.39522      0.69347
    x1              1.1573     0.045316      25.538   4.3055e-47

Number of observations: 108, Error degrees of freedom: 106
Root Mean Squared Error: 14.6
R-squared: 0.86,  Adjusted R-Squared: 0.859
F-statistic vs. constant model: 652, p-value = 4.31e-47
Model Standard Percentage Error (MPSE): 16.90%
---------------------------------------------------------------

 Model Residuals and Diagnostics:
```

ObsNo	OBS	TSS	Raw_r	Pearson_r	Standardized_r	Studentized_r	CooksD	DFFITS
1	32.47	41	4.8914	0.33567	0.34038	0.33895	0.0016369	0.056978
2	42.14	50	2.7007	0.18533	0.18724	0.18638	0.00036261	0.026807
3	63.93	110	37.484	2.5723	2.5861	2.6591	0.035961	0.27576
4	33.48	43	5.7226	0.39271	0.39804	0.39646	0.0021684	0.065592
5	52.28	80	20.966	1.4388	1.4494	1.4571	0.015611	0.17763
6	61.19	100	30.655	2.1037	2.1157	2.1516	0.025684	0.23049
7	31.39	35	0.14123	0.0096919	0.0098325	0.009786	1.4129e-06	0.0016731
8	39.54	49	4.7096	0.32319	0.32681	0.32543	0.0012029	0.048841
9	58.91	78	11.293	0.775	0.77971	0.77826	0.0037055	0.085927
10	32.52	39	2.8335	0.19445	0.19717	0.19628	0.00054842	0.032968
11	35.5	45	5.3849	0.36953	0.37425	0.37272	0.0017976	0.059715
12	59.56	90	22.541	1.5469	1.5561	1.5667	0.0145	0.17146
13	30.86	34	-0.24542	-0.016842	-0.01709	-0.017009	4.3396e-06	-0.0029321
14	36.01	50	9.7947	0.67215	0.68059	0.67885	0.0058484	0.10788
15	40.17	59	13.98	0.9594	0.96993	0.96965	0.010379	0.14404
16	36.92	38	-3.2584	-0.22361	-0.22633	-0.22532	0.00062812	-0.035284
17	33.72	37	-0.55518	-0.038099	-0.038613	-0.038431	2.0251e-05	-0.0063341
18	45.95	66	14.292	0.98074	0.98965	0.98955	0.0089361	0.13367
19	26.7	29	-0.43122	-0.029592	-0.030087	-0.029945	1.5276e-05	-0.0055012
20	32.82	39	2.4863	0.17062	0.17299	0.1722	0.00041819	0.028788
21	38.21	51	8.2487	0.56606	0.57268	0.57086	0.003857	0.08755
22	27.72	32	1.3884	0.095276	0.096822	0.096369	0.00015339	0.017433
23	29.68	35	2.1201	0.14549	0.14772	0.14703	0.00033626	0.025813
24	32.55	40	3.7988	0.26069	0.26434	0.26318	0.00098477	0.044184
25	27.91	30	-0.8315	-0.057061	-0.057982	-0.057709	5.4691e-05	-0.010409
26	30.73	35	0.90502	0.062106	0.063026	0.062729	5.9258e-05	0.010835
27	29.54	36	3.2822	0.22524	0.22869	0.22767	0.00080945	0.040055
28	27.12	33	3.0827	0.21155	0.21505	0.21408	0.00077053	0.039079
29	28.15	32	0.89075	0.061127	0.062107	0.061814	6.2292e-05	0.011109
30	28.79	34	2.1501	0.14755	0.14987	0.14917	0.00035571	0.026549
31	27.75	32	1.3537	0.092894	0.0944	0.093958	0.00014568	0.016989
32	27.66	33	2.4578	0.16867	0.17141	0.17062	0.0004816	0.030893
33	27.82	34	3.2726	0.22458	0.22822	0.22719	0.0008496	0.041037
34	24.02	28	1.6702	0.11462	0.11669	0.11615	0.0002489	0.022207
35	24.38	27	0.25362	0.017405	0.017717	0.017633	5.6763e-06	0.0033534
36	25.91	30	1.483	0.10177	0.10351	0.10303	0.00018515	0.019153
37	91.33	82	-22.225	-1.5252	-1.5341	-1.544	0.013772	-0.16704
38	90.86	99	-4.681	-0.32123	-0.32308	-0.32171	0.00060345	-0.034593
39	95.62	110	0.81041	0.055614	0.05598	0.055716	2.0683e-05	0.0064014
40	84.62	86	-10.46	-0.71779	-0.7214	-0.71976	0.002628	-0.072333
41	89.6	94	-8.2229	-0.56429	-0.56744	-0.56562	0.0018038	-0.059871
42	95.12	110	1.389	0.095322	0.09594	0.09549	5.9861e-05	0.010891
43	82.01	81	-12.439	-0.85363	-0.85777	-0.85669	0.0035745	-0.084446
44	85.01	100	3.0889	0.21198	0.21305	0.21209	0.00023077	0.021386
45	87.99	96	-4.3597	-0.29918	-0.30079	-0.2995	0.00048826	-0.031115
46	85.32	83	-14.27	-0.97925	-0.98425	-0.9841	0.0049527	-0.099511
47	87.05	91	-8.2719	-0.56765	-0.57064	-0.56882	0.0017221	-0.0585
48	87.72	92	-8.0472	-0.55223	-0.55519	-0.55337	0.0016536	-0.057319
49	83.49	83	-12.152	-0.83392	-0.83805	-0.83686	0.0034825	-0.083338
50	85.01	83	-13.911	-0.95463	-0.95948	-0.95911	0.0046804	-0.096714
51	87.29	94	-5.5496	-0.38084	-0.38286	-0.38131	0.00077911	-0.039315
52	78.87	81	-8.8055	-0.60427	-0.60711	-0.60529	0.0017386	-0.058792
53	83.6	84	-11.279	-0.77403	-0.77787	-0.77641	0.0030053	-0.077383
54	91.19	92	-12.063	-0.82781	-0.83262	-0.83141	0.0040421	-0.089781
55	86.18	78	-20.265	-1.3907	-1.3979	-1.4043	0.010154	-0.14316
56	82.73	86	-8.2725	-0.56769	-0.57047	-0.56865	0.001596	-0.056318
57	85.49	90	-7.4665	-0.51238	-0.51501	-0.51321	0.0013602	-0.051976
58	92.75	80	-25.868	-1.7752	-1.7859	-1.8049	0.01939	-0.19901
59	83.4	80	-15.048	-1.0326	-1.0377	-1.0381	0.0053327	-0.10331
60	84.74	87	-9.5986	-0.6587	-0.66202	-0.66026	0.0022177	-0.066421
61	87.64	84	-15.955	-1.0949	-1.1007	-1.1018	0.0064885	-0.11403

62	84.68	86	-10.529	-0.72255	-0.7262	-0.72457	0.0026658	-0.072853
63	84.21	93	-2.9852	-0.20486	-0.20588	-0.20495	0.00021258	-0.020526
64	81.49	80	-12.838	-0.88096	-0.88521	-0.88429	0.0037833	-0.086896
65	83.33	81	-13.967	-0.95846	-0.96319	-0.96286	0.0045892	-0.095771
66	95.71	94	-15.294	-1.0495	-1.0564	-1.057	0.0073861	-0.12161
67	82.06	78	-15.497	-1.0635	-1.0686	-1.0694	0.0055515	-0.10544
68	86.43	86	-12.554	-0.86153	-0.86602	-0.86499	0.0039165	-0.088399
69	103.58	120	1.5986	0.1097	0.11063	0.11011	0.00010381	0.014342
70	80.37	78	-13.541	-0.92926	-0.93369	-0.93312	0.0041604	-0.091163
71	86.72	85	-13.89	-0.95319	-0.95818	-0.95781	0.0048225	-0.098171
72	104.32	110	-9.2577	-0.6353	-0.6408	-0.63901	0.0035682	-0.084241
73	95.82	77	-32.421	-2.2249	-2.2396	-2.2837	0.033303	-0.26316
74	85.18	87	-10.108	-0.69364	-0.69717	-0.69547	0.0024786	-0.070235
75	122.5	170	29.703	2.0384	2.0699	2.1031	0.066895	0.37163
76	99.32	83	-30.471	-2.0911	-2.1065	-2.1418	0.032812	-0.26047
77	109.91	110	-15.727	-1.0792	-1.0905	-1.0914	0.012418	-0.15774
78	111.32	170	42.641	2.9262	2.9581	3.0737	0.095707	0.45461
79	83.9	86	-9.6265	-0.66061	-0.6639	-0.66214	0.0021995	-0.066148
80	87.48	100	0.23051	0.015819	0.015903	0.015828	1.3497e-06	0.0016352
81	109.8	170	44.4	3.0469	3.0785	3.2108	0.098618	0.4632
82	83.32	91	-3.9553	-0.27143	-0.27277	-0.27157	0.00036798	-0.02701
83	90.21	100	-2.9288	-0.20099	-0.20213	-0.20121	0.00023234	-0.021459
84	124.67	190	47.192	3.2385	3.2921	3.4581	0.18077	0.6316
85	95.23	110	1.2617	0.086586	0.087149	0.08674	4.9554e-05	0.0099086
86	105.06	120	-0.11412	-0.0078315	-0.0079009	-0.0078636	5.5578e-07	-0.0010493
87	132.52	180	28.108	1.9289	1.9689	1.9965	0.081366	0.40904
88	97.2	100	-11.018	-0.7561	-0.76132	-0.7598	0.0040124	-0.089402
89	100.7	120	4.9315	0.33842	0.34103	0.3396	0.00089859	0.042216
90	121.21	160	21.196	1.4546	1.4762	1.4846	0.032696	0.25717
91	99.27	110	-3.4136	-0.23425	-0.23598	-0.23492	0.00041112	-0.028547
92	100.88	110	-5.2768	-0.36211	-0.36492	-0.36342	0.0010349	-0.045307
93	126.93	180	34.577	2.3728	2.4148	2.4723	0.10407	0.46709
94	92.89	110	3.9697	0.27242	0.27408	0.27288	0.00045842	0.030147
95	106.92	130	7.7334	0.5307	0.5357	0.53389	0.0027161	0.073455
96	118.75	150	14.043	0.96369	0.97698	0.97677	0.013261	0.16282
97	99.24	110	-3.3789	-0.23187	-0.23358	-0.23253	0.00040242	-0.028243
98	100.02	110	-4.2815	-0.29382	-0.29603	-0.29475	0.00066256	-0.036245
99	113.79	140	9.783	0.67135	0.67926	0.67753	0.0054695	0.10432
100	99.04	100	-13.147	-0.90223	-0.90882	-0.90807	0.0060539	-0.10994
101	101.24	120	4.3066	0.29554	0.29785	0.29657	0.00069745	0.037187
102	115.07	140	8.3017	0.5697	0.57669	0.57487	0.0041089	0.090365
103	98.23	110	-2.21	-0.15166	-0.15274	-0.15204	0.00016672	-0.018176
104	101.19	120	4.3645	0.29951	0.30185	0.30055	0.00071515	0.037657
105	111.72	140	12.179	0.83574	0.84495	0.8438	0.0079117	0.12562
106	99.73	100	-13.946	-0.95703	-0.96417	-0.96385	0.006964	-0.11798
107	101.04	110	-5.4619	-0.37482	-0.37774	-0.3762	0.0011145	-0.047022
108	121.96	140	0.32818	0.022521	0.022864	0.022756	8.0275e-06	0.0039879

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--------------------------------------------------------------------
*** SUMMARY of Model for ABS-TSS:
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 Model Information:

    log10(TSS) = 1.4087 + 0.0073285*ABS

Linear regression model:
    y ~ 1 + x1

Estimated Coefficients:
                   Estimate        SE        tStat       pValue
                   _________    _________    ______    __________

    (Intercept)       1.4087      0.29502     4.775    5.7903e-06
    x1             0.0073285    0.0045198    1.6214        0.1079

Number of observations: 108, Error degrees of freedom: 106
Root Mean Squared Error: 0.22
R-squared: 0.0242,  Adjusted R-Squared: 0.015
F-statistic vs. constant model: 2.63, p-value = 0.108
Model Standard Percentage Error (MPSE): [-39.72%, +65.90%]
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Model Residuals and Diagnostics:

ObsNo	ABS	log10TSS	Raw_r	Pearson_r	Standardized_r	Studentized_r	CooksD	DFFITS
1	65.226	1.6128	-0.27397	-1.2462	-1.252	-1.2554	0.0073301	-0.12141
2	69.26	1.699	-0.21735	-0.98864	-0.99693	-0.9969	0.0083657	-0.12935
3	74.669	2.0414	0.085435	0.38861	0.39827	0.39669	0.0039919	0.088997
4	64.912	1.6335	-0.25099	-1.1417	-1.147	-1.1487	0.0061582	-0.11115
5	71.322	1.9031	-0.028338	-0.1289	-0.13058	-0.12998	0.00022396	-0.021066
6	74.136	2	0.047947	0.2181	0.22303	0.22203	0.0011374	0.04748
7	67.828	1.5441	-0.36175	-1.6455	-1.6558	-1.6697	0.017201	-0.18703
8	70.502	1.6902	-0.23523	-1.07	-1.0817	-1.0826	0.012898	-0.16074
9	73.289	1.8921	-0.053748	-0.24448	-0.24921	-0.2481	0.001212	-0.049017
10	69.45	1.5911	-0.32665	-1.4858	-1.4988	-1.5078	0.019703	-0.1997
11	68.739	1.6532	-0.25929	-1.1794	-1.1883	-1.1906	0.010635	-0.14613
12	73.64	1.9542	0.0058229	0.026487	0.027034	0.026906	1.5246e-05	0.0054958
13	63.602	1.5315	-0.34338	-1.5619	-1.5699	-1.581	0.012717	-0.16061
14	68.232	1.699	-0.20982	-0.95438	-0.96084	-0.96049	0.006266	-0.11191
15	71.08	1.7709	-0.15881	-0.72236	-0.73132	-0.72971	0.0066742	-0.11528
16	65.259	1.5798	-0.30721	-1.3974	-1.4039	-1.4105	0.0092206	-0.13643
17	66.582	1.5682	-0.32849	-1.4942	-1.5019	-1.5109	0.011601	-0.15324
18	70.529	1.8195	-0.10607	-0.48249	-0.48781	-0.48605	0.0026384	-0.072379
19	60.243	1.4624	-0.38784	-1.7641	-1.7814	-1.8001	0.031146	-0.25221
20	68.466	1.5911	-0.31944	-1.453	-1.4633	-1.4713	0.015239	-0.17554
21	69.357	1.7076	-0.20946	-0.95277	-0.96093	-0.96058	0.0079378	-0.12595
22	61.927	1.5051	-0.35743	-1.6258	-1.637	-1.6502	0.018372	-0.19324
23	64.912	1.5441	-0.34039	-1.5483	-1.5555	-1.5662	0.011326	-0.15154
24	67.98	1.6021	-0.30488	-1.3868	-1.3957	-1.4021	0.012583	-0.15936
25	62.675	1.4771	-0.39094	-1.7783	-1.7888	-1.8078	0.01903	-0.19717
26	66.725	1.5441	-0.35367	-1.6087	-1.6171	-1.6297	0.013699	-0.16681
27	66.24	1.5563	-0.33788	-1.5369	-1.5445	-1.5548	0.011809	-0.1547
28	60.184	1.5185	-0.33129	-1.5069	-1.5218	-1.5315	0.023026	-0.21596
29	62.673	1.5051	-0.36289	-1.6507	-1.6605	-1.6745	0.016405	-0.18267
30	62.137	1.5315	-0.33264	-1.5131	-1.523	-1.5327	0.015254	-0.17577
31	72.301	1.5051	-0.43345	-1.9716	-2.0031	-2.0324	0.064492	-0.36441
32	62.95	1.5185	-0.35157	-1.5992	-1.6082	-1.6205	0.014676	-0.17263
33	62.615	1.5315	-0.33614	-1.529	-1.5382	-1.5483	0.014222	-0.16976
34	59.843	1.4472	-0.40015	-1.8201	-1.8395	-1.8608	0.036228	-0.27229
35	71.414	1.4314	-0.50074	-2.2777	-2.308	-2.3571	0.071337	-0.38575
36	61.794	1.4771	-0.38449	-1.7489	-1.7612	-1.7791	0.021848	-0.21116
37	59.448	1.9138	0.069405	0.3157	0.31936	0.318	0.0011892	0.048561
38	63.652	1.9956	0.12041	0.54771	0.55052	0.5487	0.001554	0.055566
39	67.686	2.0414	0.13661	0.62138	0.62517	0.62336	0.0023886	0.068917
40	60.033	1.9345	0.085797	0.39026	0.39425	0.39267	0.0015967	0.056284
41	64.51	1.9731	0.09162	0.41675	0.41872	0.41709	0.00083267	0.040649
42	68.071	2.0414	0.13379	0.60855	0.61254	0.61073	0.0024667	0.07003
43	59.298	1.9085	0.065176	0.29646	0.30001	0.29872	0.0010837	0.046356
44	64.867	2	0.11587	0.52707	0.52953	0.52772	0.0013137	0.051083
45	65.204	1.9823	0.095679	0.43521	0.43724	0.43557	0.00089377	0.042117
46	60.02	1.9191	0.070475	0.32057	0.32385	0.32248	0.0010805	0.04629
47	63.03	1.959	0.088378	0.402	0.40425	0.40265	0.00091537	0.042618
48	64.958	1.9638	0.078996	0.35933	0.36101	0.35952	0.0006096	0.034773
49	59.989	1.9191	0.070704	0.32161	0.32493	0.32355	0.0010951	0.046602
50	61.775	1.9191	0.057616	0.26208	0.26392	0.26276	0.00049264	0.031251
51	63.166	1.9731	0.10147	0.46156	0.46408	0.46236	0.0011811	0.048422
52	57.526	1.9085	0.078161	0.35553	0.36165	0.36016	0.0022695	0.067095
53	59.949	1.9243	0.076197	0.34659	0.3502	0.34875	0.0012832	0.050448
54	62.897	1.9638	0.094101	0.42804	0.43048	0.42882	0.0010609	0.045886
55	57.32	1.8921	0.063275	0.28782	0.29297	0.2917	0.0015507	0.055449
56	61.25	1.9345	0.07688	0.3497	0.35245	0.35099	0.00098045	0.044099
57	62.616	1.9542	0.086616	0.39399	0.39635	0.39477	0.00094422	0.043283
58	56.891	1.9031	0.07742	0.35216	0.359	0.35752	0.0025302	0.070843
59	59.976	1.9031	0.054809	0.24931	0.25189	0.25077	0.00065996	0.03617
60	61.669	1.9395	0.078828	0.35856	0.36114	0.35966	0.00094261	0.04324
61	57.153	1.9243	0.09669	0.43981	0.44795	0.44625	0.0037457	0.086225

62	60.463	1.9345	0.082649	0.37594	0.37944	0.37791	0.001347	0.051694
63	62.056	1.9685	0.10496	0.47744	0.48062	0.47887	0.0015438	0.055363
64	74.183	1.9031	-0.049309	-0.22429	-0.22941	-0.22838	0.0012138	-0.04905
65	58.886	1.9085	0.068194	0.31019	0.31424	0.3129	0.0012976	0.050726
66	60.948	1.9731	0.11772	0.53548	0.53997	0.53816	0.0024553	0.06984
67	57.804	1.8921	0.059728	0.27168	0.27611	0.2749	0.0012514	0.04981
68	64.621	1.9345	0.052177	0.23734	0.23846	0.23739	0.00026858	0.023073
69	64.769	2.0792	0.19577	0.8905	0.89467	0.89383	0.0037598	0.086633
70	58.385	1.8921	0.055471	0.25232	0.25597	0.25484	0.0009557	0.043526
71	61.452	1.9294	0.070324	0.31988	0.32229	0.32092	0.0007856	0.03947
72	65.671	2.0414	0.15138	0.68856	0.69182	0.69011	0.0022695	0.067206
73	54.297	1.8865	0.079828	0.36311	0.37425	0.37272	0.0043619	0.093021
74	63.515	1.9395	0.065302	0.29704	0.29858	0.2973	0.00046517	0.03037
75	68.777	2.2304	0.31767	1.445	1.4559	1.4637	0.016094	0.18037
76	66.367	1.9191	0.023964	0.109	0.10955	0.10904	6.0195e-05	0.010921
77	68.32	2.0414	0.13196	0.60026	0.60439	0.60257	0.0025234	0.070827
78	70.313	2.2304	0.30641	1.3938	1.4084	1.4151	0.02099	0.20585
79	60.235	1.9345	0.084319	0.38354	0.38729	0.38573	0.0014747	0.054089
80	66.024	2	0.1074	0.48851	0.49087	0.48911	0.0011698	0.048195
81	70.432	2.2304	0.30554	1.3898	1.4048	1.4114	0.021427	0.20798
82	65.028	1.959	0.073739	0.33541	0.33698	0.33556	0.00053077	0.032445
83	65.814	2	0.10894	0.49552	0.49788	0.49611	0.0011852	0.048513
84	69.471	2.2788	0.36089	1.6416	1.656	1.6699	0.024161	0.22167
85	61.435	2.0414	0.18242	0.82976	0.83603	0.83484	0.0053046	0.10285
86	70.219	2.0792	0.15583	0.70884	0.71615	0.71449	0.0053171	0.10288
87	72.641	2.2553	0.31418	1.4291	1.4535	1.4612	0.036345	0.27105
88	64.914	2	0.11553	0.5255	0.52795	0.52615	0.0013047	0.050907
89	67.07	2.0792	0.17891	0.8138	0.81827	0.81698	0.0036865	0.085732
90	71.35	2.2041	0.27249	1.2395	1.2557	1.2592	0.020832	0.20468
91	60.523	2.0414	0.1891	0.86017	0.86808	0.86706	0.0069586	0.11783
92	66.246	2.0414	0.14716	0.6694	0.67271	0.67096	0.0022415	0.066781
93	72.089	2.2553	0.31822	1.4475	1.4696	1.4778	0.033256	0.25933
94	59.433	2.0414	0.19709	0.89649	0.90692	0.90615	0.0096197	0.13859
95	67.846	2.1139	0.20798	0.94605	0.95199	0.95157	0.005706	0.10678
96	70.818	2.1761	0.24836	1.1297	1.1429	1.1446	0.015413	0.17583
97	76.52	2.0414	0.071871	0.32692	0.33797	0.33655	0.0039267	0.088248
98	67.021	2.0414	0.14148	0.64356	0.64706	0.64528	0.0022879	0.067459
99	70.083	2.1461	0.22377	1.0179	1.0281	1.0283	0.010639	0.14591
100	57.57	2	0.16935	0.77032	0.78346	0.78202	0.010558	0.14505
101	65.953	2.0792	0.1871	0.85104	0.85514	0.85405	0.0035304	0.083921
102	68.675	2.1461	0.2341	1.0648	1.0727	1.0735	0.008552	0.13088
103	64.328	2.0414	0.16122	0.73331	0.73683	0.73523	0.0026075	0.072059
104	65.361	2.0792	0.19143	0.87077	0.87485	0.87387	0.0035872	0.084608
105	67.578	2.1461	0.24214	1.1014	1.108	1.1092	0.0073567	0.12143
106	60.516	2	0.14776	0.67212	0.67831	0.67657	0.0042552	0.092016
107	63.839	2.0414	0.16481	0.74964	0.7534	0.75185	0.0028485	0.075324
108	65.838	2.1461	0.25488	1.1594	1.1649	1.1669	0.0064985	0.1142

Suspended Sediment Monitoring during Pre-Installation Trials for the Champlain Hudson Power Express Project

Hudson River Report

NYSPSC Certificate Case 10-T-0139

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Acronyms and Abbreviations

ABS	Acoustic backscatter
ADCP	Acoustic Doppler current profiler
Alpha	Alpha Analytical, Inc.
APHA	American Public Health Association
BDL	Below the method detection limit
C	Celsius
Certificate	Certificate of Environmental Compatibility and Public Need
CHPE	Champlain Hudson Power Express
CMI	Caldwell Marine, Inc.
COC	Chain of custody
CTD	Conductivity-temperature-depth sensors
ft	feet
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HVDC	High voltage direct current
mL	Milliliters
The Monitoring Plan	Suspended Sediment / Water Quality Monitoring Plan for CHPE (2020 revision)
Normandeau	Normandeau Associates, Inc.
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDPS	New York State Department of Public Service
NYSPSC	New York State Public Service Commission
OBS	Optical backscatter
PCBs	Polychlorinated biphenyls
PSU	Practical Salinity Units
QAPP	Quality Assurance Project Plan
QC	Quality control
SM	Standard Method
SOP	Standard operating procedure
TRDI	Teledyne RD Instruments
TSS	Total suspended solids
USGS	United States Geological Survey
VMT	Velocity Mapping Toolbox
WQC	Water Quality Certification pursuant to Section 401 of the Federal Water Pollution Control Act, 33 U.S.C § 1341, and Article VII of the New York Public Service Law

Executive Summary

CHPE LLC contracted Normandeau Associates, Inc. (“Normandeau”) to conduct suspended sediment and water chemistry monitoring to assess the levels of sediment resuspension from the jet plow operations during the pre-installation trial in the Hudson River. Additionally, a secondary objective of the pre-installation trial monitoring was to describe quantitative relationships (if any) among the acoustic and optical backscatter data with the laboratory-derived total suspended solids (“TSS”) data in attempt to calibrate remote sensing methods for near real-time TSS monitoring during the submarine cable installation activities anticipated to occur from 2024 through 2025. The intent of the TSS sampling during the trials was to monitor sediment plumes from the jet plow operations for potential exceedance of TSS standards set forth in CHPE, LLC’s Section 401 Water Quality Certificate (“WQC”). This report documents the activities and results from TSS monitoring during the pre-installation trial in the Hudson River.

The pre-installation jet plow trial occurred along a 2,640-foot route in Hudson River on September 9, 2022. Laboratory analysis of TSS from water samples collected during the jet plow trial showed low to slightly elevated levels of TSS, but none approached exceeding ambient concentrations by 200 mg/L as per the condition described in the WQC, and all but two samples showed increases in TSS less than 10 mg/L. An increase of 55 mg/L was the maximum observed value above background for TSS levels during the jet plow trial; however, TSS levels were generally within 10 mg/L of ambient levels. It appears likely that any sediments that are resuspended due to the plow operations would only be observed as TSS at the 500-foot distance from the barge within a small width of cross-sectional area (estimated from a few feet [“ft”] to 30-35 ft wide, depending on conditions, when observable) and primarily during the times surrounding peak tidal currents within the tidal cycle.

The survey operation included an acoustic Doppler current profiler (“ADCP”) to collect vertical profile measurements of current velocity and relative acoustic backscatter (“ABS”); a multi-parameter sonde to collect vertical profile measurements of conductivity (salinity), temperature, and depth (“CTD”); and an optical backscatter (“OBS”) sensor to measure turbidity. Water samples for TSS analysis were collected concurrently with the OBS and ABS data before, during, and after the trial. These concurrent and co-located TSS, OBS, and ABS data were used to develop calibration curves to attempt to estimate TSS from both OBS and ABS data.

Statistically significant and well-correlated calibration relationships were established for TSS to both OBS and ABS, with the strength of the OBS-TSS regression indicating that OBS may be a better predictor of TSS values between the two methods (in the conditions similar to those sampled during the trials). Different hydrological or background sediment characteristics could result in variability of these calibrations. However, the ABS from ADCP provides a remote profiling instrument capable of sampling the entire water column (i.e., without being physically lowered from a vessel at a point), which is useful for locating potential sediment plumes. Based on the results from the Hudson River jet plow trial, and primarily due to the apparent variability and scale of the observable suspended sediment plume induced by the jet plow, the ADCP may be helpful in determining if a potential plume is present at 500 ft down-current from the plow and where to sample for CTD-OBS and confirmatory TSS from water samples. The ABS contour plots demonstrate that the sediment plume is observable remotely, and based on these observations, the presence and spatial variability of the plume across conditions and tides can be confirmed. While the ABS could also provide an additional estimate of near real-time TSS levels during future monitoring activities, the ABS-TSS correlation exhibited the highest degree of uncertainty among the OBS and ABS sampling methods. As such, for conditions encountered in this region of the Hudson River, the OBS sensor may be more appropriate for guiding compliance decisions during active construction.

In summary, the pre-installation trial in the Hudson River demonstrated that (1) jet plow activities produced either no observable plume or a small area of slightly elevated TSS levels within a cross-sectional transect that were well below the TSS standards identified in the WQC (at most approximately 27% of the standard for elevation above background levels); (2) the ADCP was able to detect the presence and location of a suspended sediment plume at 500 ft down-current of the plow, although one was not always observed during the trial; and (3) both the remote sensing calibrations to TSS exhibited moderate (ABS) to high (OBS) predictive power. While these calibration relationships are subject to modification during the installation phase of the Project to reflect hydrological and sediment conditions that may not have been encountered during the trials, the regression results suggest that the use of the calibration curves developed as part of the trial, particularly the OBS-TSS calibration, would be appropriate for the start of the installation phase in the Hudson River.

1 Introduction

1.1 Background

The Champlain Hudson Power Express ("CHPE") transmission project ("Project") in Lake Champlain and the Hudson River will install a high-voltage direct current ("HVDC") electric transmission line capable of delivering up to 1,250 megawatts of clean renewable energy from hydroelectric generation facilities in Canada to New York City. The electric transmission line will consist of two HVDC cables buried underwater or underground. The submarine segment of CHPE transmission route is approximately 192 miles, where 97 miles are in Lake Champlain and 95 miles are in the Hudson, Harlem, and East Rivers. Prior to commencing submarine installation activities, pre-installation trials are required to be conducted in Lake Champlain and the Hudson River to test operational conditions of the jet plow and shear plow equipment to be used during the installation process. This report provides the results of the pre-installation trial in the Hudson River.

1.2 Regulatory Overview

A Certificate of Environmental Compatibility and Public Need ("Certificate") for the Project was issued effective by the New York State Public Service Commission ("NYSPSC") on April 18, 2013. The Certificate contains several conditions for installation of the submarine portion of the CHPE route, including certain studies, which were adopted from the Joint Proposal of Settlement for Case 10-T-0139. One of these requirements was monitoring of suspended sediment and water quality chemical parameters in the water column during pre-installation trials of the jet plow equipment to be used during cable installation. On October 18, 2013, CHPE submitted a monitoring plan titled *Suspended Sediment / Water Quality Monitoring Plan* (i.e., "the Monitoring Plan"). The Monitoring Plan was developed in conjunction with the Project's Water Quality Certification pursuant to Section 401 of the Federal Water Pollution Control Act, 33 U.S.C § 1341, and Article VII of the New York Public Service Law Section 401 ("the WQC"), as well as comments received from the New York State Department of Environmental Conservation ("NYSDEC") and the New York State Department of Public Service ("NYSDPS").

1.3 Objectives

The Monitoring Plan outlined the requirements for the suspended sediment and water quality monitoring during pre-installation trials of the jet plow equipment, specifically the monitoring of total suspended solids ("TSS") and chemical parameters in the water column during the pre-installation trials. The objectives of the TSS monitoring program were to assess the amount of sediment resuspension in the water column during operation of the jet plow, and to make potential recommendations (if any) for modifications to the jet/shear plow operation or monitoring procedures based on the results of the pre-installation trials.

CHPE, LLC contracted Normandeau Associates, Inc. ("Normandeau") to conduct the TSS and water quality monitoring during the pre-installation trials which included, but was not limited to, collection of site-specific measurements of TSS from water samples, concurrently with measurements of acoustic and optical backscatter to assess the levels of sediment resuspension from the jet and shear plow operations during the pre-installation trials in Lake Champlain and the Hudson River. During the Hudson River trial, an additional survey vessel and crew performed water quality sampling for chemical parameters identified in the WQC and the Monitoring Plan (Table 1-1).

Additionally, a secondary objective of the pre-installation trial monitoring was to attempt to describe quantitative relationships (if any) among the acoustic and optical backscatter and laboratory derived TSS data for potential development of remote sensing methods for near real-time TSS monitoring during the submarine cable installation activities anticipated to occur from 2024 through 2025. The intent of the TSS monitoring during the trials was to assess the potential observable impact from the plow operations, with respect to the standards set forth in the WQC. This report documents the activities associated with the monitoring of TSS and water quality chemical parameters during the pre-installation trials in the Hudson River.

Table 1-1. Water Quality Analytical Parameters for Laboratory Analysis of Samples collected for Chemical Analysis during Pre-Installation Trials (9-Sep-2022) in the Hudson River for CHPE.

Parameter	SW-846 Method[1]	Standard	Units
Phenanthrene	EPA 8270D-SIM	45	µg/L
Total PCBs	EPA 8082A	0.09	µg/L
Total Mercury	EPA 1631E	0.7	µg/L
Dissolved/Total Cadmium	EPA 200.8	5	µg/L
Dissolved/Total Copper	EPA 200.8	200	µg/L
Dissolved/Total Lead	EPA 200.8	50	µg/L
Total Suspended Solids	SM 2540D	N/A	mg/L
Hardness	EPA 6010D	N/A	mg/L

[1]United States Environmental Protection Agency ("USEPA") Hazard Waste Test Methods (USEPA 2015).

1.4 Project Location

The pre-installation trial documented in this report occurred on September 9, 2022 in the Hudson River, north of the Newburgh-Beacon Bridge near Chelsea, NY. Figure 1-1 presents an overview map of the site location for the jet plow trial, with the coordinates provided by CHPE's marine construction contractor, Caldwell Marine, Inc. ("CMI"). The trial route was planned to be approximately 2,640 feet ("ft") in length.

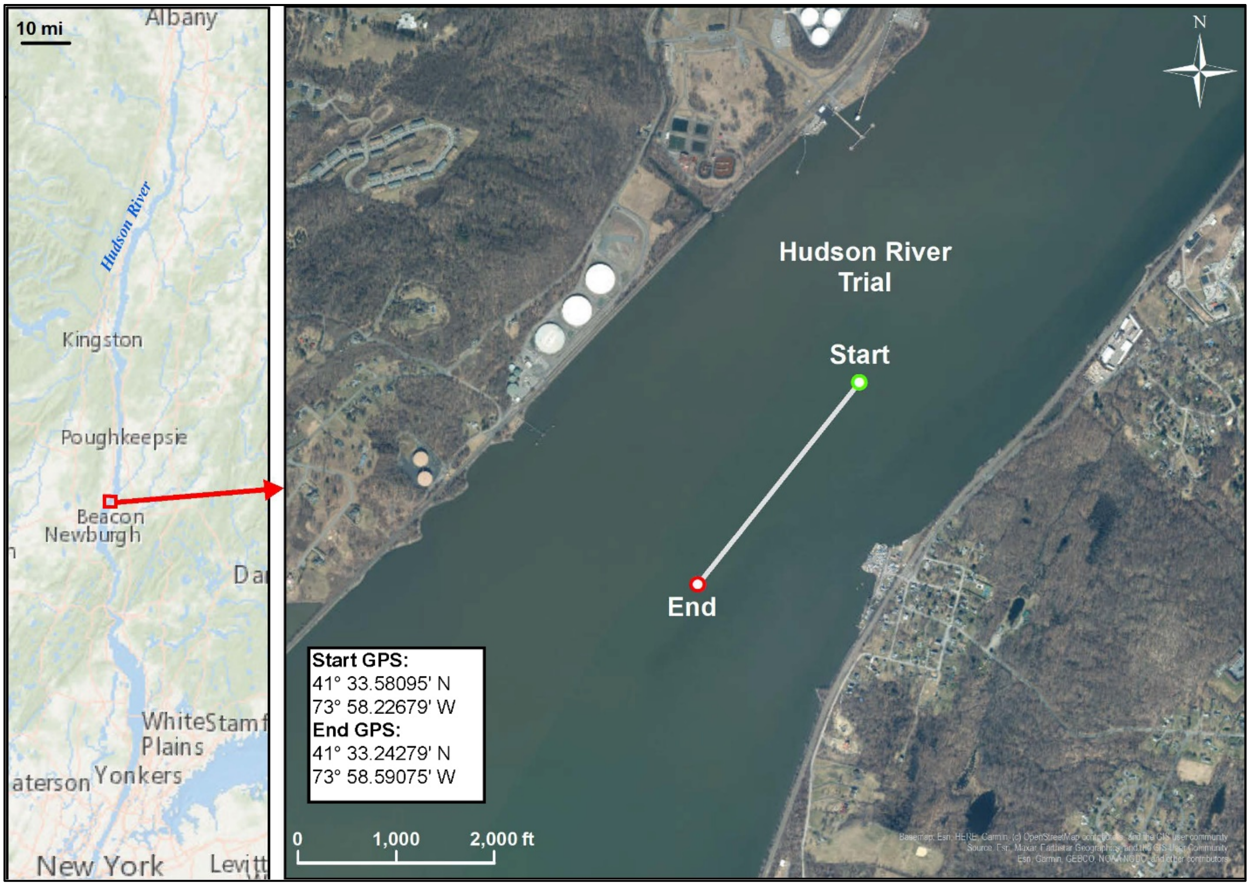

Figure 1-1. Overview of the Project site location for the Pre-Installation trial in the Hudson River, in the vicinity of Chelsea, NY. The planned start and end points of the jet plow trial route are presented.

2 Methods

2.1 Field Sampling

The survey operation included an acoustic Doppler current profiler ("ADCP") to collect vertical profile measurement of current velocity and relative acoustic backscatter ("ABS"); a multi-parameter sonde to collect vertical profile measurements of conductivity (salinity), temperature, and depth ("CTD"); an optical backscatter ("OBS") sensor to measure turbidity, a stainless steel Kemmerer water bottle sampler to collect samples for subsequent laboratory measurements of TSS, and an acrylic Kemmerer water bottle sampler to collect samples for chemical analyses. Data were georeferenced by the Global Positioning System ("GPS").

For the Hudson River trial, the procedures outlined in the Monitoring Plan were applied for each "TSS sampling event", which consisted of the following sampling activities:

1. ADCP measurements collected at the up- and down-current side of the plow, to confirm current direction, and to potentially estimate the location of a potential suspended sediment plume for down-current sampling;

2. Stationary collection of CTD-OBS measurements and water sampling to collect concurrent and co-located water samples for TSS at near-surface, mid-depth, and near-bottom depths in the water column; and
3. Concurrent ADCP measurement at the same near-surface, mid-depth, and near-bottom depths in the water column during the CTD-OBS and water sampling, to provide simultaneous ABS data.

These measurements were performed at approximately 500 ft up- and down-current of the plow as was practicable and safely navigable to achieve. The 500 ft up- and down-current distance was specified in the Monitoring Plan after the requirements in the WQC. The sampling locations on either side of the plow/barge were to be sampled as often as possible given the conditions during the duration each trial, with ADCP transects and discrete sampling conducted as outlined above and described further below. During preparation for the trial monitoring, it was determined that consistently sampling from the north-to-south side of the plow and barge would be more efficient logistically, and enable more samples to be collected, as opposed to switching the up/down-current sample collection order based on the tidal currents (which were predicted to switch directions twice during the trial period). This was done to improve communication with the other sampling teams on the water, not directly connected to the pre-installation trials monitoring.

During the Hudson River trial, an additional survey vessel collected water quality samples for the chemical parameters identified in the Monitoring Plan and WQC for Class A waters, alongside of the TSS monitoring (Table 1-1). As outlined in the Monitoring Plan and WQC, a chemical sampling event was performed for each change in jet plow speed: the plow traversed the route at speeds of 5 ft/min in the first 660 ft of route, 10 ft/min for the middle 1,320 ft of the route, and 5 ft/min for the last 660 ft of route, with a chemical sampling event for each speed segment. The second vessel and crew conducting the chemistry sampling worked alongside the primary survey vessel conducting the remote sensing and TSS monitoring, following the same protocol above in sequence with the ADCP, CTD-OBS, and TSS sampling, but only collected discrete water samples at each station for the lab analysis of the chemical parameters outlined in the Monitoring Plan and WQC (Table 1-1). During the respective trial sampling events (3 events for water chemistry, 10 events for TSS monitoring), the water chemistry samples were collected at each up-current and down-current station location immediately following collection of the ADCP, CTD-OBS, and TSS samples.

2.1.1 Equipment

Current velocity and ABS measurements were collected with a Teledyne RD Instruments ("TRDI") 600 kHz Workhorse Sentinel ADCP, attached to an aluminum pole mount deployed from the starboard side of Normandeau's 24-foot survey vessel and submerged 0.67 m below the water surface as measured to the ADCP transducer faces. A Hemisphere Vector V500 Global Navigation Satellite System ("GNSS") receiver and antenna was mounted on the top of the pole 2.33 m directly above the ADCP and was used to collect GPS coordinates for georeferencing the ADCP data and survey navigation. A weatherproof laptop computer was used on the vessel to acquire data for the surveys. The GPS signal was configured to supply positional data to HYPACK navigation software (HYPACK, version 21.0.2.0) for real-time positioning of the vessel, and to TRDI's WinRiver II (WinRiver II, version 2.23) data acquisition software for ADCP calibration, testing, and measurements. WinRiver II allowed configuration and saving of the ADCP sampling parameters for the survey, confirmation of the GPS signal integration with the ADCP data, and the ability to review the raw data in real-time while the survey was underway. The ADCP, V500 GNSS antenna, survey laptop, and additional computer monitor were powered from a sine wave power inverter onboard the vessel. A Garmin® handheld laser rangefinder was used in the field to assess distance from the barge/plow in real-time for setting the location of the ADCP transects and CTD-OBS sampling stations.

Prior to each day's survey activities, the ADCP passed all internal system and sensor tests performed with WinRiver II. ADCP compass calibrations were also conducted at the Project area each day with the ADCP in the deployed configuration per the manufacturer recommendations (TRDI 2020, 2021; Mueller et al. 2013). The ADCP was configured such that the acoustic signal would adequately profile the entire water column under the anticipated water quality conditions and expected site depths (up to 18 m [59 ft]). The ADCP was configured to collect data in 0.5-m depth layers with respect to vertical range from the ADCP (referred to herein as "bins"), with transmit acoustic pulses ("pings") set to sample fast as possible, which yielded a raw profile sampling rate of approximately two pings per second (2 Hz) for most profiles. This configuration was chosen to allow for the transects to be sampled at as high a resolution as possible with respect to the vertical axis while ensuring an acoustic profile range that extended to the river bottom and allowed for maximum data retention for analysis.

Water quality and turbidity measurements were collected with a YSI EXO3 multi-parameter sonde for CTD-OBS data collection and recorded digitally with the sonde's handheld controller during sample collection. The CTD-OBS was configured to sample at the fastest rate possible (2 Hz) to capture as much data per sample location as possible. The YSI sensors were calibrated prior to each survey per the manufacturer's recommendations and methods (YSI 2019).

Water samples for laboratory analysis of TSS were collected with a 2.2-liter Wildco® stainless-steel Kemmerer sampler. The Kemmerer sampler and CTD-OBS were mounted together with two bracket clamps such that the sampling depth of the water sample and CTD-OBS data would be co-located with respect to the water column, as practicable given the current flow. A diagram of the sampling equipment with respect to the vessel and deployment with depth is presented in Figure 2-1.

The second survey vessel (25-ft Parker) and crew mobilized to sample alongside the primary survey vessel (described above and in Section 2.1) to conduct the water chemistry monitoring and collected water samples sufficient for laboratory analysis of the chemical parameters identified in Table 1-1. These water samples were collected with an 8.2-liter Wildco® acrylic Kemmerer sampler, suitable for chemical and trace metal sampling.

All field data collection methods followed recommendations, guidelines, procedures, and methods outlined in the respective manuals for sampling equipment (i.e., ADCP, GPS, CTD-OBS, and Kemmerer samplers).

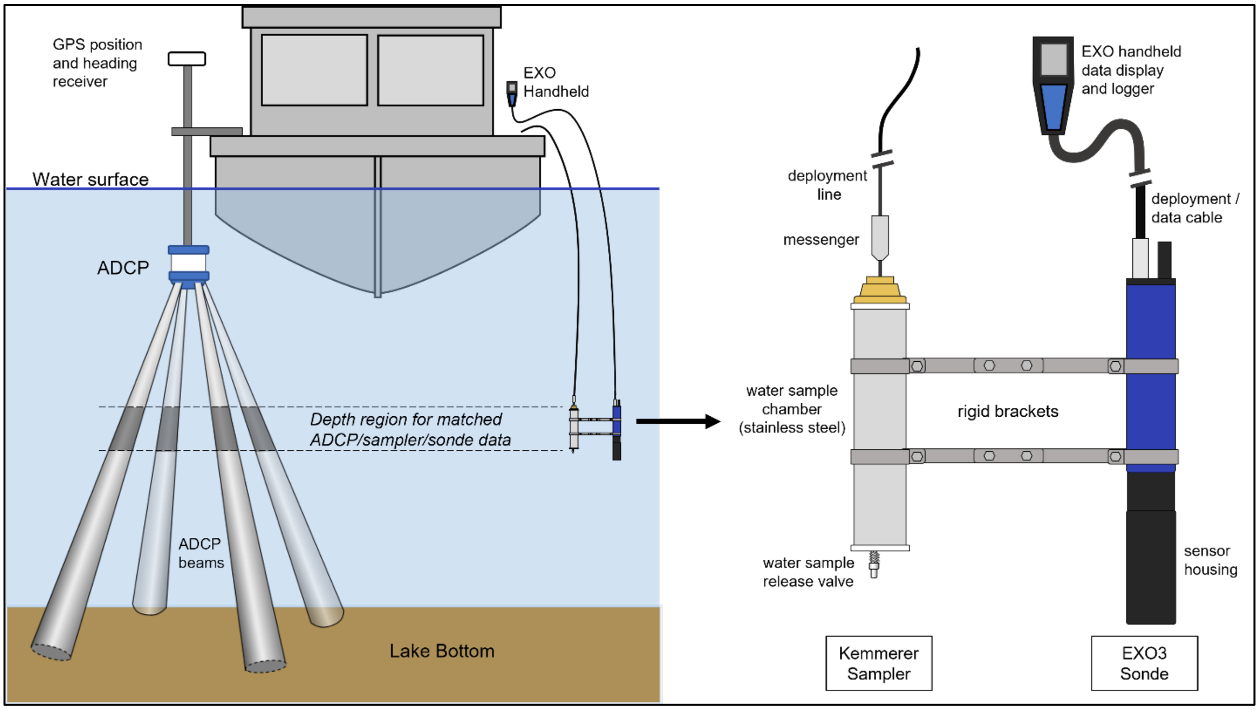

Figure 2-1. Sampling equipment schematic diagram showing the relative deployment positioning of the ADCP, CTD-OBS, and Kemmerer sampler with respect to the vessel and water column on the left-hand side. To the right is a zoomed diagram of the design of the CTD-OBS-Kemmerer mount used during TSS monitoring.

2.1.2 Sample Collection

During the Hudson River pre-installation trial, sampling occurred at approximately 500 ft up- and down-current of the jet plow. Once notified by personnel from CMI that the plow had commenced the trial, the procedure for each "TSS sampling event" was performed until the approximately 2,640-ft long trial route was completed. For each TSS sampling event, the shipboard processing occurred iteratively as follows:

1. Survey vessel attempted to verify current direction by performing two ADCP transects to collect current velocity data and confirm which side of the plow and barge were up- and down-current.
    a. Note: for the Hudson River trials, the tidal currents were predicted to reverse direction two times during the trial with predicted slack currents at 08:30 and 14:18 on September 9, 2022. Therefore, it was determined that the survey vessel would sample in a north-to-south pattern, to improve efficiency and logistics in the field at the start of the trial, and up- and down-current locations were assigned based on the tidal currents and presence/absence of a potential suspended sediment plume.
2. After collecting the ADCP transects, the vessel navigated to the north side of the plow, approximately 500 ft distance from the jet plow and in line with the plow route as best as possible, and recorded GPS coordinates and station metadata for the up-current sampling station (e.g., date/time, weather and sea state conditions, etc.).
3. A "stationary" ADCP measurement, as practicable given conditions, was started once on-station at the up-current sampling location to record concurrent ABS data with the CTD-OBS and water samples for TSS. This station's file was used to collect ABS data during the entire up-current station's sampling for CTD-OBS and water samples.

4. After starting the ADCP measurement, the CTD-OBS and Kemmerer sampler were prepared for deployment, with samples collected from near-surface, mid-depth, and near-bottom levels in the water column (but within the valid measurement range of the ADCP’s acoustic beams).
5. For each sampling depth, the CTD-OBS and coupled Kemmerer sampler were lowered to the depth being sampled based on the real-time readout from the CTD-OBS handheld controller. Once at depth (e.g., 10 ft), the equipment was held in position for approximately 20 seconds before triggering the Kemmerer sampler to close. The equipment was then held in position for another 20 seconds prior to recovery to provide a sufficient time for data collection of OBS and ABS data to assess for remote sensing correlation to TSS (described in Section 3.2).
6. When the Kemmerer sampler was at the required predetermined depth, a messenger weight was released down the connecting line to the sampler which triggered the sampling device to close. Upon retrieving the Kemmerer sampler, the first 10-20 mL of the collected sample was discharged to clear any potential contamination on the valve. The remaining sample was collected in lab-provided 950 mL containers which were labeled, secured, and stored on ice while on the survey vessel.
7. Steps 5 and 6 were repeated and reported for near-surface, mid-depth, and near-bottom at each sampling station.
8. After three samples were collected at the north side of the plow, the survey vessel navigated to the south side of the plow to repeat Steps 1 through 7. This process generally took from 10-15 minutes for each up/downriver side of the plow, and 25-35 minutes per pair of up/downriver sampling stations (i.e., “Pass”), when including navigation time.
    a. While collecting ADCP transects on the down-current side of the plow (north or south depending on tidal currents), the raw ABS data from the ADCP were reviewed in real-time to attempt to estimate the position of a suspended sediment plume, if there is one observed at 500 ft distance. When no potential plume was observed, then the down-current samples were also collected as close to in line with the plow route as possible.
9. After the south station’s sampling was completed, the vessel navigated back to the north side of the plow and repeated the entire process.

For the water chemistry sampling, “chemistry sampling events” were conducted by the second survey vessel alongside of the TSS monitoring vessel, with only one chemistry sampling event for each change in jet plow speed. The planned trial route was to be conducted at two speeds, 5 ft/min for the first and last 660 ft of the route and 10 ft/min for the middle 1,320 ft of the route. For the chemistry sampling events, the second vessel coordinated with the TSS monitoring vessel to collect the water chemistry samples in sequence with the ADCP, CTD-OBS, and TSS water samples at each up/downriver station location to complete a chemistry sampling event (i.e., the water chemistry samples were not collected on every TSS monitoring Pass).

After being notified by CMI that the pre-installation trial was completed, an additional Pass of sampling was conducted with the up-current and down-current locations being collected at the mid-point of the trial route, and south of the plow and barge, respectively, and one additional water chemistry station was sampled at the mid-point of the trial route. ADCP, CTD-OBS, and TSS sampling locations for each Pass are presented in Figure 2-2, Figure 2-3, and Figure 2-4.

After completion of the jet plow trial, samples were transferred to Alpha Analytical, Inc. (“Alpha”), the laboratory used for the TSS and chemical analyses, as described in more detail in Section 2.1.3. In addition to the sampling steps described above, a full-water-column CTD-OBS profile was collected before the trial to provide initial background water column conditions.

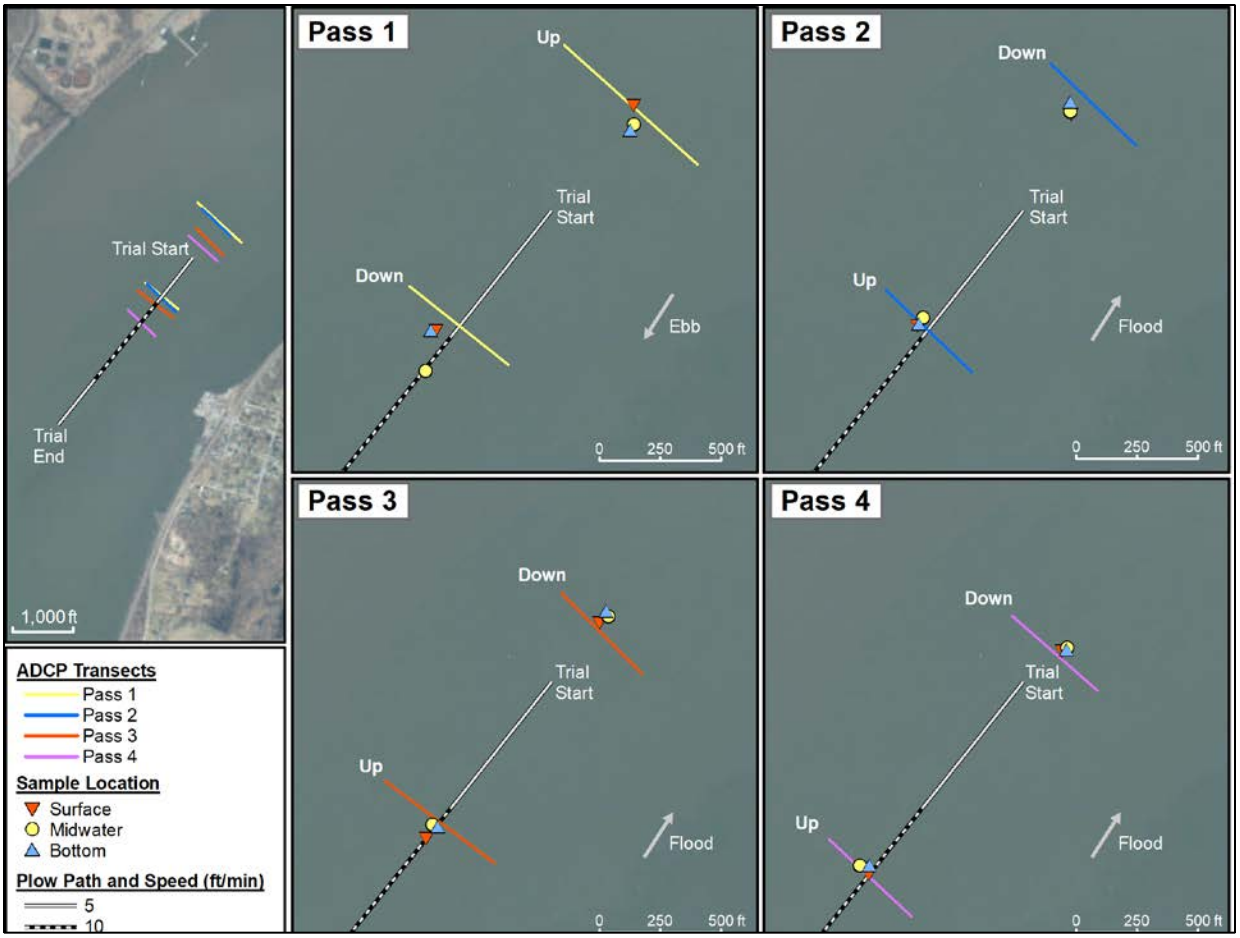

Figure 2-2. Summary of the sampling locations for Passes 1 through 4 before and during the pre-installation jet plow trial during 9-Sep-2022 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The jet plow route for the trial is shown as white or dashed black line indicating the sections of the trial route that the plow was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.

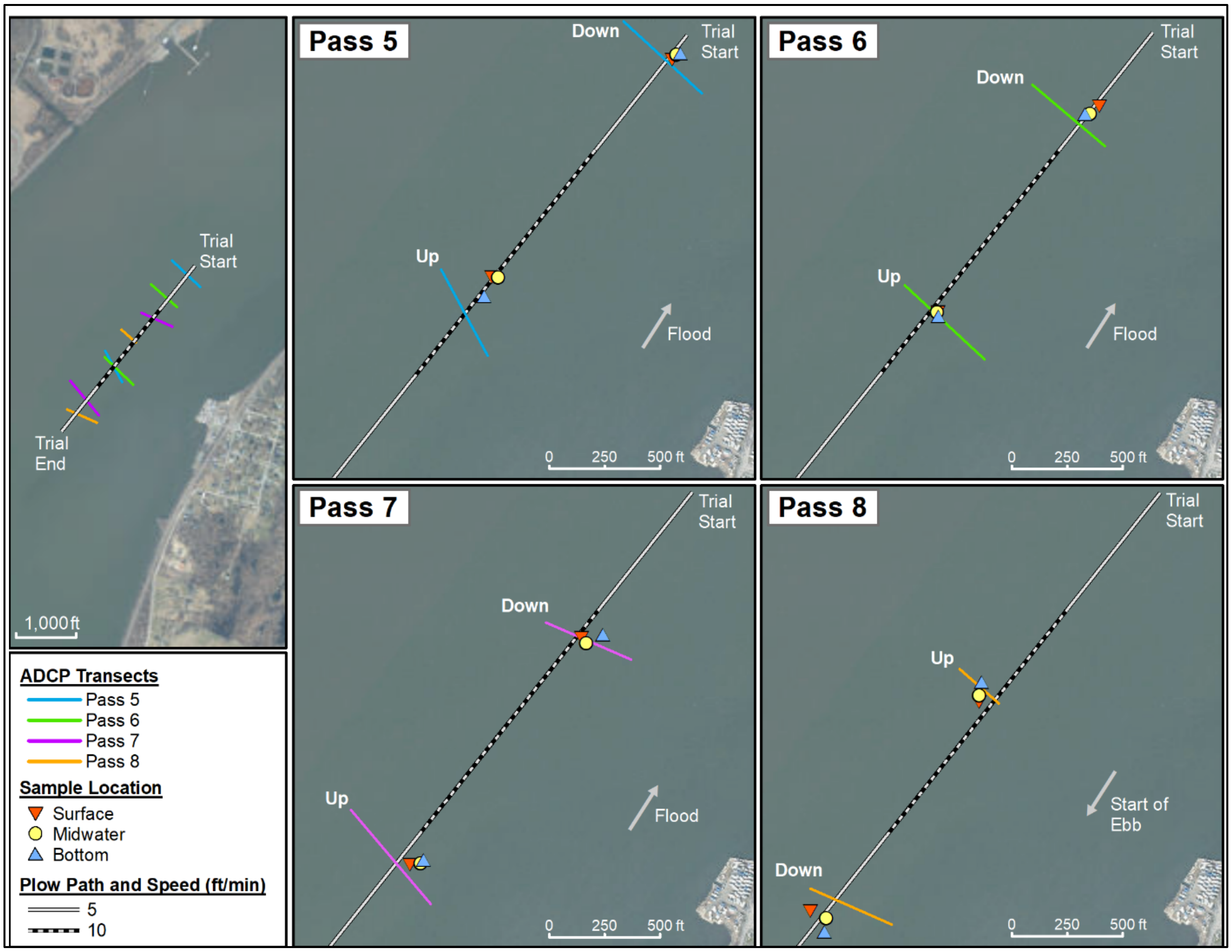

Figure 2-3. Summary of the sampling locations for Passes 5 through 8 before and during the pre-installation jet plow trial during 9-Sep-2022 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The jet plow route for the trial is shown as white or dashed black line indicating the sections of the trial route that the plow was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.

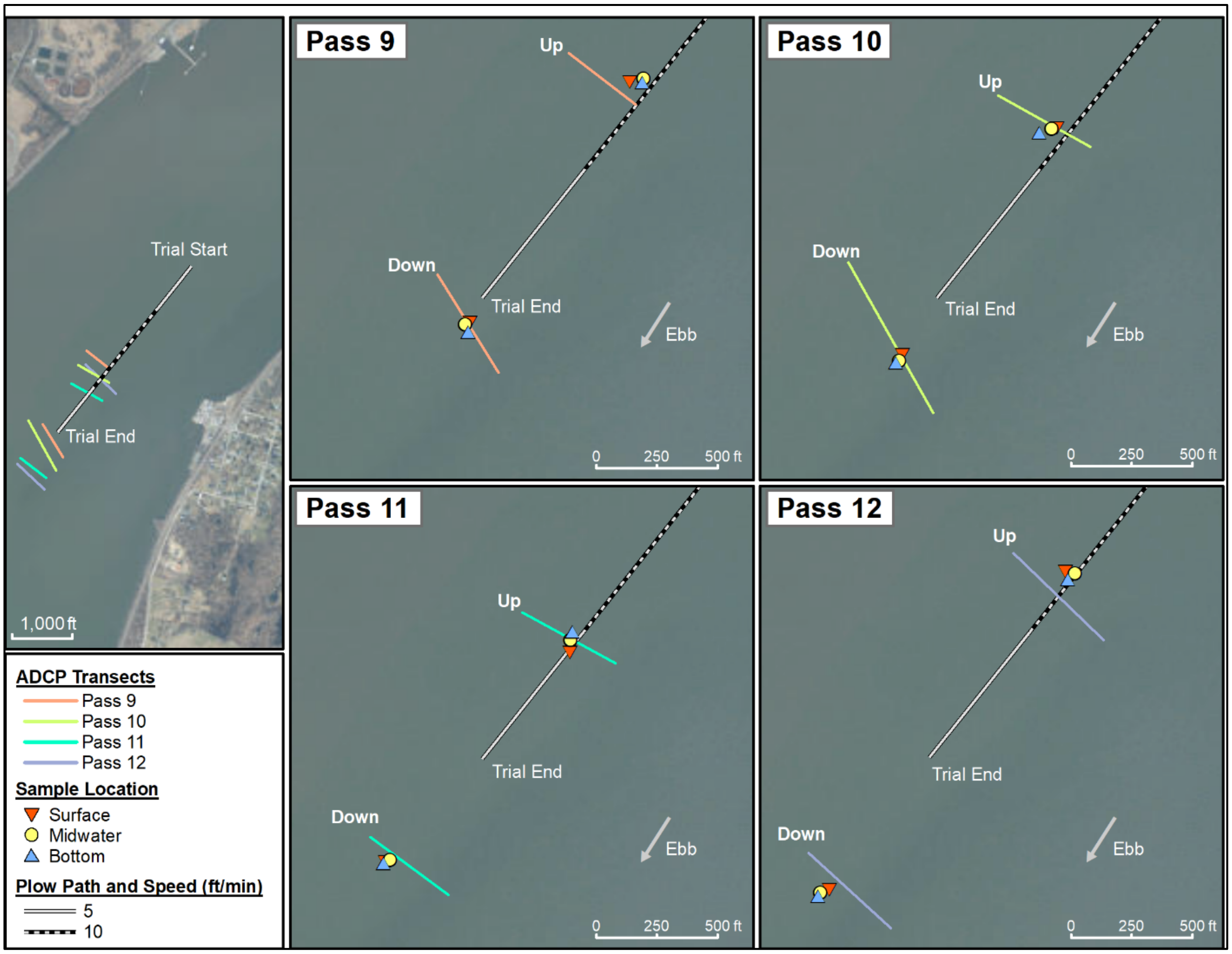

Figure 2-4. **Summary of the sampling locations for Passes 9 through 12 before and during the pre-installation jet plow trial during 9-Sep-2022 in the Hudson River near Chelsea, NY. The left panel presents a plan view of the entire trial route length and includes sampling locations for the Passes shown in the zoomed views in each of the other four panels. The jet plow route for the trial is shown as white or dashed black line indicating the sections of the trial route that the plow was operating at 5 or 10 feet per minute. Colored lines indicate the ADCP transect paths for each respective up/down-current position for each Pass ("Up" and "Down" indicated on each panel). The TSS sampling locations are shown for each Pass and Location by collection depth for near-surface ("Surface"), mid-depth ("Midwater"), and near-bottom ("Bottom") layers. Mean tidal current direction during each Pass is labeled on the panels and indicated by the arrow towards the direction of current flow.**

2.1.3 Water Sample Handling for TSS and Chemical Analyses

After completion of the trial, the water samples (stored on ice in coolers) were processed onshore in preparation to be transferred to a courier for Alpha, per the specifications required by the lab. All sample jar labels were reviewed against the field notes to confirm sample locations and times, and this information was provided to Alpha in the Chain-of-Custody ("COC") forms. The water samples were packed with enough packing material to prevent movement during shipping, with care taken not to pack materials too tightly. Transfer of samples occurred via couriers provided by Alpha, and all samples were kept on ice in coolers during transport.

2.2 Analytical Methods

2.2.1 Water Quality and TSS

The CTD-OBS data were processed using a combination of the manufacturer's software (YSI) and Normandeau-developed post-processing routines in MATLAB® software (MathWorks; Natick, MA). Each CTD-OBS data file corresponded to a concurrent and co-located water sample, as described in Section 2.1, and was truncated to approximately 30 seconds coincidental to the water sample collection. For each measurement file, the parameters recorded at 2-Hz sampling intervals were averaged over the ~30-second water sampling interval to provide the concurrent CTD-OBS data (i.e., temperature [degrees Celsius, "°C"], depth [ft], salinity [Practical Salinity Units, "PSU"], turbidity/OBS [Nephelometric Turbidity Units, "NTU"]) with the TSS data from the water sample.

All water samples collected during the trials as part of the TSS monitoring were analyzed for TSS by Alpha utilizing the laboratory analysis of dry weight TSS following Standard Method ("SM") 2540D (APHA 2018). The CTD, OBS, and TSS data were then compiled into a data table in MATLAB® with paired up-current and down-current data for each TSS sampling event (i.e., Pass), to assess whether there were observable differences in TSS levels down-current of the jet plow operation during the pre-installation trials. Additionally, the OBS data were compiled with the paired TSS data to develop a calibration relationship, if one existed, between OBS measured in the field and the lab-analyzed TSS data, using the OBS (predictor) with the TSS concentration (response). Linear modeling tools in MATLAB® software ("fitlm" function) were used to assess the relationship between OBS and TSS, detailed below in Sections 2.2.3 and 3.2.1.

The water chemistry data were also compiled separately into a data table in MATLAB® with paired up-current (i.e., for background) and down-current (i.e., for potential sediment plume) data for each chemistry sampling event, to assess whether there were any levels that exceeded the standards defined in the WQC (Table 1-1).

2.2.2 ADCP Data

2.2.2.1 Relative Acoustic Backscatter

The ABS was processed from the stationary ADCP profile measurements recorded at each up/down-current station collected concurrently with the CTD-OBS and water samples described above. The raw ADCP data were processed using a combination of manufacturer's software (TRDI) and Normandeau-developed post-processing routines in MATLAB® software. All raw ADCP data were first reviewed in the manufacturer's software which included checks on all acoustic parameters provided by the ADCP, verification of sampling configuration (e.g., compass and transducer depth offsets), and confirmation of the start and end times for each transect. During preliminary review, the raw ADCP data were pre-processed in WinRiver II using the quality control ("QC") parameters set based on the configuration settings in the field and each data file was examined for potential interference, bottom detection signal issues, and/or impacts from vessel wakes or sea state conditions (Mueller et al. 2013; Engel and Jackson 2017). The pre-processed data were then exported from WinRiver II as ASCII text files and imported into MATLAB for additional post-processing.

The ABS data were collected to attempt to calibrate the ABS to the lab-analyzed TSS from the concurrent water samples to develop a predictive relationship for estimating TSS in the field (*in situ*), following an established approach from numerous studies. The raw echo signal intensity is measured by the ADCP, which is proportional to the concentration of particles (i.e., suspended sediment, plankton, detritus), but to properly calibrate the ABS to TSS, it requires accounting for the losses due to acoustic beam spreading and acoustic absorption by water. A full derivation of the calculation of ABS is excluded here, but is well-documented in recent literature (Deines 1999; Gartner 2004; Wall et al 2006; Gostiaux and van Haren 2010; Wood and Gartner 2010; Mullison 2017). The approach relies on a simplified version of the sonar equation to determine the ABS (in dB) for each ADCP bin per ping shown below:

$$ABS = 10Log_{10}\left[\left(\frac{\sum_{i=i}^{4}\left(10^{K_{ci}(E_i - E_{ri})/10}\right)}{4}\right) - 1\right] + 20Log_{10}(R\gamma) + 2\alpha_w R \qquad \text{(Equation 1)}$$

where K_{ci} = beam-specific ADCP conversion factor from echo intensity counts to decibel (dB),
E_i = raw echo intensity, in counts, for each beam *i*,
E_{ri} = raw echo intensity noise floor, in counts, for each beam *i*,
R = range along the acoustic beams, in meters,
γ = near field correction factor for non-spherical spreading of energy close to the ADCP transducers (dimensionless), and
α_w = acoustic attenuation coefficient due to sound absorption by water, in dB/m.

After determining the ABS for each depth bin per ping, the ABS data were paired with the CTD-OBS and water sample data by first truncating the time series to the same ~40-second timeframe as deployed and recorded by the CTD-OBS for the field measurements, averaging the ABS for each depth bin over that truncated timeframe, and identifying the ADCP bin most closely aligned with the average depth of CTD-OBS (and TSS sample) data for each sample duration.

The ABS-to-TSS calibration approach then consists of performing a linear regression model of the paired ABS-TSS measurements collected concurrently before, during, and after the trial, with the ABS as the predictor variable and with $\log_{10}$-transformed TSS concentrations as the response variable. Linear modeling tools in MATLAB® software were used to assess the relationship between ABS and $\log_{10}$(TSS), as described in Sections 2.2.3 and 3.2.2.

2.2.2.2 Current Velocity

Current velocity data were primarily collected to assess the up/down-current classification of the samples collected during the TSS monitoring events. The ADCP velocity data were processed as described above and reviewed to verify the up/down-current classifications of the samples made in the field.

Current velocity measurements were reviewed in the Velocity Mapping Toolbox (“VMT”) within MATLAB® software (developed by U.S. Geological Survey [“USGS”]; Engel and Jackson 2017). ADCP transect data were processed with VMT to produce transect-mean cross section current velocities and any measurements that exceeded QC parameter thresholds for the transects were excluded from the review from each file (Mueller et al. 2013; Engel and Jackson 2017). These spurious points were typically end-of-profile data, low signal-to-noise ratio of the velocities due to little-to-no current flow, bubbles near the transducer faces, and any raw data identified in the data acquisition software as below thresholds or potential fish echoes. The transect current velocity data were filtered with a 2-dimensional moving average filter consisting of a 3-point window in the horizontal and vertical dimensions. This was applied to the data to reduce random errors from measurement noise and high-frequency variability to better resolve the velocity features at the Project site, while maintaining the high sampling interval (Parsons et al. 2013; Matte et al. 2014; Engel and Jackson 2017). Single unresolved velocity data points in a profile that may have been flagged due to bubbles, debris, or fish interference were not modified or interpolated over in the moving average filter.

2.2.3 Remote Sensing Calibrations to TSS

Linear modeling tools in MATLAB® software ("fitlm" function) were used to assess the relationship between both remote sensing parameters (OBS and ABS [predictors]) and TSS (response). TSS, OBS, and ABS data were initially assessed for statistical outliers by several outlier influence metrics, including but not limited to, three times the scaled median absolute deviation ("MAD") via the "rmoutlier" function in MATLAB®, and review of several linear model diagnostics and residuals (e.g., Cook's distance, delete-1 scaled change in fitted values ["DFFITS"], and raw, standard, and studentized residuals). A linear fit of the log-log relationship (i.e., $\log_{10}$[TSS]-$\log_{10}$[OBS]) was also used to assess whether the model and calibration were improved (Rasmussen et al. 2009).

3 Results

This section presents the results of the TSS and water chemistry monitoring during the Hudson River pre-installation trial during September 9, 2022 and development of calibration relationships (if any) between the remote sensing data (i.e., OBS and ABS) and TSS.

3.1 Jet Plow Trial

Table 3-1 and Table 3-2 and Figure 2-2, Figure 2-3, Figure 2-4 summarize the field sampling activities completed for the Hudson River jet plow trial. The results from these monitoring efforts are presented below.

3.1.1 TSS Monitoring

The pre-installation jet plow trial at the Hudson River site occurred on September 9, 2022 during 0938-1707 EDT. Conditions during the trial were fair with partly cloudy skies and light/variable northeast winds at 0-5 knots. A pre-trial ambient condition CTD-OBS profile was collected at 0727 (Figure 3-1), approximately two hours prior to the jet plow operation. The temperature profile showed a well-mixed water column with respect to temperature (~25.4°C) and relatively well-mixed salinity (near freshwater at 0.6-1.0 PSU) and turbidity (10-20 NTU). Two ADCP transects were performed two hours before the trial started to assess the ambient current velocity and indicated that river current was ebbing prior to the start of the trial, flowing southwest. Pre-trial TSS samples were collected during Pass 1, and then the monitoring crews waited for the jet plow trial to begin before collecting additional sampling. When the jet plow operations commenced at 0938, the tidal currents had switched directions, with the average flow direction switching to the northeast (flood). Plots of data from all ADCP transects collected during the Hudson River trials are included in Appendix A. Representative pairs of the up-/down-current ADCP transects are shown in Figure 3-2 (for flood currents) and Figure 3-3 (for ebb currents) for reference and perspective on the conditions.

While the jet plow was operating during the trial, a total of 10 Passes were completed, which consisted of TSS monitoring at the up- and down-current side of the plow, resulting in 60 total CTD-OBS-TSS samples and 40 ADCP transects during jet plow operation (Table 3-1). A summary of all sample measurements collected during the trial is presented in Table 3-3. To assess whether jet plow operations increased TSS levels in the water column, the change in TSS ("delta-TSS") over "background" was calculated as the difference in TSS level measured down-current from the jet plow (down-current of potential sediment plume) compared to the up-current station (control) at the same depth layer. Table 3-4 presents the results of those calculations. In addition to near-surface, mid-depth, and near-bottom delta-TSS, a depth-averaged calculation was also performed for each Pass, presented in Table 3-4. The highest TSS measurement from water samples collected during the Hudson River trial was 89 mg/L, in the near-bottom layer from the Pass 3 during the trial. This sample represented an increase of 55 mg/L delta-TSS compared to the up-current samples from the same Pass and depth, and also represented the highest observed increase in TSS during the trial (i.e., delta-TSS). This observed increase in TSS was well below the exceedance threshold of 200 mg/L delta-TSS defined in the WQC and the Monitoring Plan.

In addition to the samples collected during the trial, 30 co-located TSS, OBS, and ABS samples were collected two days before the trial during mobilization on the afternoon of September 7, 2022, 6 samples were collected approximately 1.5 to 2 hours before the trial began and 6 samples were collected within 0.5 hours of the end of the trial. In total, 102 water samples for TSS analysis were collected at the Hudson River jet plow trial site, and paired with co-located OBS and ABS data, presented in Table 3-5. The additional samples from before and after the trial were included in the remote sensing calibration analyses, detailed below in Section 3.2. Overall, only two of the samples exhibited an increase in TSS over background TSS, for the same depth layer, greater than 10 mg/L.

3.1.2 Water Chemistry Monitoring

Table 3-2 presents a summary of the field sampling for the water chemistry monitoring activities conducted for the Hudson River trial. Water chemistry sampling events were conducted for each jet plow speed during the trials. The trial route was conducted in three segments of different plow speeds: the plow travelled at 5 ft/min over the first and last 660 ft of the route and at 10 ft/min over the middle 1,320 ft (1/4 mile). Samples were water chemistry were collected for each of the three plow speeds, which were coincidental with TSS monitoring Passes 2, 6, and 10 (Figure 2-2, Figure 2-3, and Figure 2-4). Samples were collected as described in Section 2.1.2, and water chemistry results from the laboratory analyses are presented in Table 3-6. Total polychlorinated biphenyls (“PCBs”), dissolved lead, and dissolved and total cadmium were all below the laboratory’s method detection limits (“BDL”) for the respective analyses. All chemical parameters assessed for the water chemistry monitoring were substantially below the standards identified by the WQC and Monitoring Plan (Table 1-1).

Table 3-1. Achieved sampling design of TSS Monitoring during the monitoring effort for the CHPE Hudson River Pre-Installation Trial, including periods before and after the trial, on September 7 and 9, 2022.

Date	Survey Type[1]	Pass Number[2]	Location[3]	Sample Time[4] (EDT) Start	End	N Depth Layers	Total Samples	Tide Stage
7-Sep-2022	Pre-trial (Ambient)	1	Down	1035	1042	3	3	Flood
			Up	1112	1117	3	3	
		2	Down	1137	1143	3	3	Flood
			Up	1202	1209	3	3	
		3	Up	1226	1234	3	3	Start of Ebb
			Down	1256	1302	3	3	
		4	Up	1320	1327	3	3	Ebb
			Down	1344	1351	3	3	
		5	Up	1417	1425	3	3	Ebb
			Down	1439	1445	3	3	
9-Sep-2022	Pre-trial (Ambient)	1	Up	0745	0751	3	3	Ebb
			Down	0801	0807	3	3	
	Trial[5]	2	Down	0939	0945	3	3	Flood
			Up	0954	1000	3	3	
		3	Down	1009	1014	3	3	Flood
			Up	1028	1033	3	3	
		4	Down	1051	1056	3	3	Flood
			Up	1116	1121	3	3	
		5	Down	1147	1154	3	3	Flood
			Up	1212	1216	3	3	
		6	Down	1228	1232	3	3	Flood
			Up	1247	1251	3	3	
		7	Down	1313	1319	3	3	Flood
			Up	1343	1347	3	3	
		8	Up	1413	1417	3	3	Start of Ebb
			Down	1428	1432	3	3	
		9	Up	1452	1457	3	3	Ebb
			Down	1508	1512	3	3	
		10	Up	1524	1529	3	3	Ebb
			Down	1541	1545	3	3	
		11	Up	1614	1619	3	3	Ebb
			Down	1628	1633	3	3	
	Post-trial (Ambient)	12	Up[6]	1714	1719	3	3	Ebb
			Down[7]	1728	1732	3	3	

[1]Pre-Trial and Post-Trial "ambient" conditions were assessed primarily to acquire additional data that may support the remote sensing calibrations to TSS.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Location refers to the sampling position Up/Down-current of the plow.

[4]Sample times presented are the CTD-OBS and TSS water sample times. The time performing the ADCP transects for each Pass and Location are not included in this table, but typically took between 4-8 minutes prior to the sample start of each Pass in the table.

[5]Notification from CMI during the trial indicated that the plow started at 0938 and ended at 1707.

[6]The Up-current samples collected following the jet plow trial were collected at the mid-point of the route.

[7]The Down-current samples collected following the jet plow trial were collected south of the southern end of the route.

Table 3-2. Achieved sampling design of water chemistry sample collection during the monitoring effort for the CHPE Hudson River Pre-Installation Trial, including periods before and after the trial, on September 9, 2022.

Date	Survey Type	Chemistry Event Number[1]	Event Description	TSS Pass Number[2]	Location[3]	Sample Time[4] (EDT)		N Depth Layers	N Total Samples
						Start	End		
9-Sep-2022	Trial	1	Start trial, plow speed 5 ft/min.	2	Down	938	951	3	3
					Up	958	1012	3	3
		2	Plow speed increased to 10 ft/min.	6	Down	1231	1245	3	3
					Up	1255	1308	3	3
		3	Plow speed decreased to 5 ft/ min.	10	Up	1529	1541	3	3
					Down	1548	1603	3	3

[1]Event number is sequential count for the paired Up/Down-current sampling positions for each sampling event (plow speed).
[2]TSS Pass is the co-located sampling event for the TSS (and CTD-OBS-ABS) monitoring.
[3]Location refers to the sampling position Up/Down-current of the plow.
[4]Sample times presented are the water sample times from start of surface sample until the end of the bottom sample collection.

Table 3-3. Hudson River sampling results for TSS monitoring events conducted up-current and down-current of the operating jet plow during the trial on September 9, 2022 for lab-analyzed total suspended solids ("TSS"), optical backscatter ("OBS"), and acoustic backscatter ("ABS").

		TSS (mg/L)			OBS (NTU)			ABS (dB)		
Pass	**Location**	**Surface**	**Midwater**	**Bottom**	**Surface**	**Midwater**	**Bottom**	**Surface**	**Midwater**	**Bottom**
Pass 2	Up	12.0	20.0	36.0	8.8	14.0	21.7	49.6	62.1	65.9
	Down	13.0	17.0	28.0	8.2	11.3	20.0	50.6	57.5	63.5
Pass 3	Up	12.0	18.0	34.0	8.0	11.1	20.4	46.1	56.5	64.8
	Down	13.0	17.0	89.0	7.7	11.1	64.2	48.7	56.6	69.6
Pass 4	Up	12.0	19.0	32.0	8.0	13.0	19.5	48.7	57.1	66.6
	Down	15.0	18.0	42.0	9.0	10.9	25.0	49.2	59.8	66.3
Pass 5	Up	12.0	22.0	24.0	7.5	13.5	21.8	46.5	62.0	66.4
	Down	14.0	14.0	26.0	8.8	9.4	20.1	58.6	60.6	64.7
Pass 6	Up	13.0	24.0	29.0	8.9	13.5	24.0	53.0	62.5	62.8
	Down	11.0	11.0	29.0	8.0	8.3	18.6	52.5	56.1	62.8
Pass 7	Up	9.1	11.0	16.0	6.0	7.3	14.4	45.4	45.4	59.0
	Down	13.0	12.0	24.0	8.1	8.1	14.5	51.5	53.8	58.4
Pass 8	Up	10.0	12.0	13.0	6.5	7.6	8.5	51.6	59.1	50.3
	Down	9.2	12.0	13.0	6.6	8.2	11.8	50.6	55.5	54.7
Pass 9	Up	9.3	12.0	12.0	6.7	7.9	10.9	49.1	55.7	53.2
	Down	9.0	13.0	16.0	6.2	7.4	11.2	47.5	54.9	56.2
Pass 10	Up	9.1	10.0	18.0	6.1	7.8	14.4	48.7	55.1	57.7
	Down	12.0	12.0	26.0	7.0	7.9	16.9	52.4	54.1	59.4
Pass 11	Up	7.5	11.0	30.0	5.4	6.9	19.6	44.6	49.6	61.9
	Down	7.4	14.0	24.0	5.1	9.9	21.6	51.4	54.3	62.6
Mean	Up	10.6	15.9	24.4	7.2	10.2	17.5	48.3	56.5	60.9
	Down	11.7	14.0	31.7	7.5	9.3	22.4	51.3	56.3	61.8

Table 3-4. Total suspended solids (TSS) measurements taken up-current and down-current of the operating jet plow for the Hudson River trial, with the change in TSS ("delta-TSS") relative to the up-current location for a given depth layer.

Pass	Layer	TSS (mg/L)		
		Down-current	Up-current	delta-TSS
2	Surface	13.0	12.0	1.0
	Midwater	17.0	20.0	-3.0
	Bottom	28.0	36.0	-8.0
	Depth-Avg	19.3	22.7	-3.3
3	Surface	13.0	12.0	1.0
	Midwater	17.0	18.0	-1.0
	Bottom	89.0	34.0	55.0
	Depth-Avg	39.7	21.3	18.3
4	Surface	15.0	12.0	3.0
	Midwater	18.0	19.0	-1.0
	Bottom	42.0	32.0	10.0
	Depth-Avg	25.0	21.0	4.0
5	Surface	14.0	12.0	2.0
	Midwater	14.0	22.0	-8.0
	Bottom	26.0	24.0	2.0
	Depth-Avg	18.0	19.3	-1.3
6	Surface	11.0	13.0	-2.0
	Midwater	11.0	24.0	-13.0
	Bottom	29.0	29.0	0.0
	Depth-Avg	17.0	22.0	-5.0
7	Surface	13.0	9.1	3.9
	Midwater	12.0	11.0	1.0
	Bottom	24.0	16.0	8.0
	Depth-Avg	16.3	12.0	4.3
8	Surface	9.2	10.0	-0.8
	Midwater	12.0	12.0	0.0
	Bottom	13.0	13.0	0.0
	Depth-Avg	11.4	11.7	-0.3
9	Surface	9.0	9.3	-0.3
	Midwater	13.0	12.0	1.0
	Bottom	16.0	12.0	4.0
	Depth-Avg	12.7	11.1	1.6
10	Surface	12.0	9.1	2.9
	Midwater	12.0	10.0	2.0
	Bottom	26.0	18.0	8.0
	Depth-Avg	16.7	12.4	4.3
11	Surface	7.4	7.5	-0.1
	Midwater	14.0	11.0	3.0
	Bottom	24.0	30.0	-6.0
	Depth-Avg	15.1	16.2	-1.0
Mean	Surface	11.7	10.6	1.1
	Midwater	14.0	15.9	-1.9
	Bottom	31.7	24.4	7.3
	Depth-Avg	19.1	17.0	2.2

Table 3-5. Hudson River sampling results for TSS monitoring events conducted up-current and down-current of the operating jet plow during the trial for lab-analyzed total suspended solids ("TSS"), optical backscatter ("OBS"), and acoustic backscatter ("ABS"). All data below were used in the regression analysis for developing relationships to attempt to calibrate OBS and ABS for estimating TSS.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
9/7/2022	10:35:49	41.56470	-73.96535	Pre-trial (ambient)	Down	1	SUR	6.4	5.73	9.3	47.7
9/7/2022	10:38:21	41.56478	-73.96527	Pre-trial (ambient)	Down	1	MID	26.8	9.79	17.0	59.5
9/7/2022	10:42:08	41.56472	-73.96528	Pre-trial (ambient)	Down	1	BOT	44.2	10.92	22.0	60.7
9/7/2022	11:12:24	41.55952	-73.97092	Pre-trial (ambient)	Up	1	SUR	7.5	5.25	7.6	49.4
9/7/2022	11:14:41	41.55937	-73.97098	Pre-trial (ambient)	Up	1	MID	26.6	15.18	24.0	66.0
9/7/2022	11:17:37	41.55932	-73.97089	Pre-trial (ambient)	Up	1	BOT	43.6	20.16	36.0	68.9
9/7/2022	11:38:09	41.56508	-73.96681	Pre-trial (ambient)	Down	2	SUR	7.2	5.16	8.1	48.5
9/7/2022	11:40:25	41.56506	-73.96654	Pre-trial (ambient)	Down	2	MID	26.8	11.45	18.0	57.8
9/7/2022	11:43:20	41.56488	-73.96640	Pre-trial (ambient)	Down	2	BOT	42.7	14.90	25.0	61.8
9/7/2022	12:03:07	41.55909	-73.97117	Pre-trial (ambient)	Up	2	SUR	7.6	4.59	6.9	52.6
9/7/2022	12:05:14	41.55887	-73.97126	Pre-trial (ambient)	Up	2	MID	25.1	5.27	7.4	49.0
9/7/2022	12:08:59	41.55894	-73.97134	Pre-trial (ambient)	Up	2	BOT	43.8	10.70	18.0	57.4
9/7/2022	12:26:54	41.56441	-73.96608	Pre-trial (ambient)	Up	3	SUR	6.7	4.56	7.4	45.7
9/7/2022	12:30:39	41.56446	-73.96579	Pre-trial (ambient)	Up	3	MID	25.8	5.08	8.3	46.2
9/7/2022	12:34:04	41.56416	-73.96621	Pre-trial (ambient)	Up	3	BOT	41.9	9.90	14.0	53.3
9/7/2022	12:56:30	41.55985	-73.97081	Pre-trial (ambient)	Down	3	SUR	7.8	4.80	8.5	47.7
9/7/2022	12:58:43	41.55946	-73.97122	Pre-trial (ambient)	Down	3	MID	24.8	4.95	7.9	46.2
9/7/2022	13:02:20	41.55978	-73.97078	Pre-trial (ambient)	Down	3	BOT	45.8	8.34	12.0	52.3
9/7/2022	13:20:44	41.56375	-73.96614	Pre-trial (ambient)	Up	4	SUR	7.0	4.91	6.9	53.4
9/7/2022	13:22:50	41.56336	-73.96645	Pre-trial (ambient)	Up	4	MID	28.7	5.69	8.6	51.0
9/7/2022	13:27:09	41.56392	-73.96620	Pre-trial (ambient)	Up	4	BOT	46.0	9.93	16.0	53.7
9/7/2022	13:44:22	41.56149	-73.96887	Pre-trial (ambient)	Down	4	SUR	7.5	4.57	6.7	50.4
9/7/2022	13:47:18	41.56125	-73.96904	Pre-trial (ambient)	Down	4	MID	29.8	6.06	9.1	50.6
9/7/2022	13:51:23	41.56138	-73.96907	Pre-trial (ambient)	Down	4	BOT	43.0	9.76	15.0	54.5
9/7/2022	14:18:09	41.56279	-73.96720	Pre-trial (ambient)	Up	5	SUR	6.8	5.01	8.3	49.1
9/7/2022	14:21:54	41.56278	-73.96746	Pre-trial (ambient)	Up	5	MID	26.0	5.30	8.6	47.7
9/7/2022	14:25:34	41.56256	-73.96736	Pre-trial (ambient)	Up	5	BOT	41.5	10.25	17.0	55.5
9/7/2022	14:39:48	41.55760	-73.97318	Pre-trial (ambient)	Down	5	SUR	7.4	4.67	7.5	48.7
9/7/2022	14:42:24	41.55726	-73.97344	Pre-trial (ambient)	Down	5	MID	25.8	5.69	8.8	48.2
9/7/2022	14:45:41	41.55680	-73.97382	Pre-trial (ambient)	Down	5	BOT	43.8	15.80	23.0	60.0
9/9/2022	7:45:42	41.56085	-73.96921	Pre-trial (ambient)	Up	1	SUR	7.3	11.86	19.0	56.9
9/9/2022	7:47:56	41.56065	-73.96921	Pre-trial (ambient)	Up	1	MID	27.6	12.74	22.0	61.6
9/9/2022	7:50:58	41.56058	-73.96926	Pre-trial (ambient)	Up	1	BOT	43.1	13.72	21.0	62.3
9/9/2022	8:01:33	41.55833	-73.97219	Pre-trial (ambient)	Down	1	SUR	7.9	11.25	18.0	55.0
9/9/2022	8:03:49	41.55789	-73.97235	Pre-trial (ambient)	Down	1	MID	25.0	11.52	20.0	59.7
9/9/2022	8:07:08	41.55834	-73.97227	Pre-trial (ambient)	Down	1	BOT	44.7	12.30	20.0	61.8
9/9/2022	9:39:35	41.56076	-73.96972	Trial	Down	2	SUR	8.1	8.15	13.0	50.6
9/9/2022	9:41:29	41.56079	-73.96972	Trial	Down	2	MID	28.3	11.34	17.0	57.5
9/9/2022	9:44:49	41.56090	-73.96973	Trial	Down	2	BOT	46.9	19.98	28.0	63.5
9/9/2022	9:55:12	41.55838	-73.97204	Trial	Up	2	SUR	7.9	8.76	12.0	49.6
9/9/2022	9:57:24	41.55848	-73.97195	Trial	Up	2	MID	28.5	14.04	20.0	62.1
9/9/2022	10:00:02	41.55841	-73.97202	Trial	Up	2	BOT	45.4	21.72	36.0	65.9

[1]For 9/7/2022, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents., during the trial. For pre-trial. For 9/9/2022, Location refers to the sampling position Up/Down-current of the plow.
[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.
[3]Depth Layer refers to sampled levels in the water column from near-surface ("SUR"), mid-depth ("MID"), and near-bottom ("BOT"), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

Table 3-5 continued.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
9/9/2022	10:09:56	41.56034	-73.96973	Trial	Down	3	SUR	7.9	7.71	13.0	48.7
9/9/2022	10:12:09	41.56041	-73.96959	Trial	Down	3	MID	28.0	11.07	17.0	56.6
9/9/2022	10:14:42	41.56048	-73.96962	Trial	Down	3	BOT	48.9	64.19	89.0	69.6
9/9/2022	10:28:39	41.55792	-73.97234	Trial	Up	3	SUR	6.5	7.98	12.0	46.1
9/9/2022	10:30:21	41.55808	-73.97224	Trial	Up	3	MID	26.2	11.11	18.0	56.5
9/9/2022	10:32:52	41.55806	-73.97217	Trial	Up	3	BOT	44.5	20.38	34.0	64.8
9/9/2022	10:52:01	41.56002	-73.96986	Trial	Down	4	SUR	8.9	9.00	15.0	49.2
9/9/2022	10:53:59	41.56007	-73.96978	Trial	Down	4	MID	26.9	10.92	18.0	59.8
9/9/2022	10:56:29	41.56004	-73.96979	Trial	Down	4	BOT	44.3	24.99	42.0	66.3
9/9/2022	11:17:03	41.55752	-73.97277	Trial	Up	4	SUR	7.7	8.02	12.0	48.7
9/9/2022	11:18:35	41.55763	-73.97291	Trial	Up	4	MID	26.1	13.00	19.0	57.1
9/9/2022	11:21:09	41.55763	-73.97276	Trial	Up	4	BOT	45.9	19.54	32.0	66.6
9/9/2022	11:47:40	41.55938	-73.97069	Trial	Down	5	SUR	8.0	8.84	14.0	58.6
9/9/2022	11:49:55	41.55945	-73.97062	Trial	Down	5	MID	24.6	9.41	14.0	60.6
9/9/2022	11:54:08	41.55946	-73.97055	Trial	Down	5	BOT	43.7	20.07	26.0	64.7
9/9/2022	12:12:21	41.55670	-73.97368	Trial	Up	5	SUR	7.3	7.49	12.0	46.5
9/9/2022	12:13:55	41.55670	-73.97359	Trial	Up	5	MID	28.8	13.48	22.0	62.0
9/9/2022	12:16:16	41.55647	-73.97381	Trial	Up	5	BOT	45.1	21.83	24.0	66.4
9/9/2022	12:28:05	41.55877	-73.97133	Trial	Down	6	SUR	10.5	8.02	11.0	52.5
9/9/2022	12:30:05	41.55868	-73.97149	Trial	Down	6	MID	24.8	8.32	11.0	56.1
9/9/2022	12:32:26	41.55867	-73.97157	Trial	Down	6	BOT	45.3	18.57	29.0	62.8
9/9/2022	12:47:29	41.55624	-73.97402	Trial	Up	6	SUR	7.0	8.86	13.0	53.0
9/9/2022	12:49:09	41.55624	-73.97403	Trial	Up	6	MID	27.8	13.46	24.0	62.5
9/9/2022	12:51:36	41.55619	-73.97401	Trial	Up	6	BOT	44.4	23.99	29.0	62.8
9/9/2022	13:13:32	41.55789	-73.97229	Trial	Down	7	SUR	9.2	8.08	13.0	51.5
9/9/2022	13:16:39	41.55782	-73.97221	Trial	Down	7	MID	23.4	8.13	12.0	53.8
9/9/2022	13:19:41	41.55792	-73.97193	Trial	Down	7	BOT	45.2	14.51	24.0	58.4
9/9/2022	13:43:39	41.55509	-73.97514	Trial	Up	7	SUR	7.9	6.02	9.1	45.4
9/9/2022	13:45:27	41.55511	-73.97496	Trial	Up	7	MID	26.2	7.25	11.0	45.4
9/9/2022	13:47:49	41.55515	-73.97491	Trial	Up	7	BOT	44.5	14.43	16.0	59.0
9/9/2022	14:13:23	41.55710	-73.97346	Trial	Up	8	SUR	7.1	6.53	10.0	51.6
9/9/2022	14:15:00	41.55719	-73.97346	Trial	Up	8	MID	17.4	7.57	12.0	59.1
9/9/2022	14:17:12	41.55735	-73.97341	Trial	Up	8	BOT	41.2	8.52	13.0	50.3
9/9/2022	14:28:15	41.55453	-73.97626	Trial	Down	8	SUR	7.8	6.55	9.2	50.6
9/9/2022	14:29:56	41.55444	-73.97600	Trial	Down	8	MID	22.8	8.19	12.0	55.5
9/9/2022	14:32:47	41.55427	-73.97603	Trial	Down	8	BOT	42.3	11.81	13.0	54.7
9/9/2022	14:52:57	41.55648	-73.97427	Trial	Up	9	SUR	7.7	6.72	9.3	49.1
9/9/2022	14:55:35	41.55652	-73.97406	Trial	Up	9	MID	24.9	7.86	12.0	55.7
9/9/2022	14:57:45	41.55647	-73.97408	Trial	Up	9	BOT	43.7	10.86	12.0	53.2
9/9/2022	15:08:21	41.55377	-73.97670	Trial	Down	9	SUR	9.6	6.18	9.0	47.5
9/9/2022	15:10:02	41.55375	-73.97677	Trial	Down	9	MID	22.7	7.43	13.0	54.9
9/9/2022	15:12:08	41.55366	-73.97672	Trial	Down	9	BOT	42.1	11.17	16.0	56.2

[1]For 9/7/2022, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents., during the trial. For pre-trial. For 9/9/2022, Location refers to the sampling position Up/Down-current of the plow.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Depth Layer refers to sampled levels in the water column from near-surface (“SUR”), mid-depth (“MID”), and near-bottom (“BOT”), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

Table 3-5 continued.

Date	Time (EDT)	Latitude (DD)	Longitude (DD)	Survey Type	Location[1]	Pass[2]	Depth Layer[3]	Depth (ft)	OBS (NTU)	TSS (mg/L)	ABS (dB)
9/9/2022	15:24:54	41.55596	-73.97469	Trial	Up	10	SUR	7.2	6.05	9.1	48.7
9/9/2022	15:27:07	41.55595	-73.97477	Trial	Up	10	MID	23.6	7.78	10.0	55.1
9/9/2022	15:29:32	41.55591	-73.97496	Trial	Up	10	BOT	42.2	14.41	18.0	57.7
9/9/2022	15:41:18	41.55340	-73.97704	Trial	Down	10	SUR	7.6	7.04	12.0	52.4
9/9/2022	15:42:55	41.55334	-73.97708	Trial	Down	10	MID	19.7	7.92	12.0	54.1
9/9/2022	15:45:14	41.55331	-73.97714	Trial	Down	10	BOT	41.4	16.89	26.0	59.4
9/9/2022	16:14:11	41.55524	-73.97518	Trial	Up	11	SUR	7.9	5.39	7.5	44.6
9/9/2022	16:16:41	41.55539	-73.97517	Trial	Up	11	MID	25.0	6.90	11.0	49.6
9/9/2022	16:19:08	41.55547	-73.97514	Trial	Up	11	BOT	43.0	19.60	30.0	61.9
9/9/2022	16:28:56	41.55288	-73.97797	Trial	Down	11	SUR	8.0	5.08	7.4	51.4
9/9/2022	16:30:51	41.55291	-73.97791	Trial	Down	11	MID	26.8	9.87	14.0	54.3
9/9/2022	16:33:27	41.55287	-73.97800	Trial	Down	11	BOT	40.5	21.55	24.0	62.6
9/9/2022	17:14:27	41.55614	-73.97445	Post-trial (ambient)	UP[4]	12	SUR	7.7	6.25	9.5	54.0
9/9/2022	17:16:37	41.55612	-73.97431	Post-trial (ambient)	UP[4]	12	MID	31.2	9.22	12.0	53.9
9/9/2022	17:19:09	41.55605	-73.97442	Post-trial (ambient)	UP[4]	12	BOT	42.5	21.10	20.0	61.7
9/9/2022	17:28:27	41.55255	-73.97804	Post-trial (ambient)	DOWN[5]	12	SUR	7.3	5.75	8.5	54.1
9/9/2022	17:30:05	41.55253	-73.97817	Post-trial (ambient)	DOWN[5]	12	MID	25.2	7.11	11.0	55.1
9/9/2022	17:32:30	41.55248	-73.97820	Post-trial (ambient)	DOWN[5]	12	BOT	42.1	32.93	45.0	66.0

[1]For 9/7/2022, Location refers to the sampling position Up/Down-current with respect to the planned trial route (i.e. North or South end of the route, depending on the tidal currents., during the trial. For pre-trial. For 9/9/2022, Location refers to the sampling position Up/Down-current of the plow.

[2]Pass number is sequential count for the given date of paired Up/Down-current TSS sampling events.

[3]Depth Layer refers to sampled levels in the water column from near-surface (“SUR”), mid-depth (“MID”), and near-bottom (“BOT”), as specified in the Monitoring Plan, where each depth was co-located with ABS data from the ADCP. Accordingly, the SUR and BOT layers coincided with ABS data measured in bins 1 or 2 of the ADCP profile (typically 6-8 ft below the river surface) and the last valid bin within the ADCP profile (typically 6-8 ft above the river bottom), respectively, with the MID layer being approximately half-way between these.

[4]The Up-current samples collected following the jet plow trial were collected at the mid-point of the route.

[5]The Down-current samples collected following the jet plow trial were collected south of the southern end of the route.

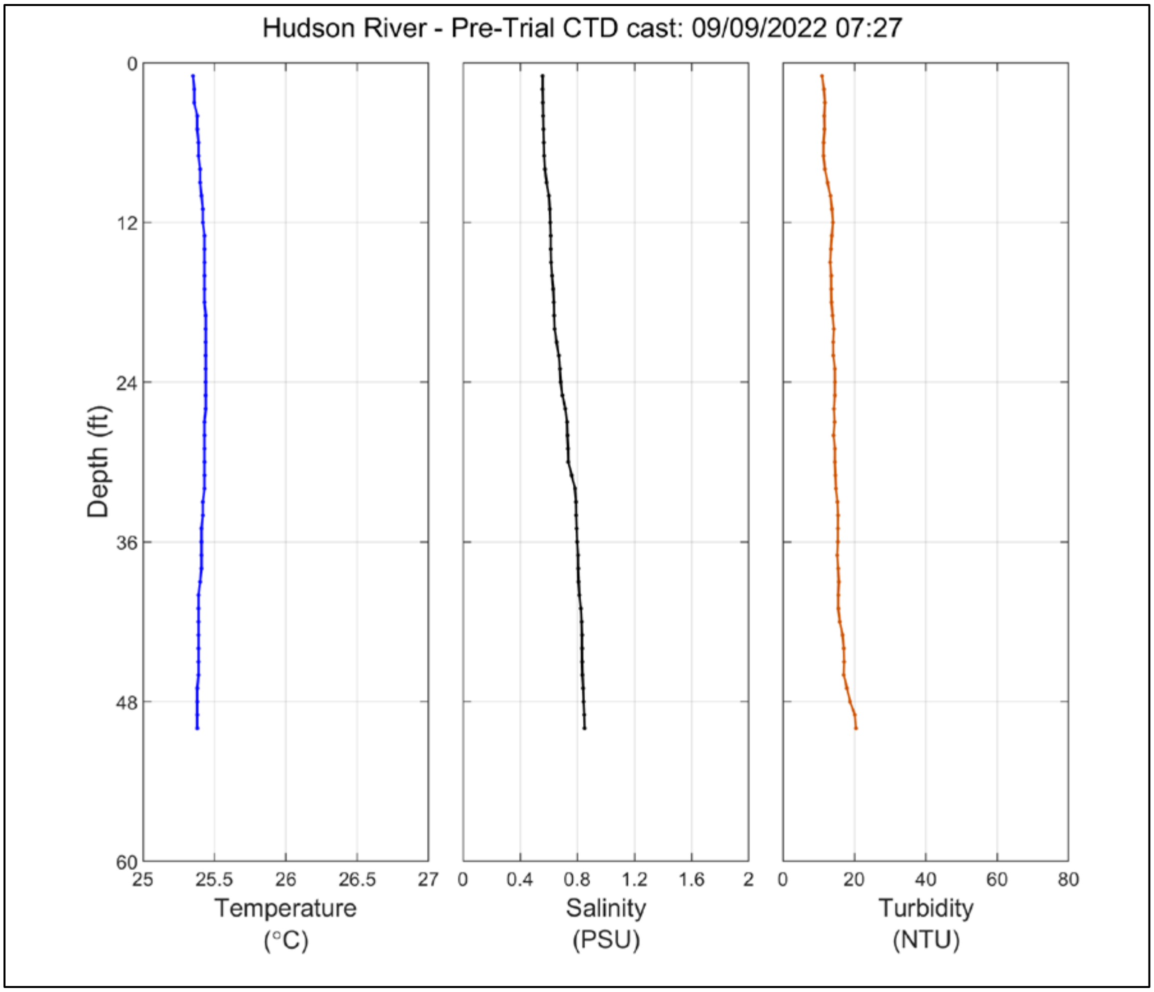

Figure 3-1. CTD-OBS profiles of temperature, salinity, and turbidity (OBS) from Hudson River site prior to of the jet plow trial near the end of ebb tidal stage.

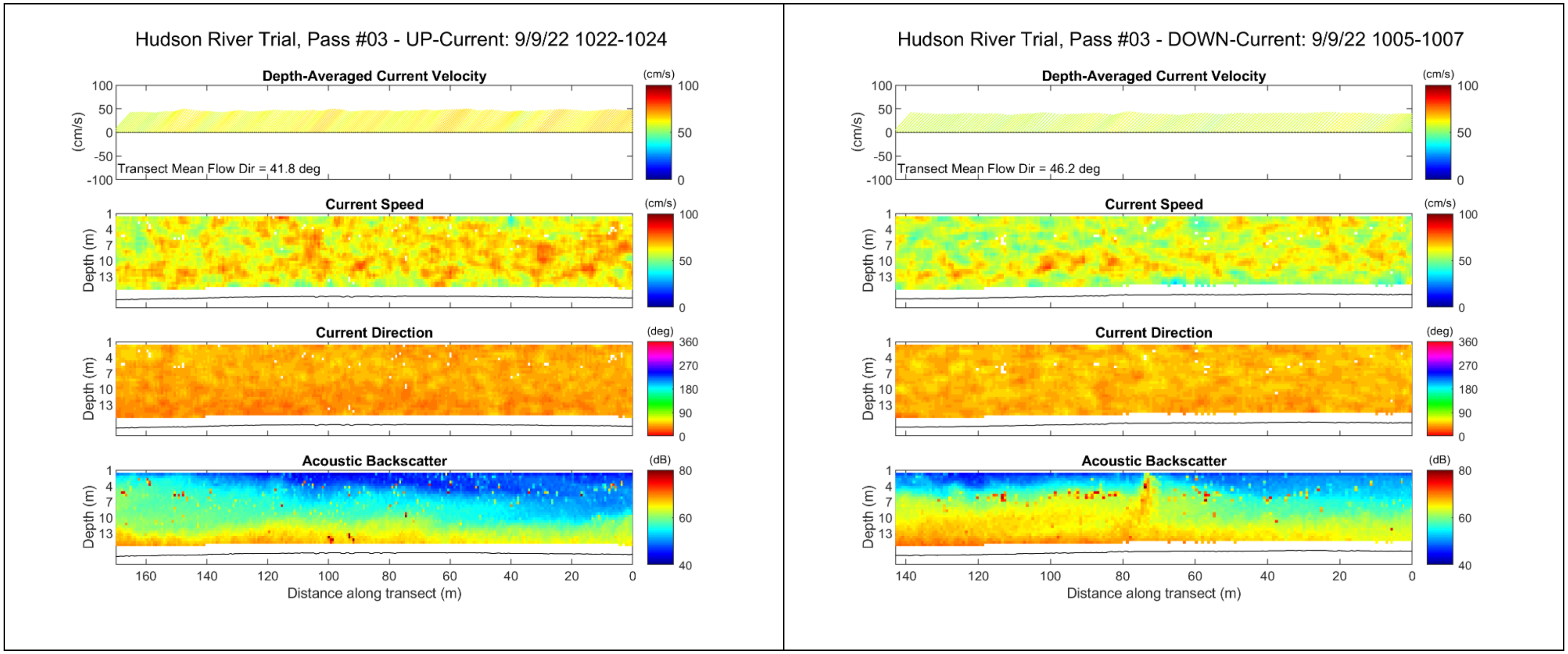

Figure 3-2. **ADCP transect data from the third Pass of the Hudson River trial TSS monitoring, during flood tidal current conditions: up-current (south side of the plow) transect is shown on the left and the down-current transect (north) is shown on the right. The top panel in each is a current velocity vector stick plot, where the sticks point toward the direction of the depth-averaged current velocity and are colored relative to the current speed. The remaining three panels are cross-sectional contour plots of current speed, direction, and relative acoustic backscatter. White cells in the current speed and direction contour plots represent unresolved velocity data (e.g., due to bubbles, debris, or fish). The location of the Pass 3 ADCP transects is shown in Figure 2-2.**

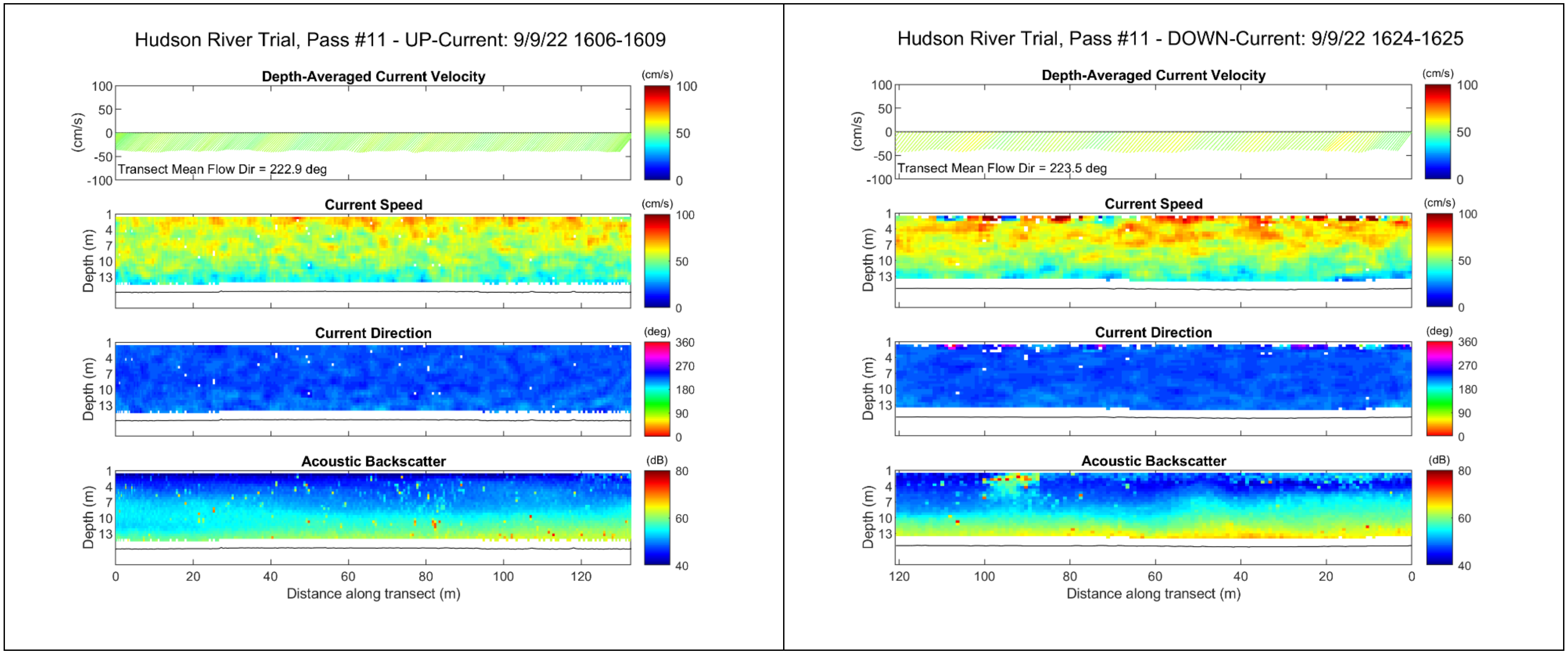

Figure 3-3. **ADCP transect data from the 11th Pass of the Hudson River trial TSS monitoring, during ebb tidal current conditions: up-current (north side of the plow) transect is shown on the left and the down-current transect (south) is shown on the right. The top panel in each is a current velocity vector stick plot, where the sticks point toward the direction of the depth-averaged current velocity and are colored relative to the current speed. The remaining three panels are cross-sectional contour plots of current speed, direction, and relative acoustic backscatter. White cells in the current speed and direction contour plots represent unresolved velocity data (e.g., due to bubbles, debris, or fish). The location of the Pass 11 ADCP transects is shown in Figure 2-4.**

Table 3-6. Hudson River monitoring results for water chemistry sampling events conducted up-current and down-current of the operating jet plow during the trial on September 9, 2022 for lab-analyzed chemical parameters presented in the table below and Table 1-1.

Depth Layer	Event Number	Location	TSS (mg/L)	Phenanthrene (ng/L)	PCBs (ug/L)	Mercury (ug/L)	Hardness (ug/L)		Copper (ug/L)		Lead (ug/L)		Cadmium (ug/L)	
							Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total
Surface	1	Up	11.0	3.82	BDL[1]	0.0030	221	219	1.447	1.941	BDL[2]	0.6243	BDL[3]	BDL[3]
		Down	12.0	3.50	BDL	0.0038	179	184	1.605	1.936	BDL	0.6610	BDL	BDL
	2	Up	12.0	5.32	BDL	0.0024	284	273	1.579	2.227	BDL	0.6798	BDL	BDL
		Down	8.2	3.48	BDL	0.0020	253	269	1.559	1.924	BDL	0.5297	BDL	BDL
	3	Up	6.3	3.68	BDL	0.0014	243	243	1.641	1.948	BDL	0.4451	BDL	BDL
		Down	8.2	3.31	BDL	0.0022	247	261	1.702	1.741	BDL	0.5950	BDL	BDL
	Mean	Up	9.8	4.27	BDL	0.0023	249	245	1.556	2.039	BDL	0.5831	BDL	BDL
		Down	9.5	3.43	BDL	0.0027	226	238	1.622	1.867	BDL	0.5952	BDL	BDL
Midwater	1	Up	16.0	4.42	BDL	0.0035	236	237	1.515	2.206	BDL	0.8902	BDL	BDL
		Down	14.0	3.88	BDL	0.0036	223	221	1.621	2.120	BDL	0.8555	BDL	BDL
	2	Up	13.0	4.55	BDL	0.0032	305	303	1.522	2.176	BDL	0.7756	BDL	BDL
		Down	15.0	4.92	BDL	0.0039	293	286	2.844	2.297	BDL	0.8969	BDL	BDL
	3	Up	11.0	6.50	BDL	0.0028	294	287	1.723	1.912	BDL	0.6723	BDL	BDL
		Down	10.0	4.72	BDL	0.0026	278	302	1.754	1.907	BDL	0.7203	BDL	BDL
	Mean	Up	13.3	5.16	BDL	0.0032	278	276	1.587	2.098	BDL	0.7794	BDL	BDL
		Down	13.0	4.51	BDL	0.0034	265	270	2.073	2.108	BDL	0.8242	BDL	BDL
Bottom	1	Up	22.0	6.52	BDL	0.0079	250	250	1.500	2.467	BDL	1.2500	BDL	BDL
		Down	28.0	6.86	BDL	0.0066	236	237	1.664	2.799	BDL	1.6760	BDL	BDL
	2	Up	17.0	4.63	BDL	0.0040	329	320	1.649	2.170	BDL	0.9237	BDL	BDL
		Down	42.0	7.63	BDL	0.0135	311	298	1.779	3.141	BDL	2.2640	BDL	BDL
	3	Up	36.0	6.56	BDL	0.0087	326	339	2.620	2.626	BDL	1.8560	BDL	BDL
		Down	27.0	5.78	BDL	0.0086	301	337	1.744	2.230	BDL	1.5310	BDL	BDL
	Mean	Up	25.0	5.90	BDL	0.0069	302	303	1.923	2.421	BDL	1.3432	BDL	BDL
		Down	32.3	6.76	BDL	0.0096	283	291	1.729	2.723	BDL	1.8237	BDL	BDL

[1]Below the Method Detection Limit ("BDL") for PCBs, Total = 0.007 ug/L

[2]Below the Method Detection Limit ("BDL") for Lead, Dissolved = 0.3430 ug/L

[3]Below the Method Detection Limit ("BDL") for Cadmium, Dissolved and Cadmium, Total = 0.0599 ug/L

3.2 Remote Sensing Calibrations to TSS

The secondary objective of the TSS monitoring activities during the pre-installation jet plow trials was to use the sample data collected to investigate the development of calibrations describing quantitative relationships (if any) between the remote sensing data and the laboratory measured TSS, to potentially use OBS and/or ABS as remote sensing methods for near real-time TSS estimates during monitoring of the submarine cable installation. All sample data collected on September 7 and 9, 2022 before the trial, during jet plow operations, and after the trial, were used to extract paired remote sensing and TSS measurements for linear regression analysis and are presented in Table 3-5.

Of the 102 data pairs of both TSS-OBS and TSS-ABS, the outlier detection metrics described in Section 2.2.3 identified between one and nine potentially influential outliers for the data pairs used in the regression analyses, depending on the specific metric. Due to the variability in identification of statistical outliers across the methods, and more importantly, the fact that none of the measurements were deemed egregious, faulty, or suitable for exclusion from the regression analysis, all measurements of TSS, OBS, and ABS were retained for the calibrations described herein.

3.2.1 Optical Backscatter

The calibration equation and curve resulting from the linear regression analysis of TSS on OBS is shown in Figure 3-4. The relationship was highly correlated and statistically significant ($R^2 = 0.946$, $p<0.0001$; see statistical details in Appendix B). A linear fit of log-log relationship (i.e., $\log_{10}$[TSS]-$\log_{10}$[OBS]) was also assessed for the TSS-OBS calibration but did not improve the correlation statistics ($R^2 = 0.945$, $p<0.0001$).

3.2.2 Acoustic Backscatter

The calibration equation and curve resulting from the linear regression analysis of $\log_{10}$(TSS) on ABS is shown in Figure 3-5. The TSS-ABS relationship was well-correlated and statistically significant ($R^2 = 0.777$, $p<0.0001$; see statistical details in Appendix B).

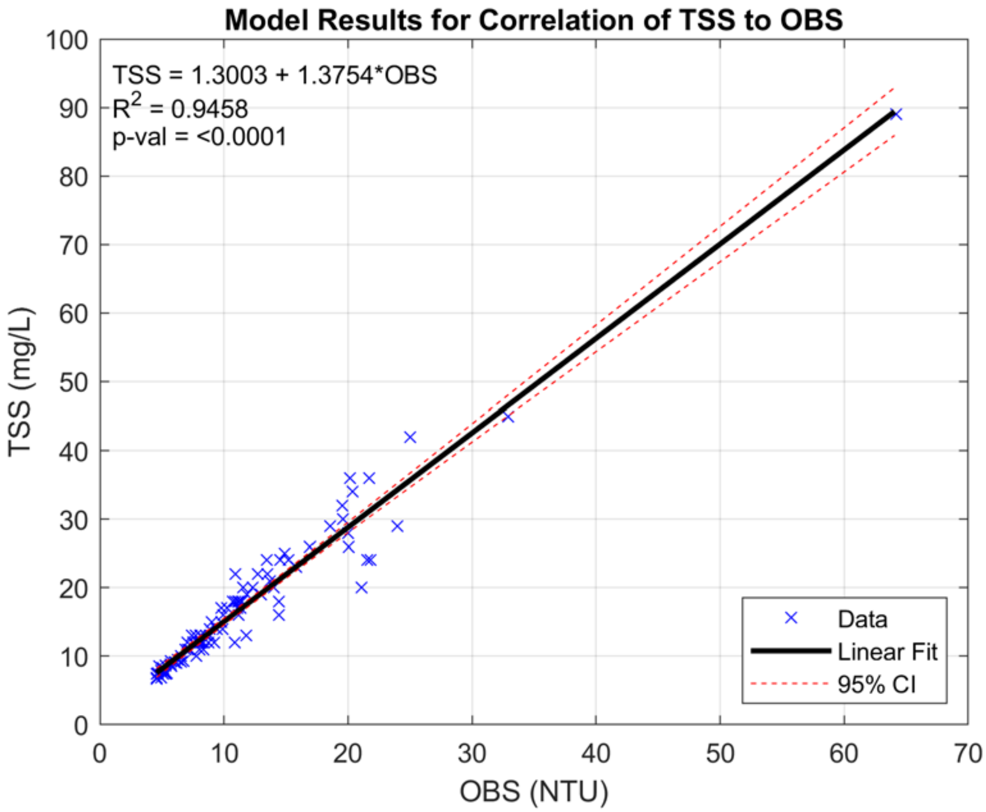

Figure 3-4. Calibration results for linear regression analysis of TSS to OBS for all paired sample data (N = 102) collected from the Hudson River trial (9-Sep-2022) and the ambient river survey (7-Sep-2022).

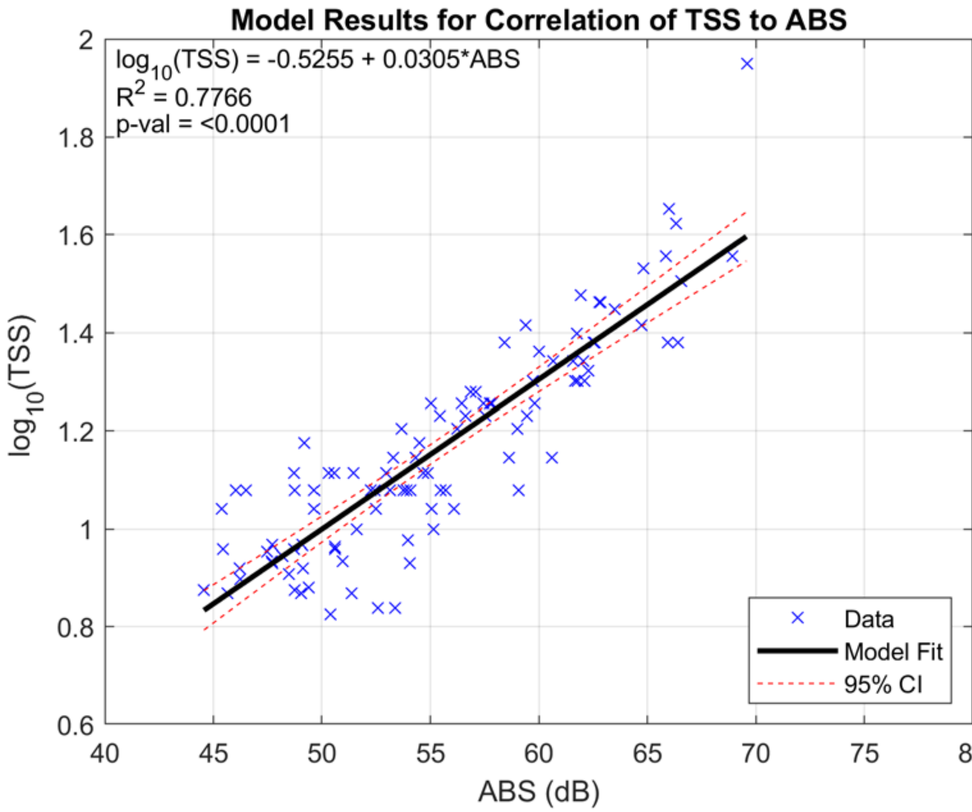

Figure 3-5. Calibration results for the linear regression analysis of log_{10}(TSS) to ABS for paired sample data (N = 102) collected from the Hudson River trial (9-Sep-2022) and the ambient river survey (7-Sep-2022).

4 Summary

4.1 Hudson River Jet Plow Trial

The standard in the WQC requires that TSS levels at 500 ft down-current from the jet plow do not increase by more than 200 mg/L greater than background TSS measured up-current of the jet plow (i.e., the "delta-TSS" as presented herein). Monitoring during the pre-installation trials in the Hudson River for CHPE showed that TSS levels ranged from <10 mg/L in near-surface samples to 89 mg/L in a near-bottom sample, with the highest calculated increase during plow operations (delta-TSS) being 55 mg/L, 72.5% lower than the exceedance threshold for delta-TSS in the Hudson River. Observations from the trial showed that, when measured at the prescribed 500 ft distance from the construction barge, changes in TSS levels were well below the permitted standards.

In addition, it is noted that a potential suspended sediment plume was observed in the ABS data in several ADCP down-current transects, specifically for Passes 3 through 7 which occurred during flood tidal currents. Of interest is that the cross-sectional width of the potential plume was small, on the order of 10–30 ft wide, as seen in the ABS contour plots (Appendix A). This pattern was observed primarily during the flood tidal currents in the first half of the trial. The apparent suspended sediment plume was not as evident or observable in the ABS data during ebb tidal currents, with the exception of a small surface signature seen in Pass 11 that may have represented portion of a plume. There were also several transects that showed some elevated ABS levels in the up-current transects (e.g., Passes 6, 8, and 9), which was also observed the CTD-OBS and TSS data (Table 3-3).

Lastly, the water chemistry sampling showed that, where the parameters were detectable by the laboratory analysis methods, the levels observed for all parameters were significantly below the standards identified by the WQC and Monitoring Plan.

4.2 Optical and Acoustic Backscatter Calibrations

Results from the regression analyses indicated that the OBS exhibited a stronger relationship with TSS concentrations ($R^2 = 0.946$) and, as such, may provide better estimates of TSS for future monitoring in similar conditions. The TSS-ABS regression, however, was also statistically significant and well-correlated ($R^2 = 0.777$). The differences observed may be attributable to varying sensitivities to different particle sizes and sediment characteristics, for which the OBS sensors and ABS from ADCP have different responsiveness. The OBS sensor is typically more sensitive to smaller particle sizes than the ABS from the 600 kHz ADCP and therefore, the ABS may slightly underestimate suspended sediments in the smaller particle size ranges (e.g., particles in the silt and clay range <40-60 µm) (Gartner 2004; Jay et al. 2015). At sites with different hydrologic or sediment characteristics, changes in estimated TSS concentrations from the OBS and ABS data could result from changes in suspended particle size distribution rather than changes in TSS, or both (Garter 2004; Wall et al. 2006; Landers 2010). However, sampling conducted during installation monitoring will provide confirmatory TSS data along with additional OBS and ABS data which, where appropriate, can be used to expand the calibrations if

Additionally, the overall range of TSS levels observed for all samples collected were relatively low, but likely representative of conditions expected in similar environments in the Hudson River. For perspective, and in relation to the standards in the WQC, the TSS-OBS and TSS-ABS calibration curves were re-plotted on a larger TSS scale increased to 200 mg/L (or $\log_{10}$[200 mg/L] for the TSS-ABS curve), approximating values that would likely need to be observed to exceed those thresholds (Figure 4-1 and Figure 4-2).

4.3 Conclusions

TSS levels observed during the pre-installation trial in the Hudson River were comparable to ambient TSS levels, which was evident in the sample data as only two of the samples exhibited an increase in TSS over background TSS for the same depth layer greater than 10 mg/L. This suggests that jet plow operations did not result in substantial increases in TSS in general and specifically that increases in TSS were well below the standards identified by the WQC and the Monitoring Plan. Based on the observations from the jet plow trial, it appears likely that increases in TSS due to the plow operations would only be observed at the 500 ft distance from the barge within a small width of cross-sectional area (estimated 10-30+ ft, and depth-dependent) and primarily during the times surrounding peak tidal currents within the tidal cycle.

Statistically significant and well-correlated calibration relationships were established for TSS to both OBS and ABS, with the strength of the OBS-TSS regression indicating that OBS may be a better predictor of TSS values between the two methods. The ABS data from ADCP provides a remote profiling instrument capable of sampling the entire water column (i.e., without being physically lowered from a vessel at a point), which would be useful for locating potential sediment plumes. Based on the results from the Hudson River jet plow trial, and primarily due to the apparent variability and scale of the observable suspended sediment plume induced by the jet plow, the ABS data may be helpful in determining if a potential plume is present at 500 ft down-current from the plow and where to sample for CTD-OBS and confirmatory TSS from water samples. The ABS contour plots demonstrate that the sediment plume is observable remotely, and based on these observations, the presence and spatial variability of the plume across conditions and tides can be confirmed. While the ABS could also provide an additional estimate of near real-time TSS levels during future monitoring activities, the ABS-TSS correlation exhibited the highest degree of uncertainty among the OBS and ABS sampling methods. As such, for conditions encountered in this region of the Hudson River, the OBS sensor may be more appropriate for guiding compliance determinations during active construction.

In summary, the pre-installation trial in the Hudson River demonstrated that (1) jet plow activities produced either no observable plume or a small area of slightly elevated TSS levels within a cross-sectional transect that were well below the TSS standards identified in the WQC (at most approximately 27% of the standard for elevation above background levels); (2) the presence and location of a suspended sediment plume at 500 ft down-current of the plow was able to be detected in the ABS data, although one was not always observed during the trial; and (3) both the remote sensing calibrations to TSS exhibited moderate (ABS) to high (OBS) predictive power. While these calibration relationships are subject to modification during the installation phase of the Project to reflect hydrological and sediment conditions that may not have been encountered during the trials, the regression results suggest that the use of the calibration curves developed as part of the trial, particularly the OBS-TSS calibration, would be appropriate for the start of the installation phase in the Hudson River.

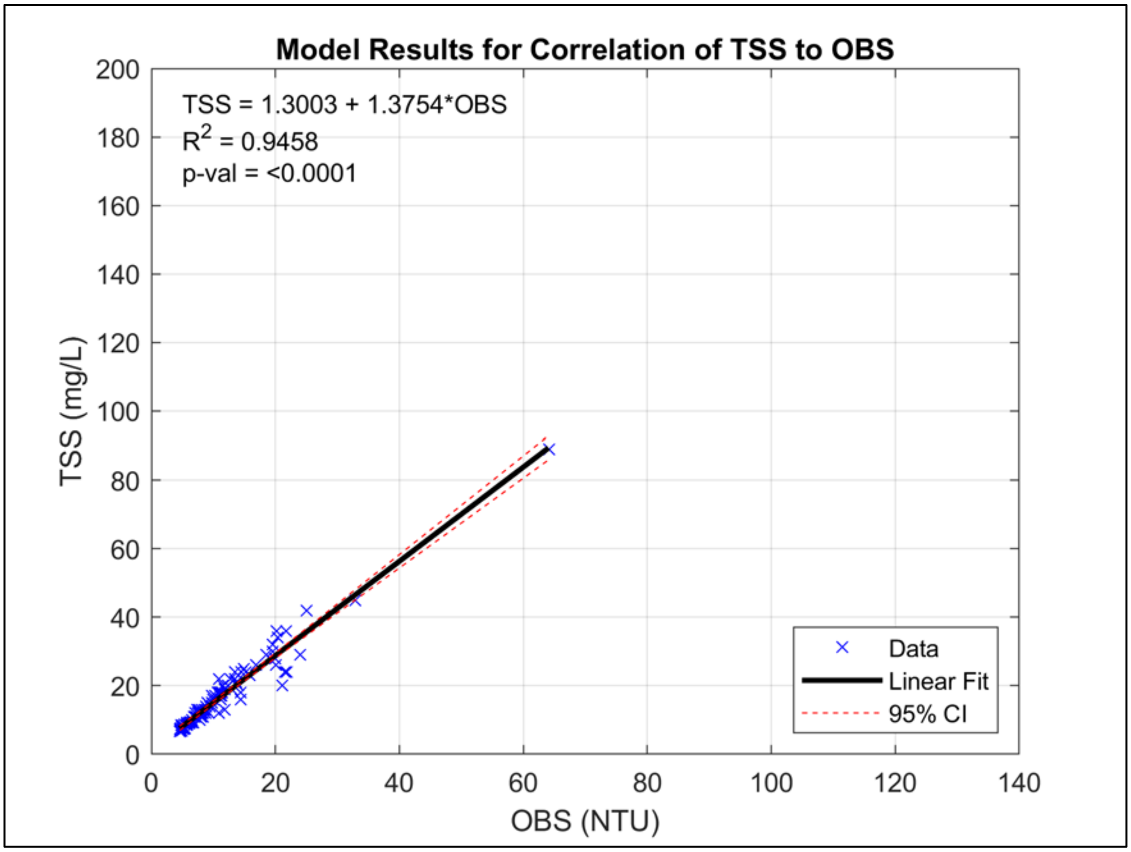

Figure 4-1. Calibration curve from linear regression analysis for TSS to OBS, plotted on increased scale to illustrate levels observed during the trials relative to the WQC standards for the Hudson River.

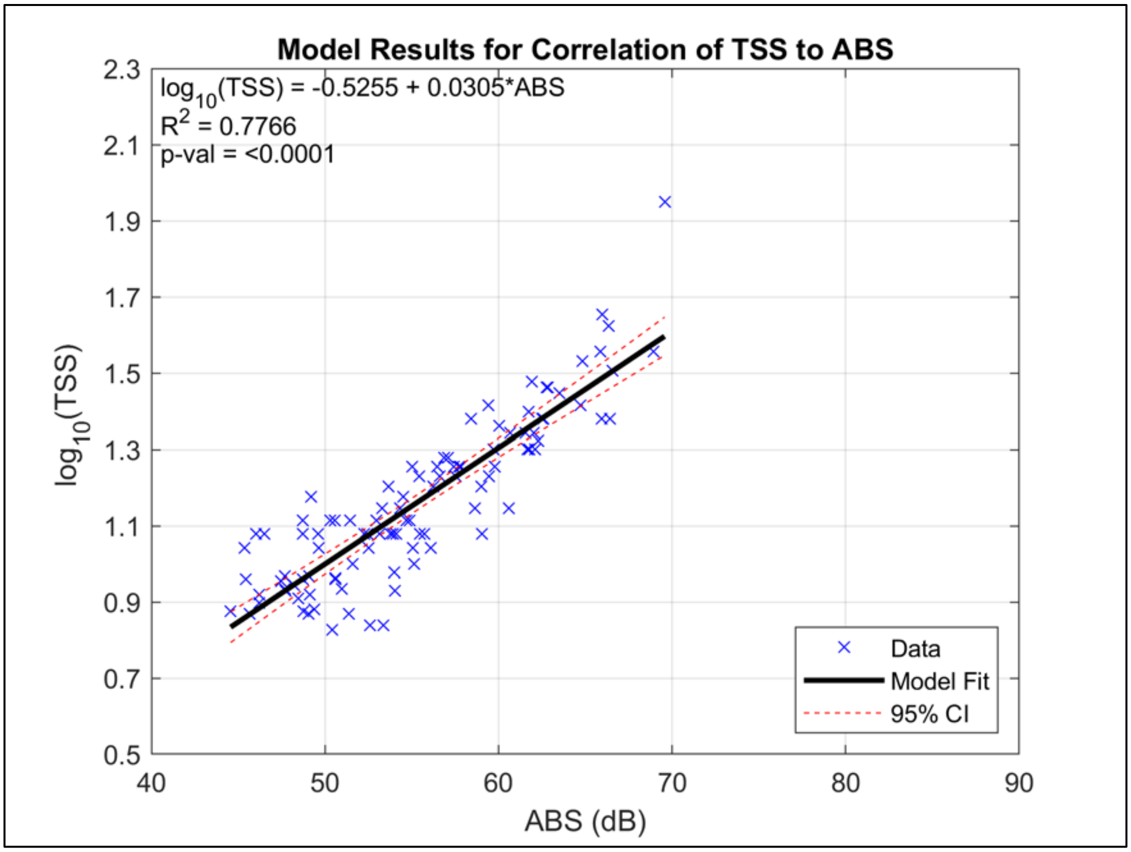

Figure 4-2. Calibration curve from linear regression analysis for TSS to ABS, plotted on increased scale to illustrate levels observed during the trials relative to the WQC standards for the Hudson River.

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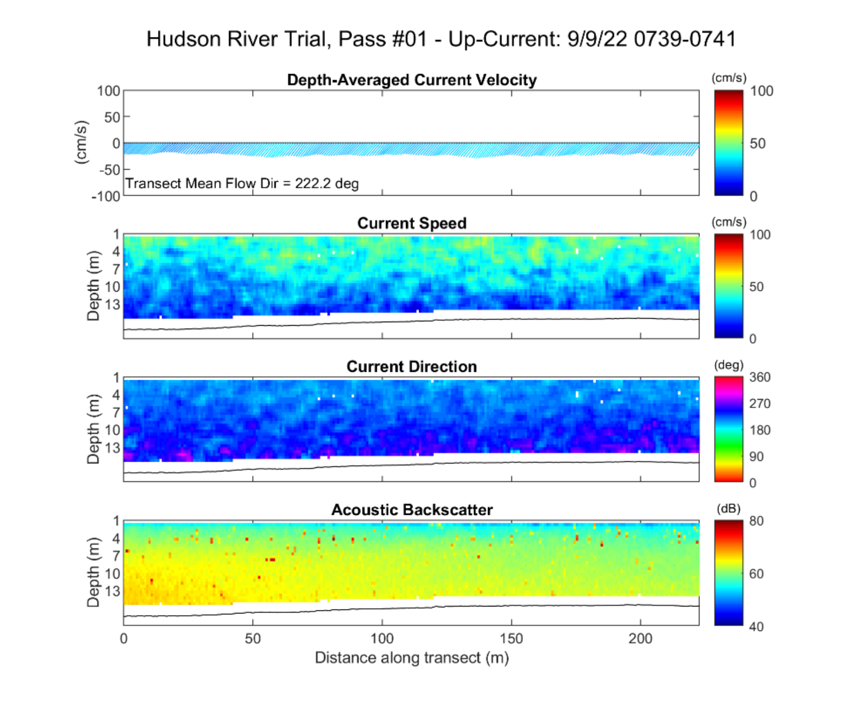
Appendix A. ADCP Velocity and ABS Transects from the Hudson River Trial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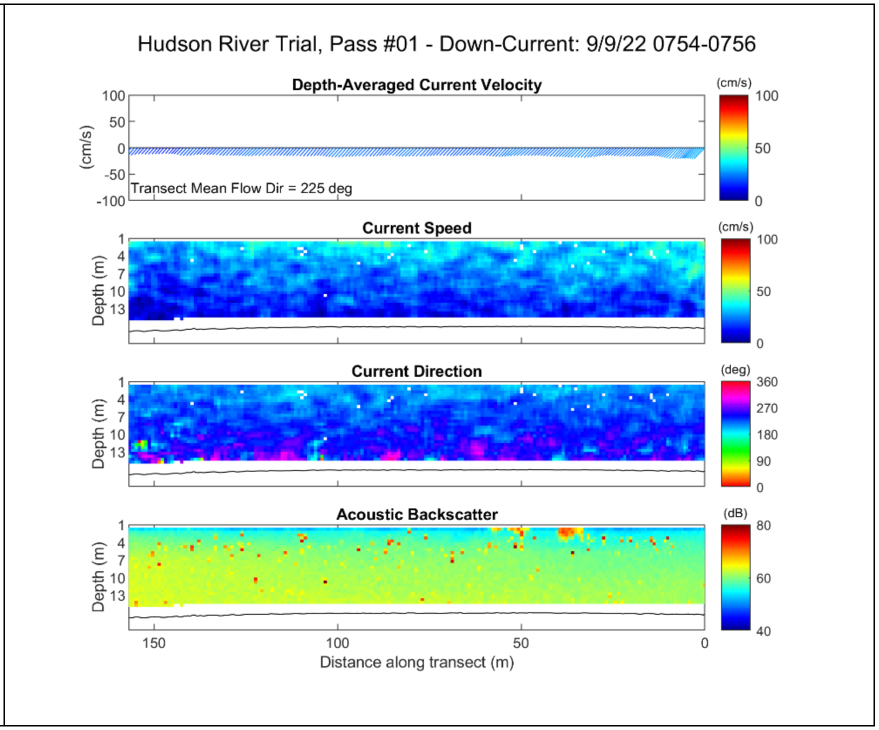
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Current Direction
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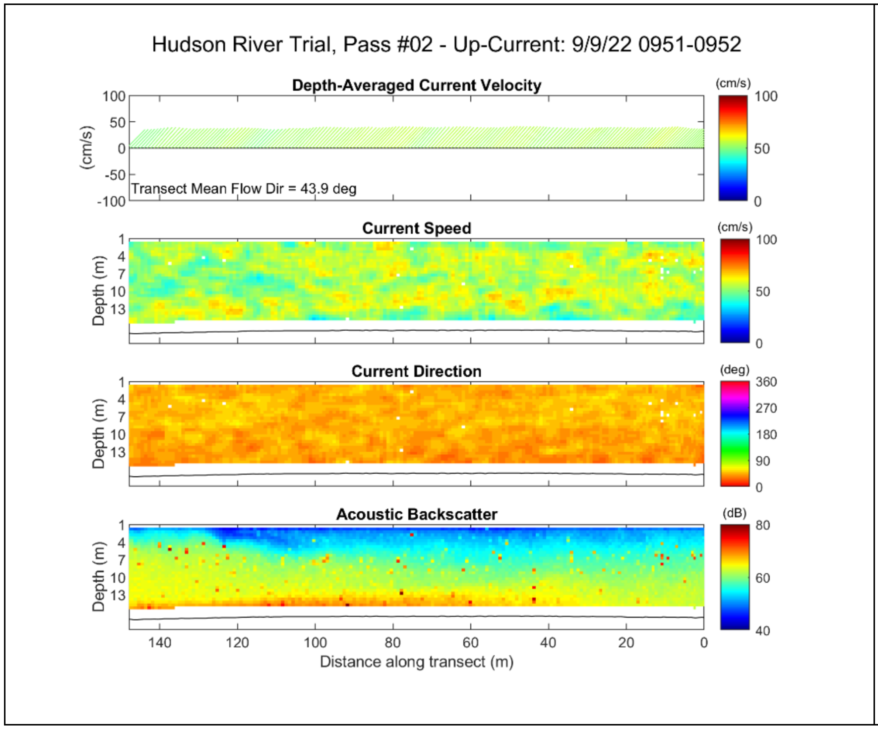
(cm/s)
(deg)
(dB)
Distance along transect (m)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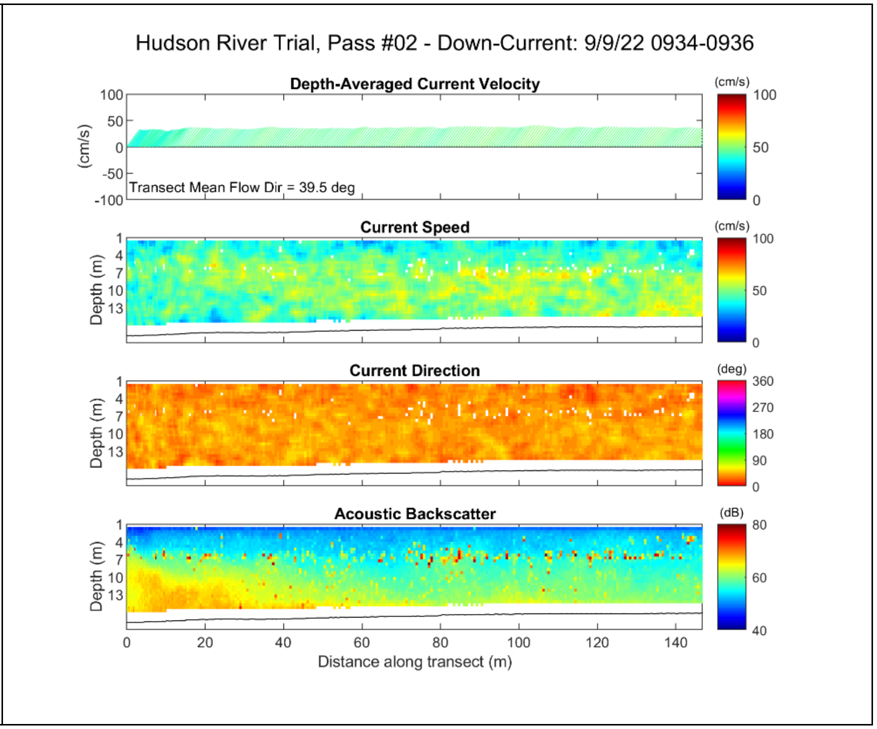
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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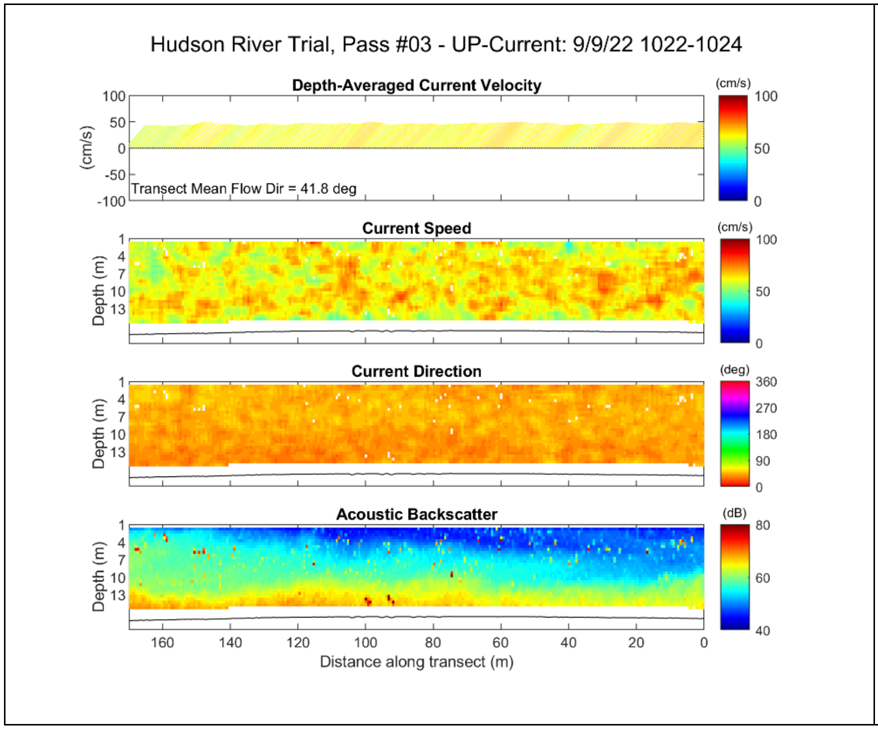
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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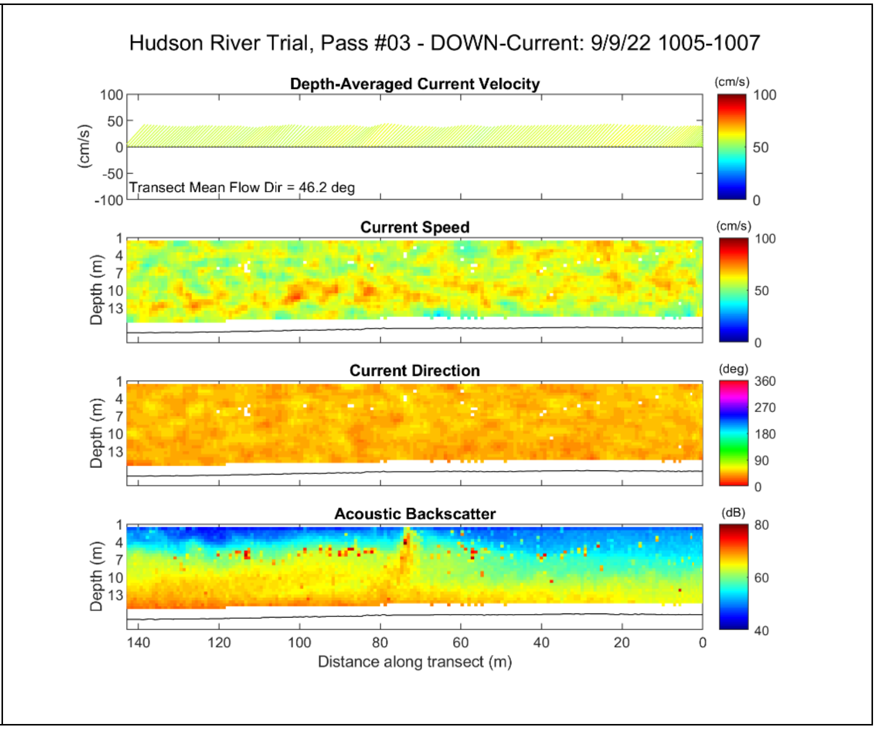
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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Current Direction
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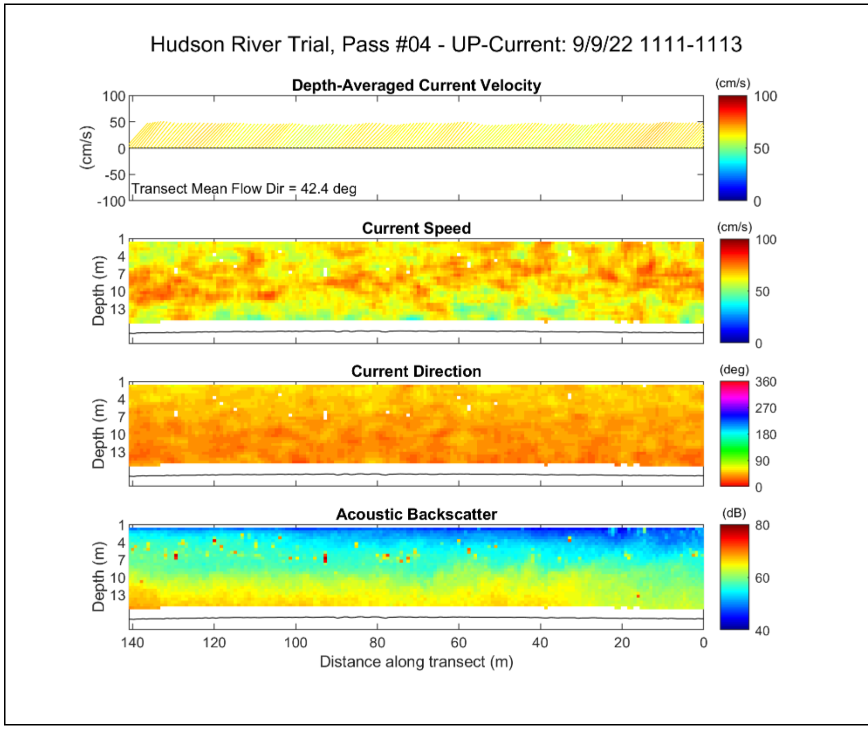
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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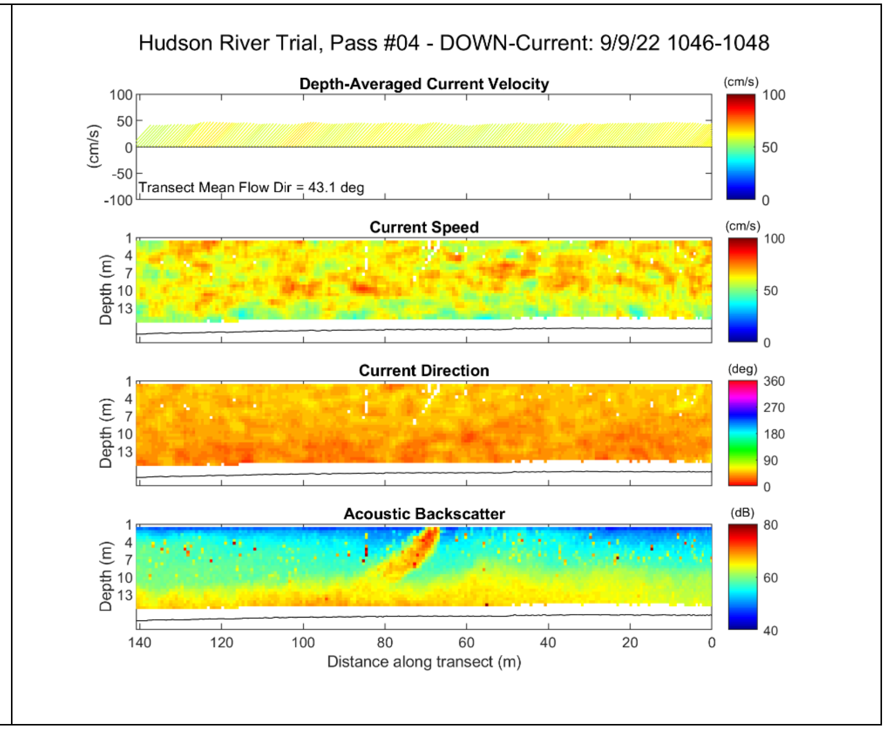
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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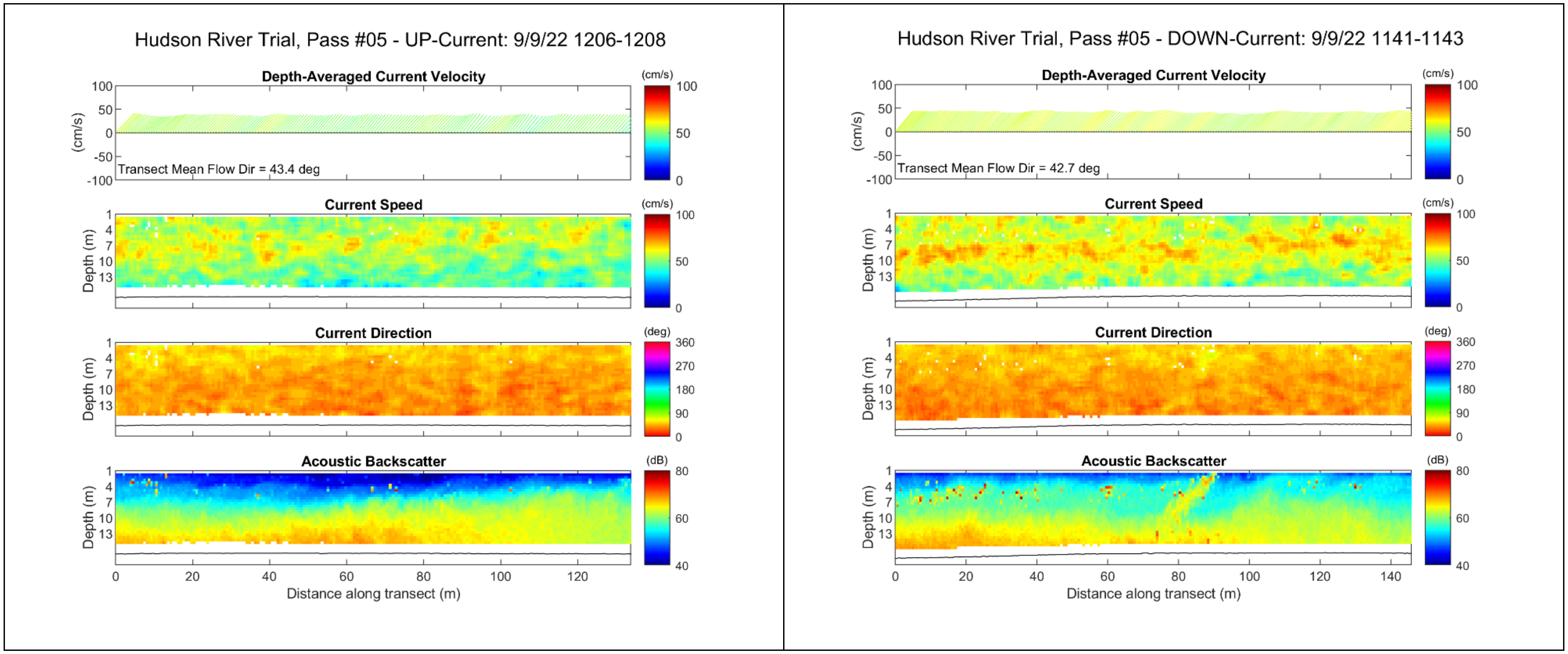
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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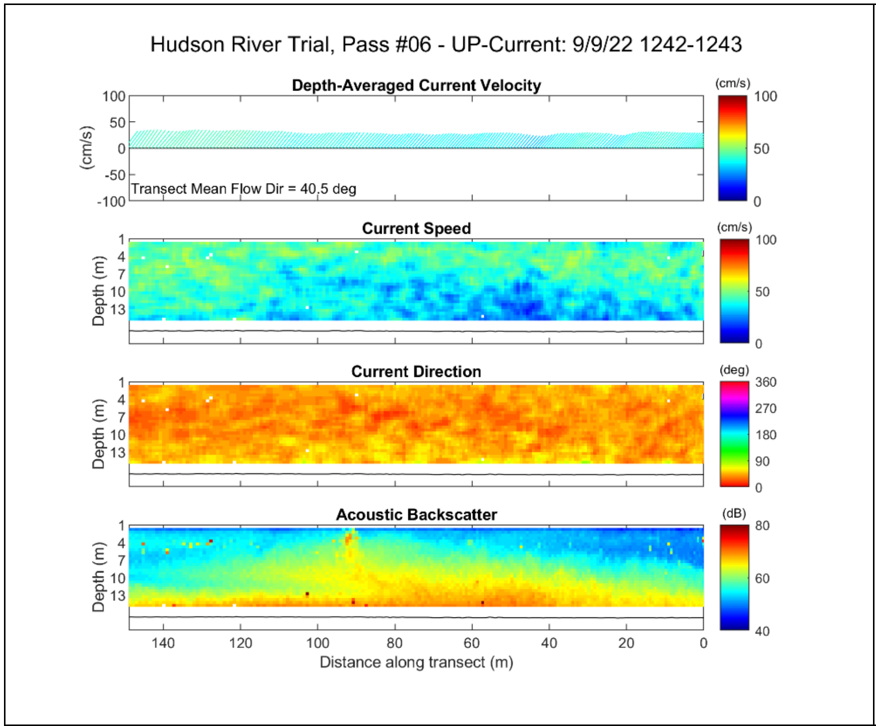
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)
Hudson River Trial, Pass #05 - DOWN-Current: 9/9/22 1141-1143
Depth-Averaged Current Velocity
Transect Mean Flow Dir = 42.7 deg
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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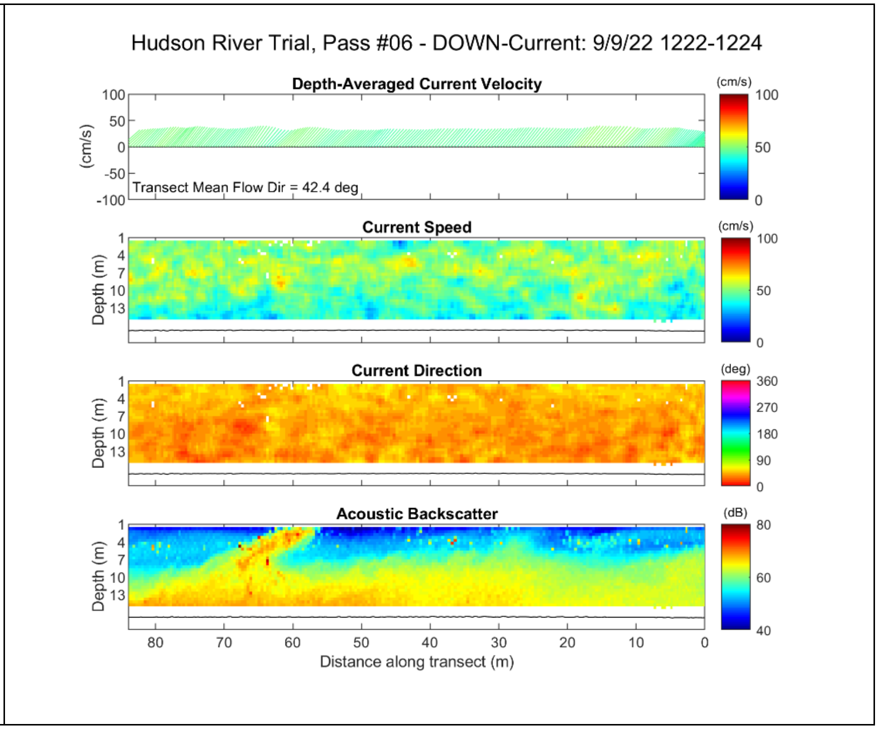
Current Speed
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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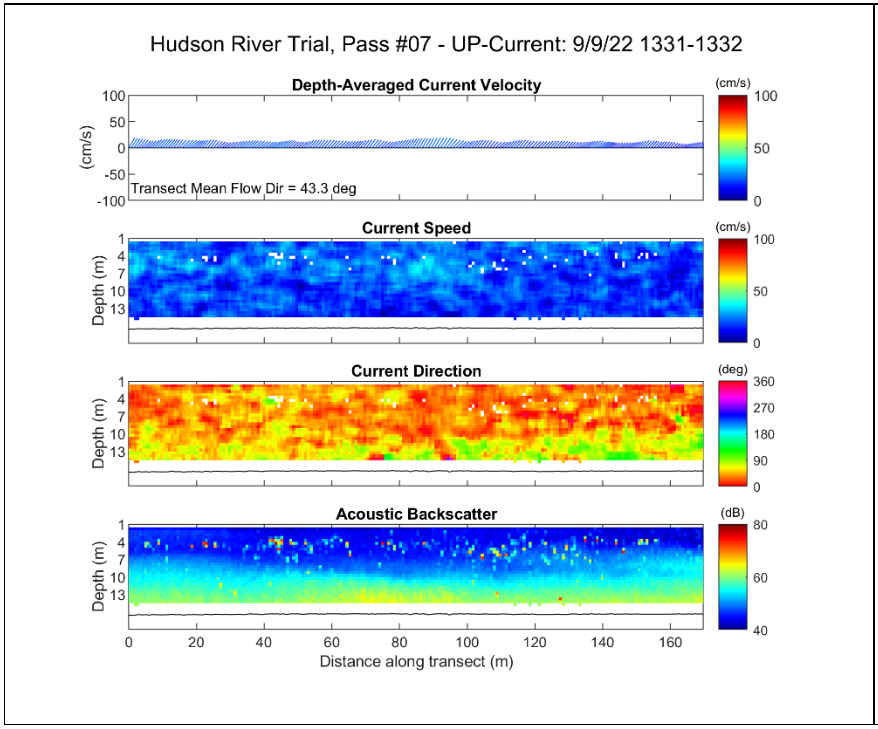
Depth (m)
Current Direction
(deg)
Acoustic Backscatter
(dB)
Distance along transect (m)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Current Direction
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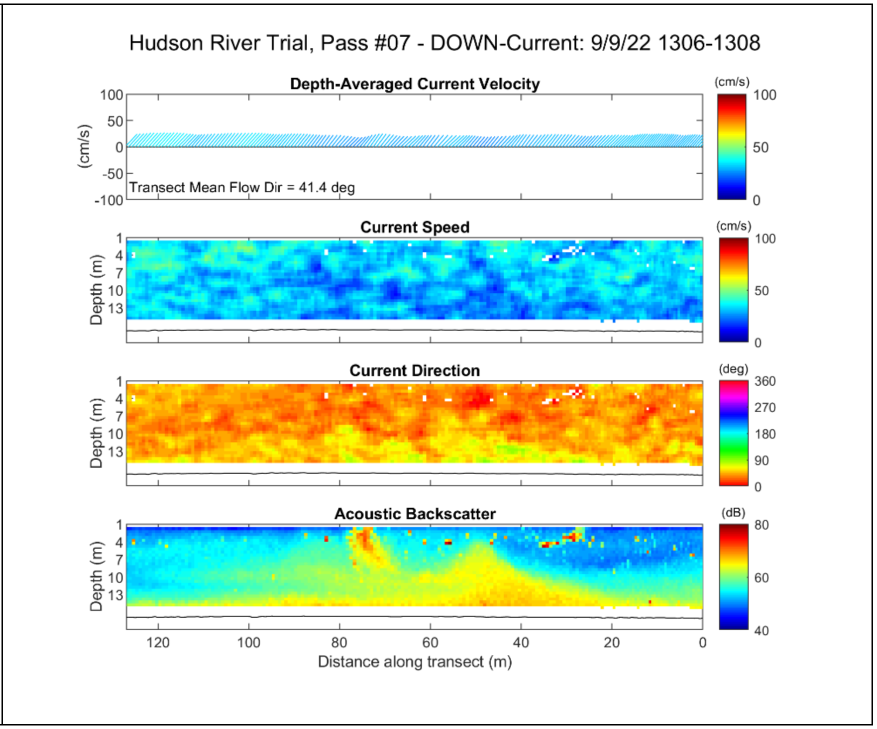
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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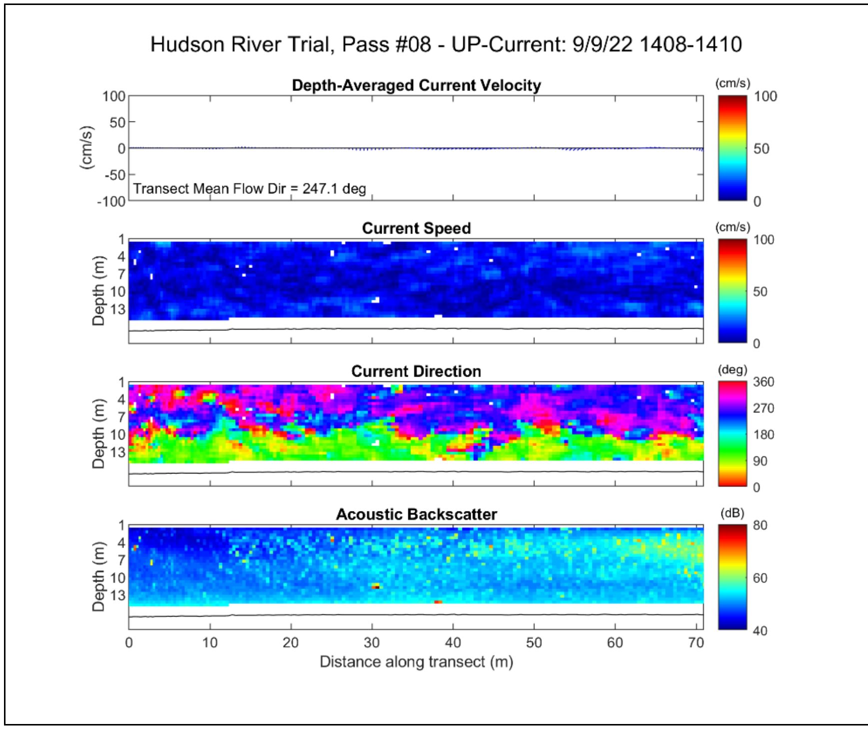
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Current Speed
Current Direction
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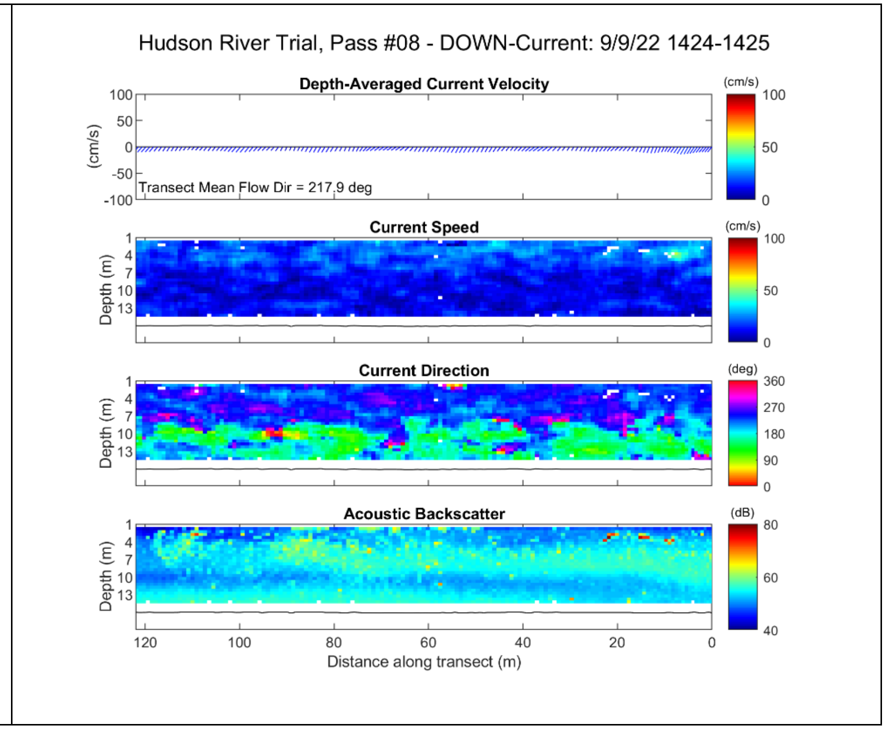
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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Current Direction
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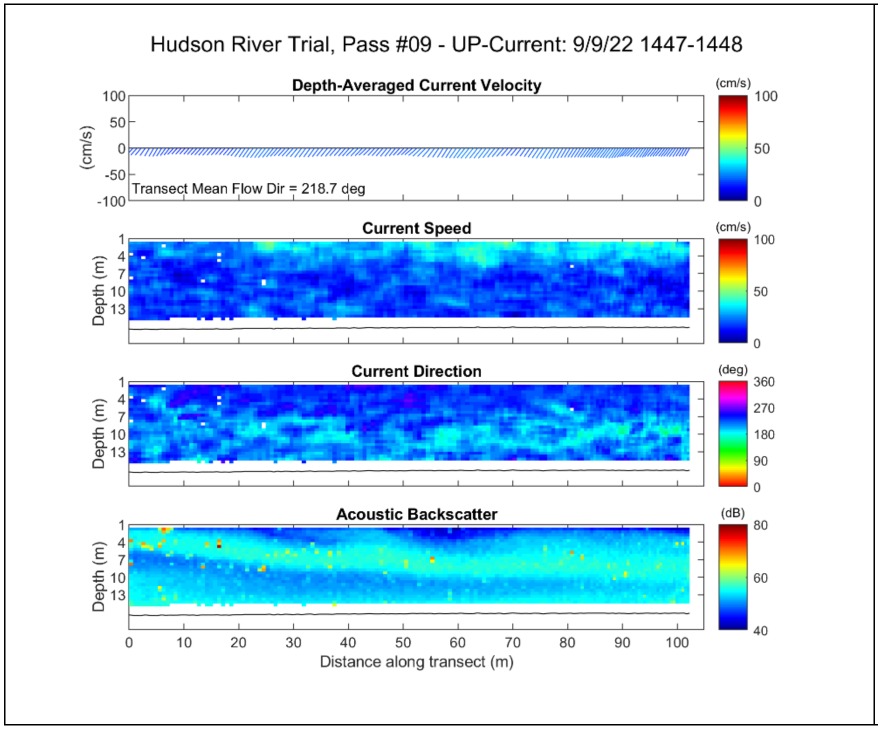
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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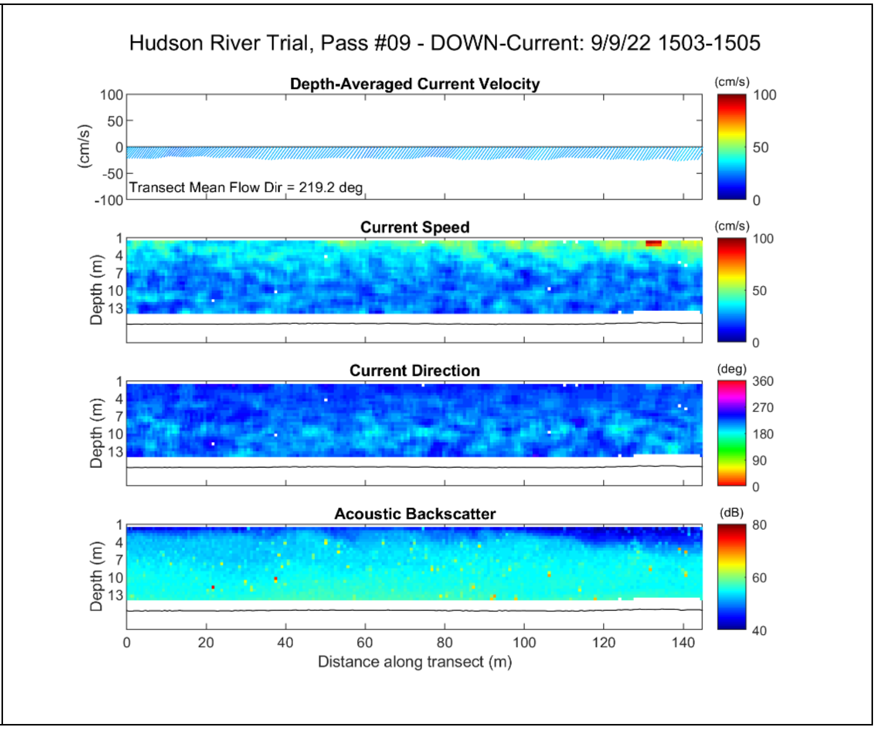
Current Speed
Current Direction
Acoustic Backscatter
Distance along transect (m)
Depth (m)
(cm/s)
(deg)
(dB)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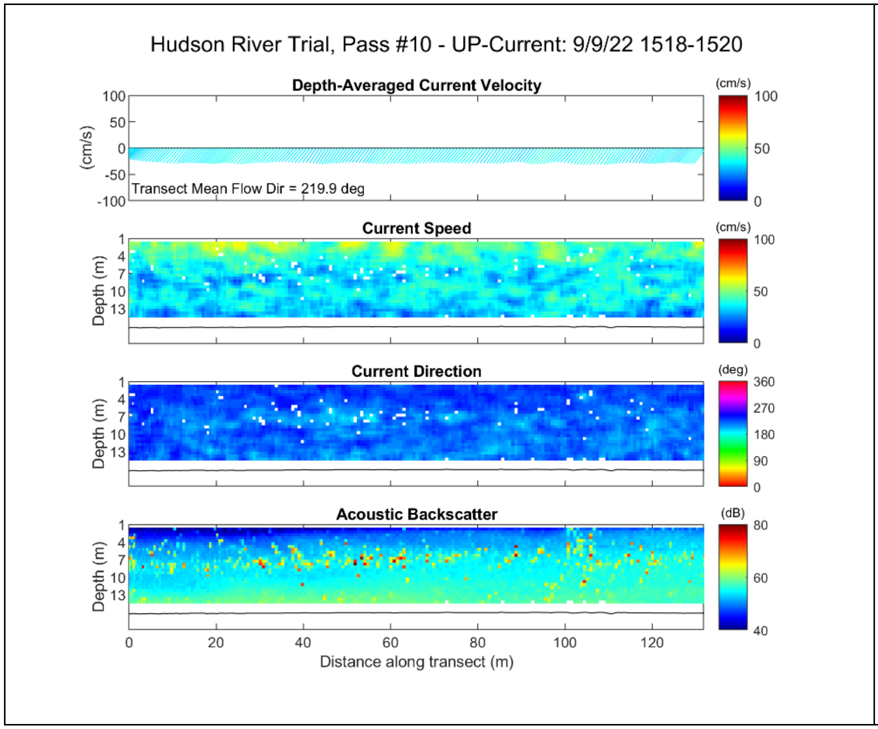
Depth-Averaged Current Velocity
Transect Mean Flow Dir = 219.2 deg
Current Speed
Current Direction
Acoustic Backscatter
Distance along transect (m)
Depth (m)
(cm/s)
(deg)
(dB)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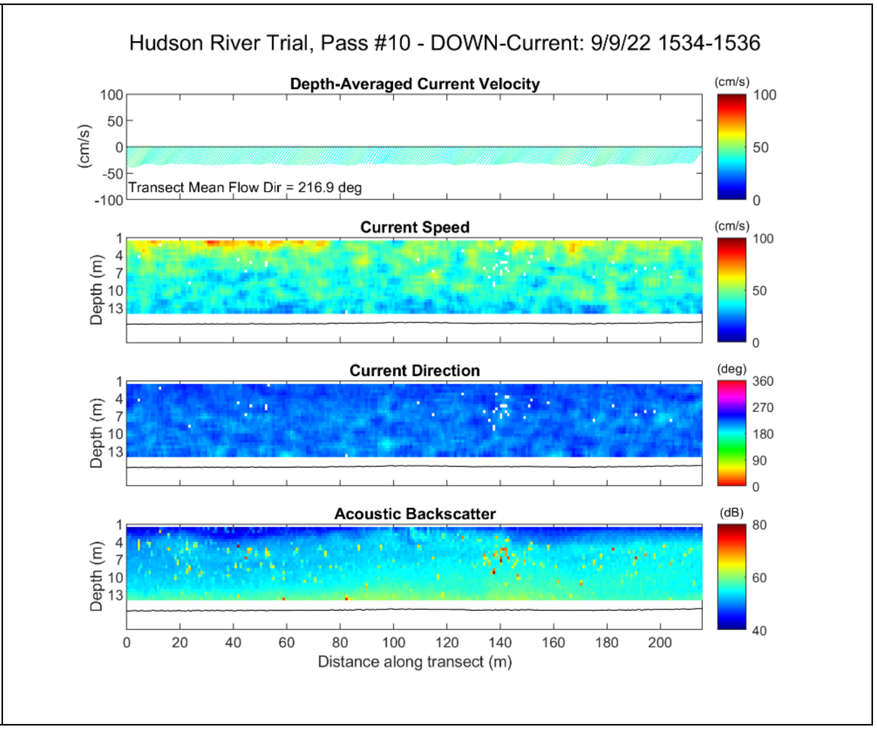
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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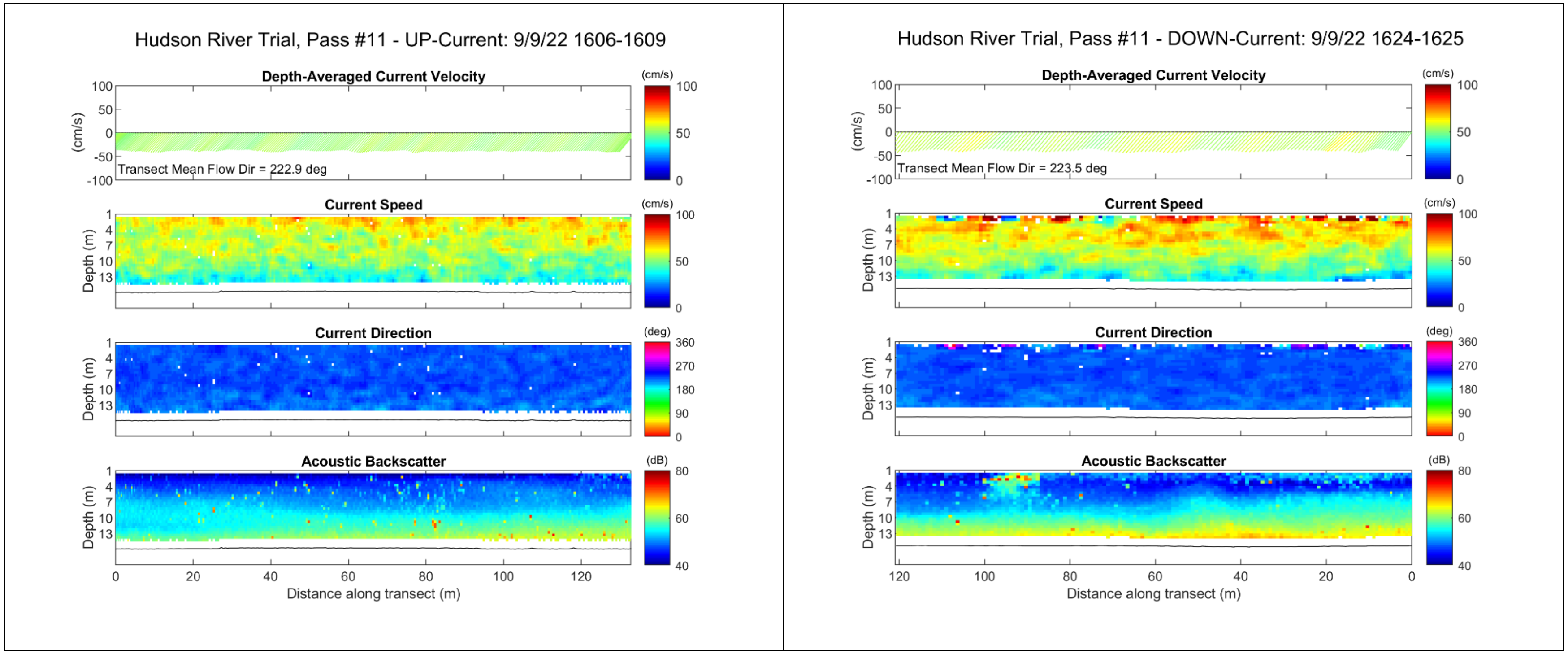
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
Distance along transect (m)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Current Direction
Acoustic Backscatter
Distance along transect (m)
Hudson River Trial, Pass #11 - DOWN-Current: 9/9/22 1624-1625
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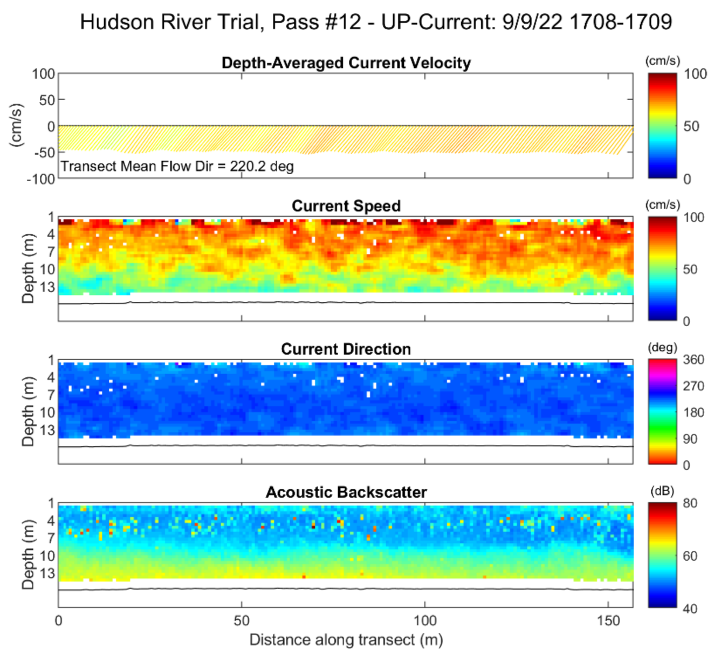
Current Speed
Current Direction
Acoustic Backscatter
Distance along transect (m)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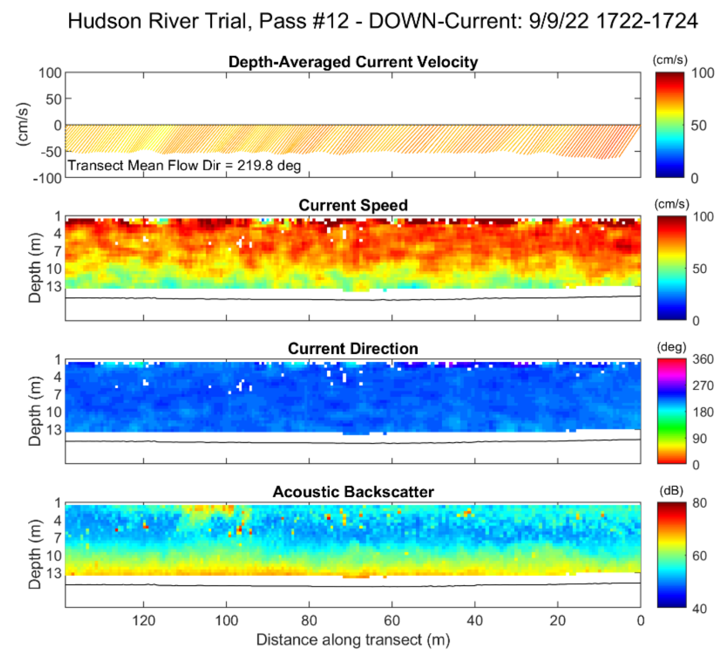
Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)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Depth-Averaged Current Velocity
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Current Speed
Current Direction
Acoustic Backscatter
Depth (m)
(cm/s)
(deg)
(dB)
Distance along transect (m)

Appendix B. Linear Regression Model Results from MATLAB® Output for TSS to OBS and TSS to ABS

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*** SUMMARY of Linear Model for OBS-TSS:
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 Model Information:

    TSS = 1.3003 + 1.3754*OBS

Linear regression model:
    y ~ 1 + x1

Estimated Coefficients:
                   Estimate       SE       tStat       pValue
                   ________    ________    ______    __________

    (Intercept)     1.3003      0.44531    2.9201     0.0043242
    x1              1.3754     0.032921     41.78    4.0411e-65

Number of observations: 102, Error degrees of freedom: 100
Root Mean Squared Error: 2.53
R-squared: 0.946,  Adjusted R-Squared: 0.945
F-statistic vs. constant model: 1.75e+03, p-value = 4.04e-65
Model Standard Percentage Error (MPSE): 15.20%
---------------------------------------------------------------
```

Model Residuals and Diagnostics:

ObsNo	OBS	TSS	Raw_r	Pearson_r	Standardized_r	Studentized_r	CooksD	DFFITS
1	5.73	9.3	0.11854	0.04685	0.047201	0.046965	1.6777e-05	0.0057637
2	9.79	17	2.2344	0.88307	0.88758	0.88663	0.0040319	0.089703
3	10.92	22	5.6801	2.2449	2.256	2.3041	0.025226	0.22941
4	5.25	7.6	-0.92126	-0.3641	-0.36701	-0.36541	0.0010786	-0.046243
5	15.18	24	1.8209	0.71965	0.7242	0.72246	0.0033217	0.081312
6	20.16	36	6.9713	2.7552	2.7881	2.8887	0.093318	0.4476
7	5.16	8.1	-0.29747	-0.11757	-0.11852	-0.11793	0.0001138	-0.015012
8	11.45	18	0.95118	0.37593	0.37778	0.37616	0.00070742	0.037453
9	14.9	25	3.206	1.2671	1.2748	1.2789	0.0099888	0.14179
10	4.59	6.9	-0.71349	-0.28199	-0.28444	-0.28313	0.00070636	-0.037413
11	5.27	7.4	-1.1488	-0.45402	-0.45763	-0.45581	0.0016726	-0.057609
12	10.7	18	1.9827	0.78362	0.78751	0.786	0.0030826	0.078369
13	4.56	7.4	-0.17223	-0.068068	-0.068662	-0.068319	4.1325e-05	-0.0090458
14	5.08	8.3	0.012558	0.0049634	0.0050039	0.0049788	2.0497e-07	0.00063706
15	9.9	14	-0.91693	-0.36239	-0.36423	-0.36265	0.00067561	-0.036599
16	4.8	8.5	0.59767	0.23621	0.23821	0.23708	0.00048188	0.030898
17	4.95	7.9	-0.20864	-0.082458	-0.083142	-0.082728	5.7558e-05	-0.010676
18	8.34	12	-0.77129	-0.30483	-0.30655	-0.30515	0.00053085	-0.032436
19	4.91	6.9	-1.1536	-0.45594	-0.45974	-0.45792	0.0017691	-0.059248
20	5.69	8.6	-0.52644	-0.20806	-0.20963	-0.20863	0.0003326	-0.025668
21	9.93	16	1.0418	0.41174	0.41383	0.41211	0.00087102	0.041564
22	4.57	6.7	-0.88598	-0.35016	-0.35321	-0.35166	0.0010921	-0.046531
23	6.06	9.1	-0.53535	-0.21158	-0.2131	-0.21208	0.00032817	-0.025496
24	9.76	15	0.27562	0.10893	0.10949	0.10895	6.1442e-05	0.01103
25	5.01	8.3	0.10884	0.043015	0.043369	0.043152	1.5539e-05	0.0055468
26	5.3	8.6	0.0099676	0.0039394	0.0039706	0.0039507	1.2543e-07	0.00049835
27	10.25	17	1.6017	0.63302	0.63619	0.63428	0.0020341	0.063591
28	4.67	7.5	-0.22352	-0.088341	-0.089101	-0.088658	6.8584e-05	-0.011654
29	5.69	8.8	-0.32644	-0.12902	-0.12999	-0.12935	0.00012789	-0.015914
30	15.8	23	-0.031871	-0.012596	-0.012681	-0.012618	1.0932e-06	-0.0014712
31	11.86	19	1.3873	0.54827	0.551	0.54908	0.001515	0.054853
32	12.74	22	3.1769	1.2556	1.262	1.2658	0.0082184	0.12859
33	13.72	21	0.82899	0.32763	0.32943	0.32796	0.00059763	0.034418
34	11.25	18	1.2263	0.48464	0.48704	0.48517	0.0011744	0.048278
35	11.52	20	2.8549	1.1283	1.1339	1.1355	0.0063776	0.1131
36	12.3	20	1.7821	0.70431	0.70787	0.70609	0.0025346	0.071019
37	8.15	13	0.49004	0.19367	0.19478	0.19384	0.000218	0.02078
38	11.34	17	0.10247	0.040499	0.040699	0.040495	8.2036e-06	0.0040303
39	19.98	28	-0.7811	-0.30871	-0.3123	-0.31089	0.0011432	-0.0476
40	8.76	12	-1.349	-0.53314	-0.53604	-0.53412	0.0015682	-0.055804
41	14.04	20	-0.61114	-0.24154	-0.2429	-0.24175	0.00033372	-0.025713
42	21.72	36	4.8257	1.9072	1.9351	1.9625	0.055123	0.33673
43	7.71	13	1.0952	0.43286	0.43544	0.43367	0.0011365	0.047482
44	11.07	17	0.47383	0.18727	0.18819	0.18728	0.00017537	0.018638
45	64.19	89	-0.58812	-0.23244	-0.32403	-0.32258	0.04953	-0.31333
46	7.98	12	-0.27614	-0.10914	-0.10977	-0.10923	7.0342e-05	-0.011802
47	11.11	18	1.4188	0.56075	0.56352	0.56158	0.0015722	0.055882
48	20.38	34	4.6687	1.8452	1.8679	1.8918	0.043122	0.29744
49	9	15	1.3209	0.52206	0.52486	0.52295	0.0014771	0.054155
50	10.92	18	1.6801	0.66403	0.66731	0.66545	0.0022071	0.066255
51	24.99	42	6.3281	2.501	2.5553	2.6298	0.14341	0.55116
52	8.02	12	-0.33116	-0.13088	-0.13164	-0.13099	0.00010078	-0.014127
53	13	19	-0.18071	-0.071422	-0.071795	-0.071437	2.6988e-05	-0.0073101
54	19.54	32	3.8241	1.5114	1.528	1.5384	0.025804	0.22872
55	8.84	14	0.541	0.21382	0.21497	0.21395	0.0002507	0.022285
56	9.41	14	-0.24298	-0.096031	-0.096531	-0.096052	4.866e-05	-0.0098161
57	20.07	26	-2.9049	-1.1481	-1.1616	-1.1637	0.016006	-0.17924
58	7.49	12	0.39781	0.15722	0.15819	0.15741	0.0001534	0.01743
59	13.48	22	2.1591	0.85332	0.85792	0.85678	0.0039793	0.089092
60	21.83	24	-7.3256	-2.8952	-2.9381	-3.0584	0.12889	-0.5285
61	8.02	11	-1.3312	-0.5261	-0.52915	-0.52724	0.0016284	-0.056861

62	8.32	11	-1.7438	-0.68918	-0.69307	-0.69126	0.0027183	-0.07354
63	18.57	29	2.1582	0.85298	0.86122	0.8601	0.0071987	0.11983
64	8.86	13	-0.4865	-0.19228	-0.19332	-0.19238	0.00020243	-0.020024
65	13.46	24	4.1866	1.6546	1.6635	1.6786	0.01494	0.17442
66	23.99	29	-5.2965	-2.0933	-2.1338	-2.1731	0.088867	-0.42936
67	8.08	13	0.58632	0.23173	0.23306	0.23196	0.00031412	0.024946
68	8.13	12	-0.48245	-0.19068	-0.19177	-0.19084	0.00021169	-0.020477
69	14.51	24	2.7424	1.0839	1.0902	1.0913	0.0070224	0.11862
70	6.02	9.1	-0.48033	-0.18984	-0.19121	-0.19029	0.00026551	-0.022933
71	7.25	11	-0.27209	-0.10754	-0.10821	-0.10767	7.3643e-05	-0.012076
72	14.43	16	-5.1476	-2.0344	-2.0463	-2.0801	0.024548	-0.22523
73	6.53	10	-0.28179	-0.11137	-0.11213	-0.11157	8.5824e-05	-0.013037
74	7.57	12	0.28778	0.11374	0.11443	0.11386	7.9605e-05	0.012555
75	8.52	13	-0.018863	-0.007455	-0.0074964	-0.0074588	3.1264e-07	-0.00078678
76	6.55	9.2	-1.1093	-0.43842	-0.44139	-0.43961	0.0013268	-0.051305
77	8.19	12	-0.56498	-0.22329	-0.22457	-0.2235	0.00028871	-0.023915
78	11.81	13	-4.544	-1.7959	-1.8048	-1.8257	0.016236	-0.18229
79	6.72	9.3	-1.2431	-0.49131	-0.49458	-0.4927	0.0016329	-0.056931
80	7.86	12	-0.11109	-0.043905	-0.044164	-0.043943	1.1518e-05	-0.0047756
81	10.86	12	-4.2373	-1.6747	-1.683	-1.6988	0.014047	-0.16919
82	6.18	9	-0.8004	-0.31633	-0.31858	-0.31714	0.00072266	-0.037846
83	7.43	13	1.4803	0.58506	0.58866	0.58673	0.0021378	0.065173
84	11.17	16	-0.66371	-0.26231	-0.26361	-0.26238	0.000344	-0.026108
85	6.05	9.1	-0.52159	-0.20614	-0.20763	-0.20663	0.00031191	-0.024857
86	7.78	10	-2.0011	-0.79086	-0.79555	-0.79408	0.0037671	-0.086639
87	14.41	18	-3.12	-1.2331	-1.2403	-1.2437	0.0090011	-0.13454
88	7.04	12	1.0167	0.40184	0.40442	0.40272	0.0010527	0.045692
89	7.92	12	-0.19362	-0.076521	-0.076969	-0.076585	3.4782e-05	-0.008299
90	16.89	26	1.4689	0.58055	0.58505	0.58312	0.0026623	0.072729
91	5.39	7.5	-1.2138	-0.47973	-0.48349	-0.48163	0.0018383	-0.060402
92	6.9	11	0.20931	0.082722	0.083262	0.082847	4.5331e-05	0.0094743
93	19.6	30	1.7416	0.6883	0.69593	0.69412	0.0053961	0.10362
94	5.08	7.4	-0.88744	-0.35074	-0.3536	-0.35204	0.0010235	-0.045046
95	9.87	14	-0.87567	-0.34608	-0.34784	-0.34631	0.000617	-0.034973
96	21.55	24	-6.9405	-2.743	-2.7823	-2.8821	0.11149	-0.48915
97	6.25	9.5	-0.39667	-0.15677	-0.15788	-0.15711	0.00017597	-0.018668
98	9.22	12	-1.9817	-0.78319	-0.78732	-0.78581	0.003275	-0.080777
99	21.1	20	-10.322	-4.0793	-4.1344	-4.5178	0.23222	-0.74471
100	5.75	8.5	-0.70897	-0.2802	-0.2823	-0.28099	0.00059859	-0.034441
101	7.11	11	-0.07953	-0.031432	-0.031632	-0.031474	6.3904e-06	-0.0035571
102	32.93	45	-1.5927	-0.62947	-0.65981	-0.65794	0.021493	-0.20674

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--------------------------------------------------------------------
*** SUMMARY of Model for ABS-TSS:
--------------------------------------------------------------------
 Model Information:

    log10(TSS) = -0.52548 + 0.030501*ABS

Linear regression model:
    y ~ 1 + x1

Estimated Coefficients:
                   Estimate        SE         tStat       pValue
                   ________    _________    _______    __________

    (Intercept)    -0.52548     0.091124    -5.7667    9.0404e-08
    x1             0.030501    0.0016359     18.645    2.5634e-34

Number of observations: 102, Error degrees of freedom: 100
Root Mean Squared Error: 0.102
R-squared: 0.777,  Adjusted R-Squared: 0.774
F-statistic vs. constant model: 348, p-value = 2.56e-34
Model Standard Percentage Error (MPSE): [-20.91%, +26.44%]
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```

Model Residuals and Diagnostics:

ObsNo	ABS	log10TSS	Raw_r	Pearson_r	Standardized_r	Studentized_r	CooksD	DFFITS
1	47.704	0.96848	0.038936	0.38215	0.387	0.38535	0.0019133	0.061596
2	59.468	1.2304	-0.057928	-0.56856	-0.57263	-0.5707	0.0023543	-0.068388
3	60.672	1.3424	0.017319	0.16998	0.17145	0.17062	0.00025542	0.022492
4	49.381	0.88081	-0.099906	-0.98058	-0.99004	-0.98994	0.0095004	-0.13783
5	65.953	1.3802	-0.10595	-1.0399	-1.0606	-1.0613	0.022666	-0.21305
6	68.91	1.5563	-0.020068	-0.19697	-0.20285	-0.20187	0.001247	-0.049699
7	48.469	0.90849	-0.04441	-0.43588	-0.44077	-0.43898	0.0021895	-0.065906
8	57.837	1.2553	0.016642	0.16334	0.16428	0.16348	0.00015542	0.017545
9	61.748	1.3979	0.040025	0.39285	0.3969	0.39522	0.0016342	0.056929
10	52.576	0.83885	-0.23931	-2.3488	-2.3628	-2.4195	0.033335	-0.2644
11	49.044	0.86923	-0.10121	-0.99339	-1.0035	-1.0036	0.01032	-0.14367
12	57.434	1.2553	0.028926	0.2839	0.28547	0.28415	0.00044961	0.029849
13	45.651	0.86923	0.0023058	0.022632	0.023028	0.022912	9.3617e-06	0.0043054
14	46.213	0.91908	0.035006	0.34358	0.3491	0.34756	0.0019735	0.062549
15	53.303	1.1461	0.045782	0.44934	0.45181	0.45001	0.0011241	0.047226
16	47.726	0.92942	-0.00082127	-0.0080607	-0.0081626	-0.0081217	8.4804e-07	-0.0012958
17	46.228	0.89763	0.013092	0.1285	0.13056	0.12991	0.00027538	0.023353
18	52.25	1.0792	0.010978	0.10775	0.10842	0.10788	7.3176e-05	0.012038
19	53.378	0.83885	-0.26377	-2.5889	-2.603	-2.6824	0.037043	-0.28049
20	50.956	0.9345	-0.094236	-0.92492	-0.93185	-0.93123	0.0065237	-0.11415
21	53.662	1.2041	0.092842	0.91124	0.91608	0.91534	0.0044726	0.094502
22	50.399	0.82607	-0.18569	-1.8225	-1.8374	-1.8599	0.027704	-0.23826
23	50.597	0.95904	-0.058746	-0.57659	-0.58116	-0.57922	0.0026851	-0.073038
24	54.504	1.1761	0.039137	0.38413	0.38606	0.38441	0.00075218	0.038621
25	49.13	0.91908	-0.053979	-0.5298	-0.53513	-0.53321	0.0028933	-0.075798
26	47.689	0.9345	0.005395	0.052952	0.053625	0.053357	3.6824e-05	0.0085389
27	55.448	1.2304	0.064696	0.63499	0.63813	0.63623	0.0020163	0.063313
28	48.743	0.87506	-0.086202	-0.84607	-0.85513	-0.85397	0.0078763	-0.12534
29	48.188	0.94448	0.0001651	0.0016204	0.0016394	0.0016312	3.1725e-08	0.00025063
30	60.025	1.3617	0.056374	0.55331	0.55763	0.55569	0.0024342	0.069533
31	56.856	1.2788	0.070055	0.68759	0.69118	0.68937	0.0025058	0.070606
32	61.569	1.3424	-0.010026	-0.098401	-0.099387	-0.098894	9.9481e-05	-0.014035
33	62.288	1.3222	-0.052158	-0.51193	-0.5177	-0.5158	0.0030396	-0.077683
34	55.036	1.2553	0.10208	1.0019	1.0069	1.0069	0.0050326	0.10033
35	59.714	1.301	0.0051599	0.050644	0.05102	0.050765	1.9408e-05	0.0061991
36	61.77	1.301	-0.057573	-0.56508	-0.57093	-0.569	0.0033943	-0.082114
37	50.571	1.1139	0.096933	0.95139	0.95895	0.95856	0.0073407	0.12112
38	57.531	1.2304	0.0011613	0.011398	0.011462	0.011404	7.3189e-07	0.0012038
39	63.505	1.4472	0.03564	0.34981	0.35461	0.35305	0.0017389	0.058714
40	49.621	1.0792	0.091158	0.89471	0.90301	0.90217	0.0075973	0.12315
41	62.099	1.301	-0.067604	-0.66353	-0.67079	-0.66893	0.0049472	-0.099195
42	65.865	1.5563	0.072821	0.71473	0.72881	0.72709	0.010565	0.14502
43	48.722	1.1139	0.15332	1.5049	1.5211	1.5312	0.025007	0.22514
44	56.628	1.2304	0.028702	0.28171	0.28316	0.28185	0.00041389	0.028638
45	69.603	1.9494	0.35187	3.4536	3.5661	3.798	0.42111	0.97739
46	46.046	1.0792	0.20018	1.9648	1.9971	2.028	0.066274	0.36969
47	56.455	1.2553	0.058797	0.57709	0.58003	0.5781	0.0017187	0.058433
48	64.818	1.5315	0.079911	0.78432	0.79754	0.79608	0.01081	0.14677
49	49.198	1.1761	0.20096	1.9724	1.992	2.0225	0.039643	0.2859
50	59.798	1.2553	-0.043174	-0.42375	-0.42694	-0.42519	0.001377	-0.052264
51	66.328	1.6232	0.12562	1.233	1.2589	1.2627	0.033729	0.2605
52	48.739	1.0792	0.11807	1.1589	1.1713	1.1735	0.014789	0.17231
53	57.093	1.2788	0.062813	0.6165	0.61979	0.61787	0.0020537	0.06389
54	66.567	1.5051	0.00024625	0.0024169	0.0024696	0.0024572	1.3432e-07	0.0005157
55	58.629	1.1461	-0.11665	-1.1449	-1.1522	-1.1541	0.0084424	-0.13016
56	60.601	1.1461	-0.17682	-1.7355	-1.7503	-1.7689	0.026315	-0.23184
57	64.73	1.415	-0.03389	-0.33263	-0.33816	-0.33666	0.0019171	-0.061646
58	46.513	1.0792	0.18597	1.8253	1.8532	1.8765	0.053077	0.32989
59	62.041	1.3424	-0.02442	-0.23968	-0.24228	-0.24114	0.00063915	-0.035585
60	66.412	1.3802	-0.11995	-1.1773	-1.2024	-1.2052	0.031141	-0.25013
61	52.501	1.0414	-0.034489	-0.33851	-0.34054	-0.33903	0.00069889	-0.037221

62	56.098	1.0414	-0.14419	-1.4152	-1.4223	-1.4297	0.01016	-0.14329
63	62.841	1.4624	0.07114	0.69824	0.70686	0.70508	0.0062051	0.11112
64	52.965	1.1139	0.023907	0.23464	0.23598	0.23486	0.00031769	0.025087
65	62.517	1.3802	-0.0011487	-0.011274	-0.011406	-0.011349	1.5322e-06	-0.0017418
66	62.777	1.4624	0.073109	0.71756	0.72633	0.7246	0.0064829	0.1136
67	51.46	1.1139	0.069823	0.68531	0.69006	0.68824	0.0033129	0.081185
68	53.775	1.0792	-0.035541	-0.34883	-0.35067	-0.34912	0.00064936	-0.035879
69	58.42	1.3802	0.12379	1.215	1.2225	1.2255	0.0092438	0.13631
70	45.43	0.95904	0.098847	0.97018	0.98773	0.9876	0.017808	0.1887
71	45.37	1.0414	0.18303	1.7964	1.8292	1.8513	0.06163	0.35532
72	58.998	1.2041	-0.069913	-0.68619	-0.69077	-0.68896	0.0031957	-0.079736
73	51.611	1	-0.048716	-0.47814	-0.48138	-0.47953	0.0015768	-0.055941
74	59.061	1.0792	-0.19679	-1.9315	-1.9445	-1.9724	0.025557	-0.22933
75	50.309	1.1139	0.10492	1.0298	1.0383	1.0387	0.0089757	0.13404
76	50.597	0.96379	-0.05401	-0.53011	-0.5343	-0.53239	0.0022695	-0.06713
77	55.481	1.0792	-0.087592	-0.85971	-0.86395	-0.86285	0.0036966	-0.085874
78	54.685	1.1139	-0.028541	-0.28013	-0.28153	-0.28023	0.0003971	-0.028051
79	49.092	0.96848	-0.0034028	-0.033398	-0.033736	-0.033567	1.1573e-05	-0.0047869
80	55.712	1.0792	-0.094638	-0.92886	-0.93347	-0.93286	0.0043279	-0.092976
81	53.151	1.0792	-0.01652	-0.16214	-0.16304	-0.16225	0.00014866	-0.017159
82	47.47	0.95424	0.03182	0.31232	0.31643	0.315	0.0013285	0.051313
83	54.871	1.1139	-0.034203	-0.3357	-0.33737	-0.33587	0.00056702	-0.033526
84	56.243	1.2041	0.014111	0.1385	0.1392	0.13851	9.7911e-05	0.013925
85	48.708	0.95904	-0.0011505	-0.011292	-0.011414	-0.011356	1.4113e-06	-0.0016716
86	55.135	1	-0.1562	-1.5331	-1.5407	-1.5515	0.011766	-0.15448
87	57.735	1.2553	0.019765	0.19399	0.19509	0.19415	0.0002167	0.020718
88	52.43	1.0792	0.0054655	0.053644	0.053969	0.053699	1.7711e-05	0.005922
89	54.089	1.0792	-0.045124	-0.44289	-0.44517	-0.44338	0.0010231	-0.045054
90	59.396	1.415	0.12878	1.264	1.2729	1.2769	0.011509	0.15219
91	44.565	0.87506	0.041238	0.40475	0.41307	0.41135	0.0035399	0.083792
92	49.645	1.0414	0.052648	0.51673	0.52151	0.5196	0.0025241	0.070791
93	61.921	1.4771	0.11391	1.1181	1.1299	1.1315	0.013631	0.16534
94	51.377	0.86923	-0.17236	-1.6917	-1.7036	-1.7202	0.020443	-0.20417
95	54.322	1.1461	0.014723	0.14451	0.14524	0.14453	0.00010742	0.014585
96	62.592	1.3802	-0.0034388	-0.033752	-0.034152	-0.033981	1.3906e-05	-0.0052473
97	53.979	0.97772	-0.14322	-1.4057	-1.413	-1.4201	0.010384	-0.14484
98	53.916	1.0792	-0.03986	-0.39123	-0.39327	-0.3916	0.00080799	-0.040029
99	61.664	1.301	-0.054336	-0.5333	-0.53873	-0.53681	0.0029696	-0.076791
100	54.047	0.92942	-0.19361	-1.9002	-1.91	-1.9361	0.018887	-0.19701
101	55.061	1.0414	-0.11256	-1.1048	-1.1102	-1.1116	0.0061167	-0.11073
102	65.989	1.6532	0.16593	1.6286	1.6613	1.6762	0.055905	0.33739