2024-2025 Nechako River Substrate Monitoring

Final Report

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DISCLAIMER

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- Steven McAdam — White Sturgeon Recovery Lead, BC WLRS
- Angie Coulter — Aquatic Conservation Biologist, BC WLRS

The following NHC personnel participated in the study:

- Andre Zimmermann — Principal
- Simon Gauthier-Fauteux — Geomorphologist
- Flavien Beaud — Geomorphologist

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1 INTRODUCTION

1.1 Background

The Nechako white sturgeon (*Acipenser transmontanus*) population has undergone recruitment failure since 1967 (McAdam et al., 2005). To promote the recovery of this population, the Nechako White Sturgeon Recovery Initiative (NWSRI) constructed two spawning pads in 2011 within a critical spawning reach of the Nechako River located near Vanderhoof, BC (Figure 1.1). Although the spawning pads initially supported natural recruitment (Steve McAdam, pers. comm.), subsequent monitoring has shown that one of the spawning pads (*Lower Patch*) began to infill with fine sediment soon after placement, thus decreasing the biological functionality of the substrate over time (NHC, 2012).

Figure 1.1 White sturgeon spawning reach on the Nechako River at Vanderhoof, BC.

In response to the sedimentation of the spawning pad, a series of investigations were commissioned to better understand how sediment transport within the area affects the quality of spawning and incubation habitat (NHC, 2013, 2014, 2015, 2016a, 2018). In addition to these studies, instream works were conducted in 2016 (NHC, 2016b) and 2020 (NHC, 2021) as part of continued efforts to develop feasible restoration methods able to effectively remediate the quality of the spawning substrate and promote natural recruitment in the Nechako River.

1.2 Restoration and monitoring

Restoration of spawning substrate has long been identified as a critical action to promote natural recruitment of Nechako white sturgeon. However, restoring habitat within the mainstem channel of the Nechako River presents multiple challenges spanning all aspects of implementation, including: complex permitting (e.g., Species at Risk Act); logistics and planning; mechanical limitations (e.g., depth and velocity); natural and interannual variability in site conditions (e.g., turbidity and discharge); as well as geomorphological and biological factors (e.g., unpredictability of annual spawning locations in relation to restored areas).

Due to the multidisciplinary nature of effective restoration design, the Nechako White Sturgeon Restoration Advisory Group (NWS-RAG) was formed in 2024 to assemble expertise from different disciplines, plan and implement large-scale habitat restoration. The NWS-RAG led the following activities in 2024-2025 as part of this project:

- October 29-30, 2024: Initial field testing of substrate cleaning tools and methods.
- November 2024 - March 2025: Re-design and fabrication of improved substrate cleaning tools.
- April 23-25, 2025: Pre-treatment substrate sampling prior to restoration of the Lower Patch spawning pad.
- April 29-30, 2025: Trial restoration (pilot study) and instream testing of improved substrate cleaning tools and methods.
- May 5-10, 2025: Main restoration of the Lower Patch spawning pad.
- May 12-13, 2025: Post-treatment substrate sampling to evaluate effectiveness of treatment and monitor longevity of effects.
- June 18-20, 2025: Post-treatment substrate sampling to monitor longevity of effects.

A detailed explanation of the substrate cleaning tools and methods, including their development, implementation, and performance, is provided in Sea to Sky Energy Solutions (2022) and Coulter and McAdam (in prep.), and thus not provided herein. In brief, a series of cleaning mechanisms were tested, including a perforated excavator bucket and a proprietary *tube screen* (Photo 1.1). The tube screen was intended to be dragged along the riverbed to breakup the surficial layer of cobbles and mechanically sort the substrate by lifting coarser gravels and cobbles to the surface and allowing finer sands to settle below. Previous testing of the tube screen in side-channel environments (Sea to Sky Energy Solutions, 2022) showed that the device was effective in producing the desired substrate conditions. However, subsequent examination found that the pre-existing substrate within the side-channel was looser, less compacted, and finer than the substrate within the mainstem channel of the Nechako River, which might explain the success in those locations.

Subsequent testing of the tube screen on the Lower Patch spawning pad on October 29-30, 2024, revealed that the device did not have the weight nor stability to effectively restore the substrate of the spawning pad, leading to a redesigned tool termed a *sled* (Photo 1.2). This sled was the primary tool used for the larger-scale restoration of the Lower Patch on May 5-10, 2025, which was operated using an excavator with a boom extension.

Photo 1.1 Tube screen initially tested as a substrate cleaning device on the Lower Patch on October 29-30, 2024; device is intended to be dragged on its side.

Photo 1.2 Sled used during the larger-scale restoration of the Lower Patch on May 5-10, 2025; a boom extension was also used for greater reach (not shown).

1.3 Scope of work

NHC was contracted to contribute to the restoration efforts by assisting the NWS-RAG with the following:

- Provide advice, as needed, regarding the design and planning of pilot and full-scale substrate cleaning tests.
- Develop and implement field sampling methodologies to monitor substrate conditions.
- Train local technicians to support the implementation of substrate monitoring methodologies, as and when feasible.

Sampling methodologies developed and implemented by NHC as part of this project are described in the following section of this report (Section 2). The results of the monitoring program are subsequently presented in Section 3.

2 METHODOLOGY

The two main techniques used to evaluate the substrate composition were underwater imagery and freeze core sampling. The underwater imagery was used to capture relatively highresolution imagery of the surficial composition of the substrate, while the freeze core sampling was used to characterize the subsurface composition to a depth of approximately 20-30 cm below the surface. The two methodologies are complementary and were used in combination, as the freeze core sampling does not accurately capture the surficial layer of sediment because surficial grains exposed to flowing water do not freeze to the core. Conversely, the underwater imagery provides very accurate observations of the surficial layer of sediment, to a depth of about one or two grains thick, below which no information is provided (i.e., not visible). Taken together, these methodologies have the potential to provide a relatively accurate depiction of the substrate composition both on the surface and at-depth.

The following subsections provide more detailed descriptions of the sampling methodologies used in this study.

2.1 Spatial positioning

Accurate, real-time spatial positioning was achieved using Emlid Reach RS2 Global Navigation Satellite System (GNSS) receivers with Real-Time Kinematic (RTK) corrections. NHC developed a simplified workflow that can be used by local technicians with no prior surveying experience, which can be provided upon request.

In brief, the receivers were pre-programmed to function upon powering up, eliminating the need to configure the devices on-site. The units can be operated using any smartphone or tablet by connecting to a local Wi-Fi network created by the receivers through the *Emild Flow* app. After a profile has been created, the receivers and survey can be accessed via web browser through an application called *Flow 360*, allowing for remote configuration of both the devices and survey parameters. In practice, this allowed NHC to create survey projects remotely, whereby all points and configurations would be pre-loaded and ready for use by the field crew at the start of each day. This also allowed NHC to remotely download the survey data at the end of each day, with no action required from the field crew.

The Emlid Flow app contains a mapping interface that allows for high-accuracy navigation to specific points. The mapping interface was used to ensure that samples were reliably collected at the same locations to monitor changes over time.

2.2 Underwater imagery

Underwater imagery was collected using a GoPro Hero 8 camera. The images were collected via timelapse at 1-second intervals. A linear-lens camera profile was used to collect the substrate images to reduce distortion associated with the wide-angle lens. Although the Bluetooth connection capabilities of the GoPro do not function underwater, images were reviewed on a tablet at the end of each filming sequence to ensure good quality photos had been recorded and saved. The photos were uploaded automatically to the Cloud via Wi-Fi at the end of each day to ensure data backup and allow for remote download and viewing. The upload is automatic when the GoPro camera is connected to a charging cable in the presence of a known Wi-Fi network.

2.3 Freeze core sampling

Freeze core sampling has previously been used to investigate substrate composition (e.g., Rood and Church, 1994; Ryan, 1970; Zimmermann et al., 2005), but typically in shallow-water environments. A modified sampling methodology was developed for this study that could be used in deeper-water conditions (up to 3 m) with available resources. The following points outline the general steps used to collect freeze core samples as part of this project:

1. Navigate to the sampling location using the GNSS RTK rover.
2. Deploy bow and port anchors to stabilize the boat.
3. Pre-screen the area using the underwater camera to get a sense of local variability substrate composition.
4. Set freeze coring pipe on the bed, measure and record height from the bed to the top of the freeze coring pipe.
5. Record the location of the freeze core by measuring a point using the GNSS RTK rover.
6. Drive the freeze coring pipe into the bed using a post-pounder until embedment depth of 25-30 cm is achieved.
7. Measure and record the height from the bed to the top of the freeze coring pipe to confirm embedment depth.
8. Use the underwater camera to record imagery of the substrate characteristics surrounding the freeze coring pipe.
9. Insert the inner pipe into the freeze corer (funnel already threaded on) and secure the top of the inner pipe with a hose clamp to ensure the bottom of the pipe is 30-50 cm above the bottom of the freeze coring pipe.
10. Pour 5-10 L of liquid nitrogen into the inner pipe via the funnel. It is important to pour the liquid nitrogen slowly to allow for sufficient degassing and prevent back-splashing.
11. Wait until degassing stops, usually 5-10 seconds but no more than 15 seconds.
12. Pull the boat forward on its anchor, tilt the freeze corer forwards, and pull the core up as rapidly as possible while avoiding excessive abrasion of the sediment core.
13. Complete the datasheet and photo-document the composition and stratigraphy of the sediment core using scaled images. Place the core in the holder with the graduations, then take photos from directly above the core, rotating the core ¼ turn each time.
14. Repeat for next sample.

Specific project Health and Safety Plans (HSP), Job Safety Analyses (JSA), and Safe Work Procedures (SWP) were developed as part of this work to ensure safe working procedures. These documents can be provided upon request.

3 RESULTS

Section 3.1 briefly describes the results of the restoration and resulting treatment area. The subsequent sections describe the results of the substrate monitoring. Detailed results are also visually shown in Appendix A and Appendix B for pre-treatment and post-treatment substrate conditions, respectively.

3.1 Restoration and treatment area

The main restoration effort on the Lower Patch spawning pad was conducted between May 5-10, 2025. The provisional discharge at Vanderhoof during this period was 130-135 m^3/s (Water Survey of Canada Gauge 08JC001).

The substrate cleaning was intended to cover the entire area of the Lower Patch. However, the water depth at the time of the restoration prevented the excavator from accessing much of the wetted area; thus, the machine was limited to working along the bank with a boom extension. Overall, an estimated 18% (1,655 m^2) of the total Lower Patch area (9,325 m^2) was treated as part of the restoration effort. The treated area is shown below in Figure 3.1.

Table 3.1 summarizes the different sampling events conducted as part of the study, which are further discussed throughout the remainder of this report.

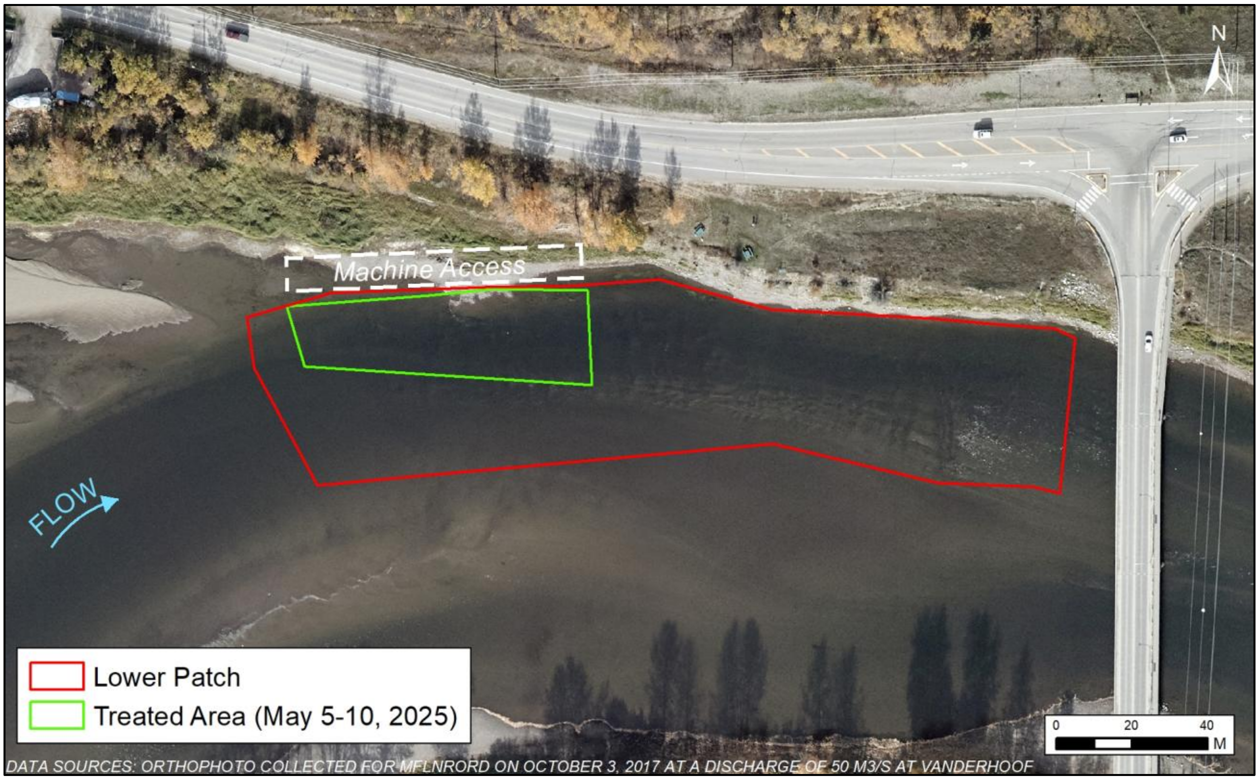

Figure 3.1 An estimated 18% (1,655 m^2) of the total Lower Patch area (9,325 m^2) was treated during the restoration on May 5-10, 2025.

Table 3.1 Summary of sampling events conducted as part of this study.

Date	Discharge[1]	Water Temp.[2]	Event	Data collected	Comments
April 23-25, 2025	105-110 m^3/s	4.5-9.5˚C	Pre-treatment sampling	Freeze cores; UW images	Samples collected across the Lower Patch
May 9, 2025	130-135 m^3/s	7.5-10.0˚C	Substrate treatment	UW images	Images collected across Lower Patch and upstream
May 12-13, 2025	125-130 m^3/s	8.5-12.5˚C	Post-treatment sampling	Freeze cores; UW images	Samples collected within reduced area[3] where treatment occurred
June 18-20, 2025	85-90 m^3/s	15.0-19.5˚C	Post-treatment sampling	Freeze cores; UW images	Samples collected within reduced area[3] where treatment occurred

Note:
1. Provisional discharge at Water Survey of Canada (WSC) gauge 08JC001 Nechako River at Vanderhoof.
2. Water temperature obtained from WSC gauge 08JC001; as stated by WSC, *data is provided as-is and is not quality controlled in any way*. Reported water temperatures were cross-referenced to Bublitz hydrometric station installed by NHC in 2021 as a cursory quality check, showing good agreement (±2˚C).
3. Reduced area that was treated during the restoration shown on Figure 3.1.

3.2 Pre-treatment (April 2025)

A total of 11 sites were sampled on April 23-25, 2025, using paired underwater photos and freeze coring. The samples were distributed across the Lower Patch spawning pad (Figure 3.2) because the specific area where the restoration was to take place had not yet been determined at the time of the sampling. Site-specific descriptions of the pre-treatment substrate characteristics and conditions are provided in Table 3.2, while Figure 3.3 presents a visual classification of the substrate conditions. All sampling results are shown visually in Appendix A.

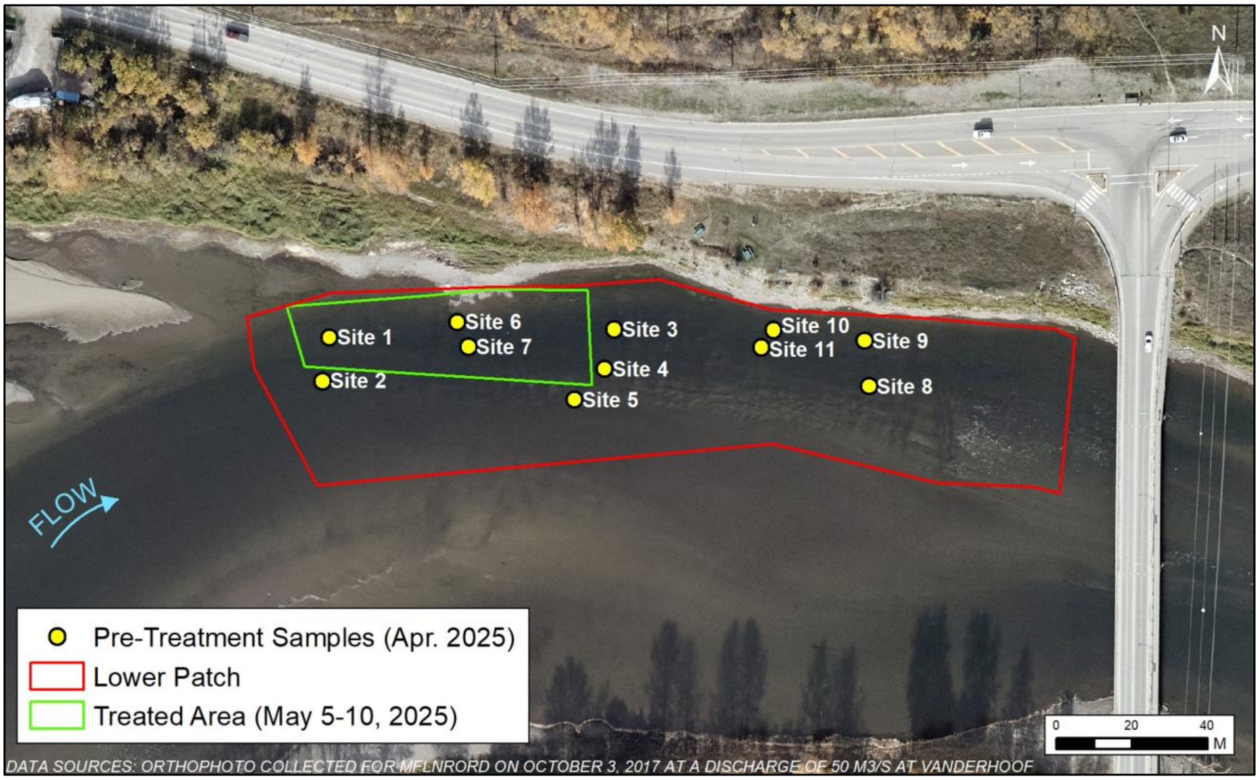

Figure 3.2 Locations of pre-treatment sampling sites (April 23-25, 2025) shown in relation to where the restoration treatment was performed in May 2025.

Table 3.2 Site-specific descriptions of pre-treatment substrate characteristics observed on April 23-25, 2025 ; shading reflects the substrate classification shown on Figure 3.3 (Green = good, Moderate = yellow, Poor = red).

Sample Location	Substrate Characteristics	
	Surface (camera)	Subsurface (freeze core)
Site 1	Gravels and cobbles embedded into surficial sand matrix. Organic debris also present, indicating relatively slow near-bed flow velocities.	High proportion of cobbles in the upper 10 cm of the core embedded into sand matrix; no clean interstices observed. Lower 20 cm of the core is predominantly fine to coarse gravel embedded into sand matrix with no cobble. Lack of cobbles at-depth suggests that cobbles placed in 2011 have not been buried and remain within the upper 10 cm of the substrate.
Site 2	Fine to medium gravels intermixed with high proportion of sand. Only a few cobbles visible, some of which are arranged into local clusters.	Relatively uniform mixture of fine to medium gravels in a sand matrix; no apparent layering or stratification. Ice within the upper 10 cm of the core suggests a local surficial layer of coarse gravels and cobbles was present above the core. *While the core indicates that good quality interstitial habitat was present, review of underwater imagery suggests that surficial cobbles were highly localized; the conditions shown by the core are not considered generally representative of the surrounding substrate.*
Site 3	High proportion of cobbles and medium to coarse gravels with very limited surficial sand; relatively large voids visible between some cobbles.	Relatively high proportion of medium to coarse gravels with trace cobbles in a sand matrix. Gravels intermixed throughout the core. Upper 7 cm of core contains layer of coarse gravels with clean interstitial voids to a depth of two to three grains thick.
Site 4	Poorly sorted mixture of fine gravels to cobbles with high proportion of sand.	Relatively uniform mixture of fine to coarse gravels in a sand matrix; no apparent layering or stratification. Pockets of sand up to 5 cm thick.
Site 5	Fine gravels to cobbles with moderate surficial sand. Small voids visible between the fine gravels but voids are likely limited to surface (depth of one grain thick, or approx. 1 cm).	Relatively uniform mixture of fine to medium gravels in a sand matrix, with transition to predominantly sand horizon with fewer gravels and trace cobbles approximately 30 cm deep.
Site 6	High proportion of cobbles and coarse gravels with very limited surficial sand; relatively large voids visible between some cobbles. Numerous mussels present.	Surficial layer of cobbles and large gravels (and a mussel) underlain by predominantly sand matrix with trace gravels.
Site 7	Cobbles and mixed fine to coarse gravels embedded into surficial sand matrix.	Layer of fine to coarse gravels in upper 10 cm of core underlain by uniform matrix of sand and very fine gravel. Limited presence of clean voids observed between coarser gravels of the upper core.
Site 8	Poorly sorted mixture of fine gravels to cobbles with high proportion of sand.	Gravels intermixed throughout the core in a sand matrix. Upper 10-15 cm of core contains greater

Sample Location	Substrate Characteristics	
	Surface (camera)	Subsurface (freeze core)
	Organic debris is also present, indicating relatively low near-bed flow velocities.	proportion of coarser gravels. Limited presence of clean voids observed between coarser gravels of the upper core.
Site 9	High proportion of cobbles and coarse gravels with very limited surficial sand; relatively high abundance of voids visible between cobbles and gravels. Numerous mussels present.	Layer of coarse gravels (and mussels) in upper 5-10 cm of core underlain by uniform matrix of sand with trace gravels. Core shows clear demarcation from brown to grey sand matrix at a depth of 5-15 cm.
Site 10	High proportion of cobbles and coarse gravels with very limited surficial sand; relatively high abundance of voids visible between cobbles and gravels. Numerous mussels present.	Medium to coarse gravels in grey sand matrix. Ice within the upper 5-7 cm of the core suggests a local surficial layer of coarse gravels and cobbles was present above the core. Increasing proportion of fine gravel in lower 10 cm of the core.
Site 11	N/A	High proportion of large cobbles throughout the core in a sand and fine gravel matrix. Ice within the upper 5 cm of the core suggests a local surficial layer of coarse gravels and cobbles was present above the core.

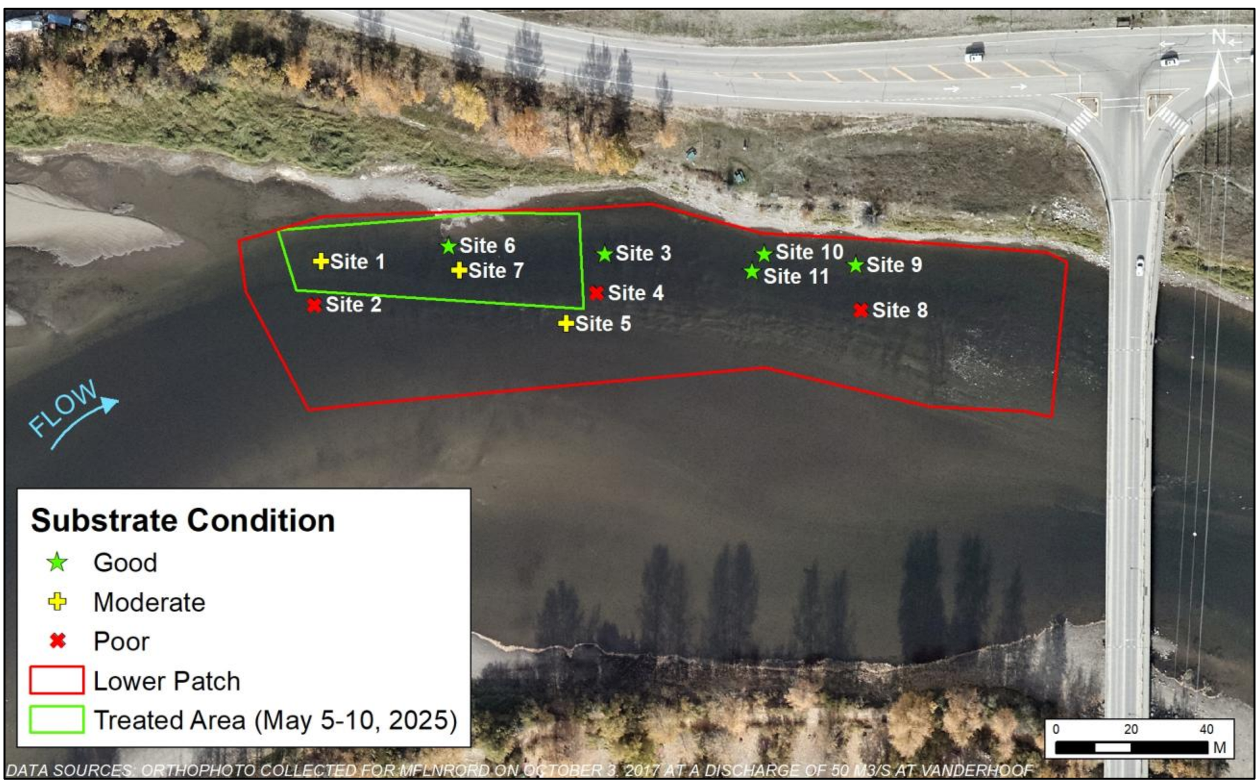

Figure 3.3 Visual classification of pre-treatment substrate conditions observed on April 23-25, 2025; substrate descriptions provided in Table 3.2.

3.3 Post-treatment (May 2025)

A total of 12 sites were sampled on May 12-13, 2025. The samples were distributed across the portion of the Lower Patch where restoration took place between May 5-10, 2025, immediately preceding the sampling event. As seen on Figure 3.4, only three of the pre-treatment sampling locations (Site 1, Site 6, Site 7) were within the restored area because, as previously stated, the specific area where the restoration was to take place had not yet been determined at the time of the pre-treatment sampling.

Site-specific descriptions of the post-treatment substrate characteristics and conditions are provided in Table 3.3, while Figure 3.5 presents a visual classification and comparison of the substrate conditions between the pre-treatment and post-treatment sampling events. All sampling results are shown visually in Appendix B.

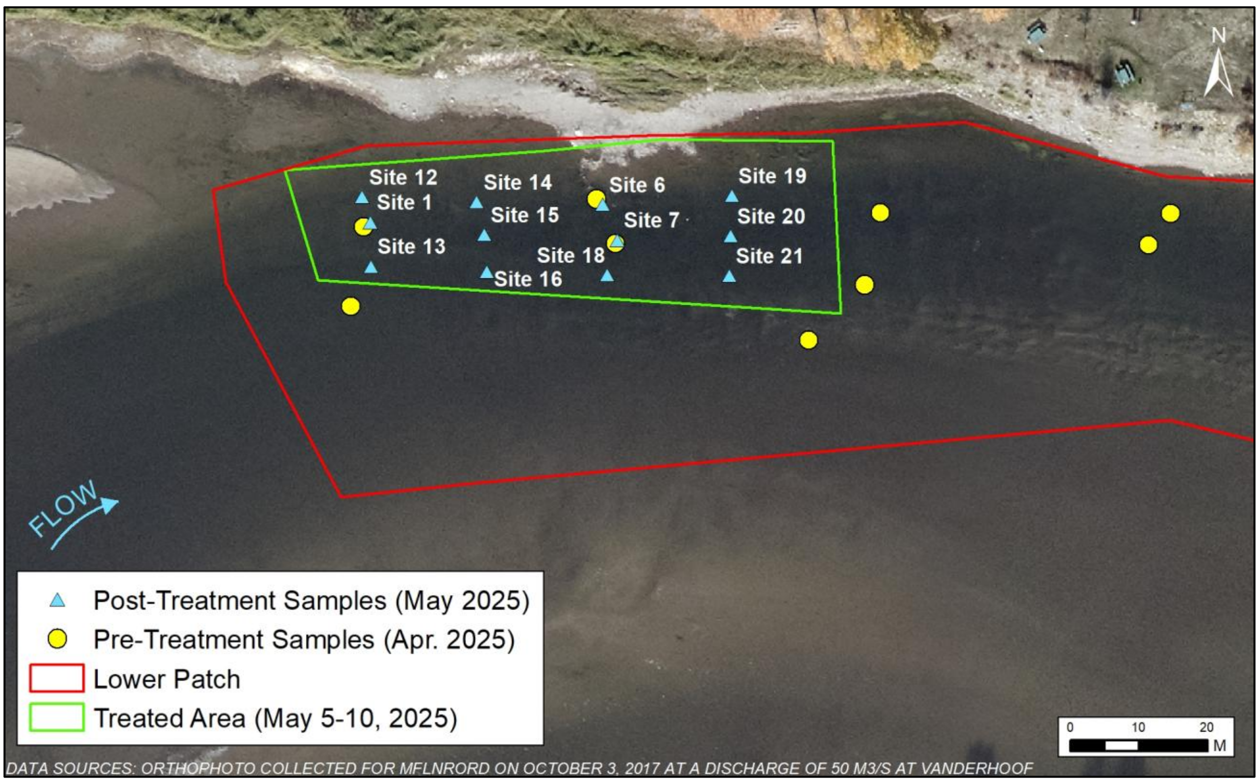

Figure 3.4 Spatial comparison of pre-treatment (April 23-25, 2025) and post-treatment (May 12-13, 2025) sampling locations; only three sites overlap (Site 1, Site 6, Site 7) because the specific area where the restoration was to take place had not yet been determined at the time of the pre-treatment sampling.

Table 3.3 Site-specific descriptions of post-treatment substrate characteristics observed on May 12-13, 2025; Sites 1, 6, and 7 (bolded) are the repeat sampling sites from pre- and post-treatment conditions. Sites are ordered from upstream to downstream, north to south (see Figure 3.4). Shading reflects the substrate classification shown on Figure 3.5 (Green = good, Moderate = yellow, Poor = red).

Sample Location	Substrate Characteristics	
	Surface (camera)	Subsurface (freeze core)
Site 12	Substrate appears recently disturbed with high proportion of surficial sand draped over fine to coarse gravels and trace cobbles.	High proportion of fine to coarse gravels in upper 10 cm and lower 10 cm of core embedded in a sand matrix, separated by approximately 15 cm thick layer of predominately sand matrix with fine gravels.
Site 1	Gravels and cobbles embedded into surficial sand matrix. Thin sand drape overlying much of the area with localized accumulations of gravels providing some, albeit highly limited, interstitial voids.	High proportion of fine to coarse gravels distributed uniformly throughout core, limited sand matrix. Upper 10 cm of core contains layer of coarse gravels and cobbles containing clean interstitial voids. Ice within the upper 4 cm of core suggests a local surficial layer of coarse gravels and cobbles was present above the core to a depth of two to three grains thick. *While the core indicates that good quality interstitial habitat was present, review of underwater imagery suggests that the substrate conditions were highly variable; the localized conditions shown by the core are not considered generally representative of the surrounding substrate.*
Site 13	Approximately 5 cm thick layer of sand moving as bedload overtop of gravels.	Predominantly sand matrix with fine to medium gravels in upper 15-20 cm of core, with increasing proportion of medium to coarse gravel in lower 10 cm of core embedded in sand matrix.
Site 14	Surficial layer of medium to coarse gravels with cobbles. Surficial sand drape varying in thickness across the area. Moderately high abundance of voids visible between cobbles and gravels where sand drape is locally thinner or absent.	Relatively high proportion of fine to coarse gravels with some cobbles distributed throughout upper 10-15 cm of core in a sand matrix, underlain by layer of uniform fine sediment (fine sand, silt, clay). Ice within the upper 2-4 cm of core suggests a local surficial layer of coarse gravels and cobbles was present above the core.
Site 15	High proportion of fine to coarse gravels with cobbles overlying sandy matrix. Low to moderate amount of surficial sand forming local deposits in lee of larger cobbles.	High proportion of poorly sorted gravels and cobbles distributed throughout core in a sand matrix. No apparent layering of stratification and the presence of large cobbles throughout core suggests recent mixing by restoration techniques. Upper 8 cm of core contains layer of coarse gravels and cobbles with clean interstitial voids. Ice within the upper 2-3 cm of core suggests a local surficial layer of coarse gravels

Sample Location	Substrate Characteristics	
	Surface (camera)	**Subsurface (freeze core)**
		and cobbles was present above the core to a depth of two to three grains thick. *While the core indicates that good quality interstitial habitat was present, review of underwater imagery suggests that the substrate conditions were highly variable; the localized conditions shown by the core are not considered generally representative of the surrounding substrate.*
Site 16	Surficial layer of sand moving as bedload overtop of gravels and cobbles.	Predominantly sand matrix with fine to medium gravels in upper 20 cm of core, with increasing proportion of medium to coarse gravel in lower 10 cm of core embedded in sand matrix.
Site 6	High proportion of cobbles and coarse gravels with little to no surficial sand; high abundance of voids visible between the gravels and cobbles.	Layer of medium to coarse gravels in upper 5 cm of core underlain by uniform matrix of sand and fine gravel. Limited clean interstitial voids observed between gravels. Ice within the upper 2-3 cm of core suggests a local surficial layer of coarse gravels and cobbles was present above the core.
Site 7	High proportion of cobbles and coarse gravels with little to no surficial sand; high abundance of voids visible between the gravels and cobbles.	Predominantly sand matrix with fine to medium gravels in upper 15 cm of core, with increasing proportion of fine gravel at-depth. Ice within the upper 6-7 cm of core suggests a local surficial layer of coarse gravels and cobbles was present above the core.
Site 18	Surficial layer of sand moving as bedload overtop of gravels and cobbles.	Fine to coarse gravels intermixed throughout the core in a sand matrix.
Site 19	Poorly sorted mixture containing sand, fine to coarse gravels, and cobbles overlying a sandy matrix. Substrate appears recently disturbed. Gravels and cobbles do not appear sufficiently thick to create interstitial voids to a depth greater than one grain thick.	Poorly sorted mixture of sand, fine to coarse gravels, and cobbles in upper 15 cm of core. Core shows clear demarcation to uniform grey sand matrix at a depth of 15 cm.
Site 20	Poorly sorted mixture containing sand, fine to coarse gravels, and cobbles overlying a sandy matrix.	Fine to coarse gravels intermixed throughout core in sand matrix. Upper 5 cm of core contains layer of medium to coarse gravels with clean interstitial voids. Ice within the upper 2-3 cm of core suggests a local surficial layer of coarse gravels and cobbles was present above the core.
Site 21	High proportion of surficial sand moving as bedload through gravels and cobbles.	Predominantly sand matrix with fine to medium gravels in upper 15-20 cm of core, with increasing proportion of medium to coarse gravel in lower 10 cm of core embedded in sand matrix.

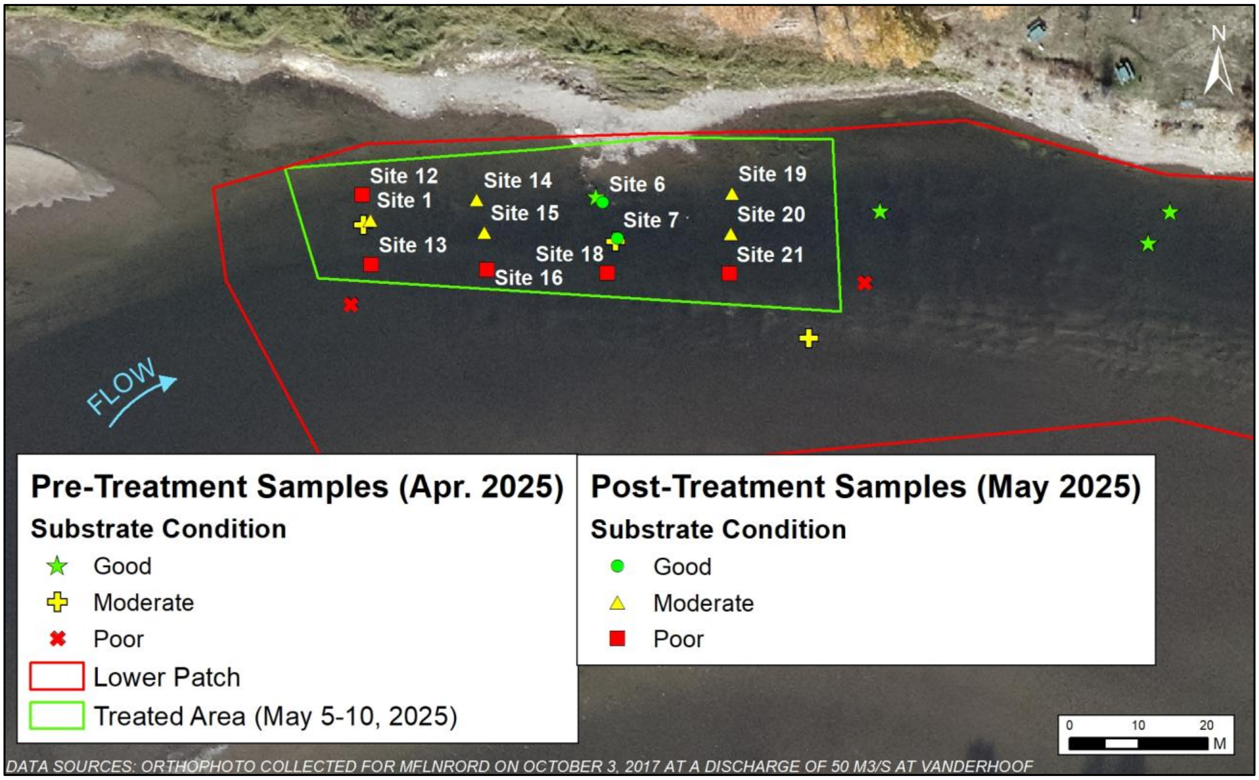

Figure 3.5 Visual classification of post-treatment substrate conditions observed on May 12-13, 2025, compared to pre-treatment conditions observed on April 23-25, 2025; substrate descriptions provided in Table 3.2 and Table 3.3.

3.4 Post-treatment (June 2025)

The 12 post-treatment sites initially sampled on May 12-13, 2025, were resampled on June 18-20, 2025, to monitor changes in substrate conditions (Figure 3.6). No notable changes in substrate conditions were found to have occurred between the May 2025 and June 2025 sampling events; refer to Appendix B for a visual comparison of the substrate conditions observed during each sampling event.

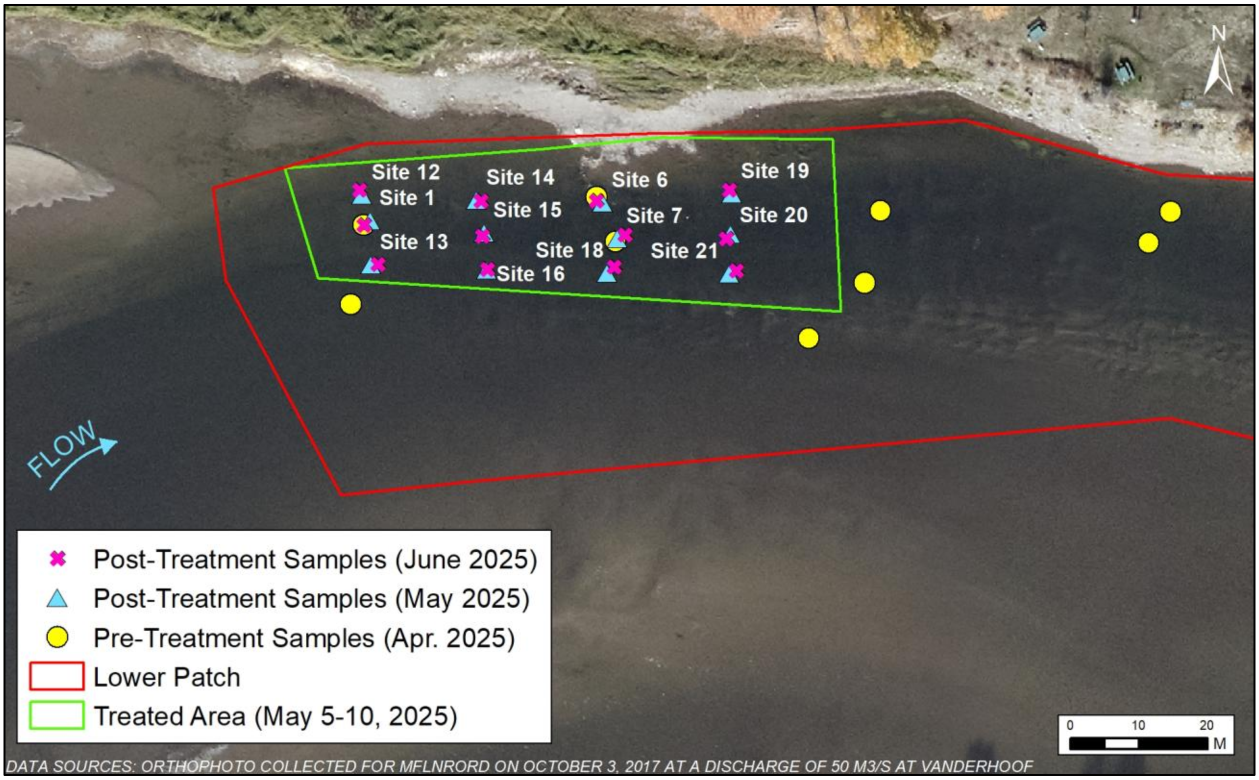

Figure 3.6 Spatial comparison of pre-treatment (April 23-25, 2025) and post-treatment (May 12-13, 2025; June 18-20, 2025) sampling locations; post-treatment samples collected in May and June spatially correspond for repeated site monitoring.

4 DISCUSSION

The following subsections discuss the methods (Section 4.1) and results (Section 4.2) of the habitat restoration completed in May 2025, as informed by the results of the substrate sampling program presented in Section 3.

4.1 Restoration methods

As previously mentioned, approximately 18% (1,655 m^2) of the total area of the Lower Patch spawning pad could be accessed by the excavator used to perform the restoration in May 2025. Flow depth at the time of the restoration prevented the excavator from accessing the remaining area of the spawning pad, despite a relatively low discharge of 130-135 m^3/s (Table 3.1). A similar restoration approach was attempted in 2016, when a S2-3 Kaiser 4x4 Spyder Walking Excavator was able to access approximately 7,260 m^2 of the Lower Patch area during a lower discharge of approximately 75 m^3/s (NHC, 2016b). While the previous attempt was able to access a greater portion of the spawning pad, the method of mechanical remediation (i.e., using the bucket to sift and rake the substrate) showed mixed results; the mechanical remediation successfully restored the quality of the substrate locally, but the overall method required intensive cleaning effort, had a slow production rate, and was limited by poor visibility and low flow velocities that were insufficient to transport displaced sand further downstream.

Should substrate remediation or cleaning be a continued focus of the NWSRI, it is critical that methods be developed that are not depth-limited or at least have an operational range of up to 3 m of depth. Such methods may include an excavator or winch operating the sled from a barge or temporary working platform. It is also considered critical that future restoration efforts make use of high-accuracy spatial positioning systems to be able to resolve, with greater certainty, which areas were treated and with what intensity. Lack of spatial positioning data can reduce conclusively of results due to the spatial uncertainty that is introduced, especially when improvements in physical habitat are considered relative to localized egg detection and spawn monitoring data.

4.2 Restoration results

Substrate monitoring data suggest that the restoration method used in May 2025 was relatively ineffective at producing the desired substrate condition, which NHC understands consists of a surficial mixture of fine to coarse gravels and cobbles with clean interstitial voids to a depth of two to three grains thick. As seen on Figure 3.5, only one sampling location (Site 7) showed improvement from pre- to post-treatment conditions. The effectiveness of the restoration method was likely limited by the following factors:

- Uncertainty in exactly where the cleaning techniques were being applied on the riverbed and associated uncertainty in cleaning intensity (e.g., the sled being drawn towards the same low points in the channel despite being pulled from different locations upstream).
- Limited ability of the sled to penetrate into an armored or embedded substrate.
- Insufficient proportion of coarse gravels and cobbles in the in-situ substrate mixture, or in other words too much sand, limiting the ability of the sled to vertically sort the sediment and produce a surficial layer composed of coarse grains.

Of the limitations above, the insufficient proportion of coarse grains and excessive amount of sand is considered the greatest limitation observed during the 2025 restoration. This is particularly the case along the center and southern portions of the spawning pad (Site 13, Site 16, Site 18, Site 21 on Figure 3.5), where the substrate is regularly exposed to relatively large volumes of sand being transported along the riverbed. To this end, the results of the restoration treatment may not have been much improved even if the excavator could have accessed these offshore environments due to limitations associated with the restoration tools and pre-existing composition of the riverbed.

The lack of large gravels and cobbles is particularly evident along the upstream, southern portion of the Lower Patch spawning pad (see Sites 13 and 16 in Appendix B). These locations were found to contain only a very limited number of cobbles, presumed to have been placed during construction of the spawning pad in 2011. It is uncertain whether the lack of cobbles in these areas reflects: inconsistent/non-uniform material placement in 2011; inaccurate mapping of the spawning pad extents; burial by finer sand and gravel; or downstream transport of the placed cobbles. Of the potential explanations listed above, it is most likely that the lack of coarse substrate in these areas reflects inconsistent placement and/or inaccurate mapping; no survey of the thickness nor extent of the placed substrate was done following construction, which complicates the analysis and is recommended for future gravel placement work. Burial of the placed cobbles by finer sand and gravel is also possible; however, the cores showed no evidence of a buried cobble layer to depths of 40 cm at Sites 13 or 16 (Appendix B). In contrast, Sites 18 and 21, located further downstream on the spawning pad, showed greater evidence of placed cobbles both on the surface and at-depth (Appendix B). The varying proportion of coarse gravels and cobbles in the pre-existing substrate has direct implications for the potential effectiveness of different restoration treatments; for example, insufficient gravels and cobbles would limit the effectiveness of dredging or mechanical raking, as digging through sandy gravel will likely still result in a sandy gravel substrate. Further recommendations regarding potential restoration treatments and their effectiveness are provided in Section 5.

In comparison to the sites discussed above, the treatment did produce very good results at Site 6 and Site 7 (Figure 3.5). The pre-existing substrate at these sites contained a high proportion of gravels and cobbles and relatively low proportion of surficial sand (Table 3.2; Figure 3.3). The restoration methods used in May 2025 may therefore be effective at restoring moderately degraded habitat, such as a veneer of sand overtop of gravels and cobbles, but less effective in highly degraded habitats with high sand content. This finding has important implications for the planning of future restoration efforts within the spawning reach, where the focus may shift from remediation or cleaning of existing substrate to placement of additional spawning substrate to effectively coarsen the composition of the surficial sediment mixture (see Section 5).

No notable changes in substrate conditions were found to have occurred between the May 2025 and June 2025 sampling events (Section 3.4). However, this offers little information about the potential longevity of restored substrates across much of the Lower Patch, given that the substrate quality in May was generally moderate to poor across most sampling locations (Figure 3.5). The highest quality substrate observed on the spawning pad (Site 6 and Site 7) remained relatively unchanged between these two sampling events (Figure 4.1; Figure 4.2), as this area is not frequently exposed to sand bedload (NHC, 2014, 2016a, 2018). Despite the inconclusive findings regarding substrate infilling rates and potential longevity of restoration treatments, previous sediment transport studies (NHC, 2014, 2016a, 2018, 2023a) indicate that the quality of restored substrate would not persist within the center and southern portions of the Lower Patch due to frequent exposure to sand transport. Additional study would be required to more precisely define the duration of which restored substrate habitat may remain biologically functional before becoming overwhelmed with sand (see Section 5).

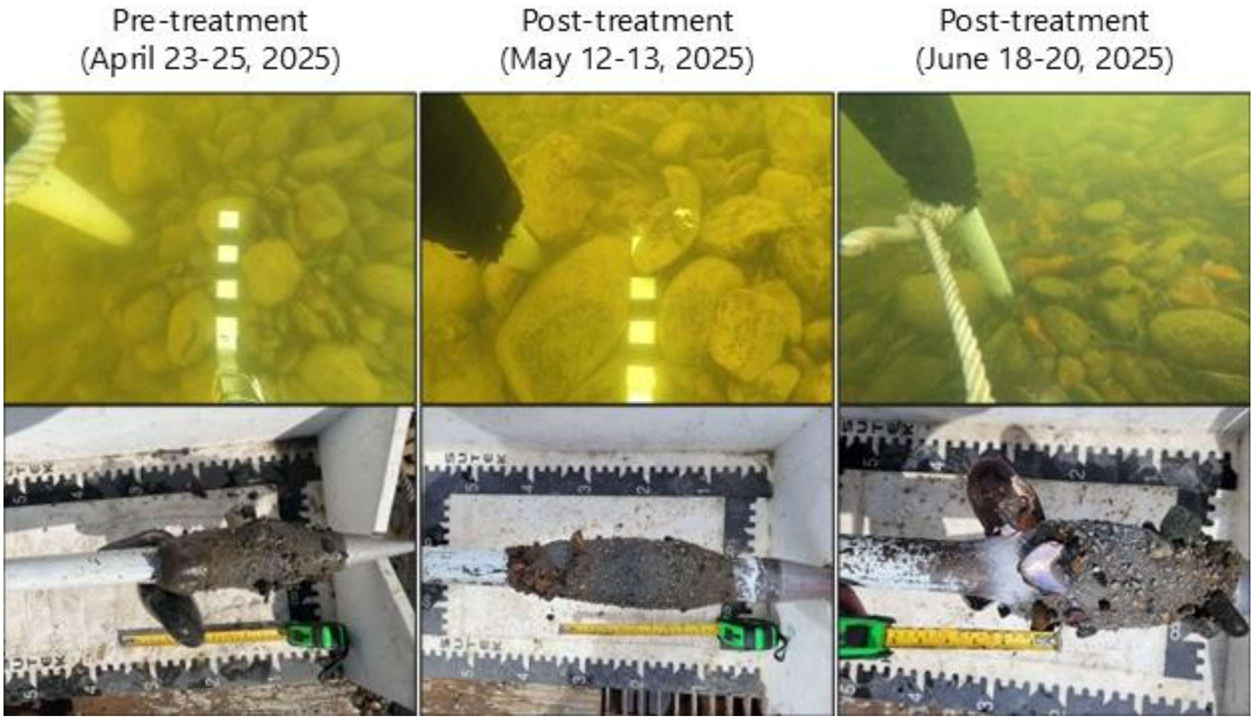

Figure 4.1 Comparison of substrate conditions at Site 6 during each sampling event.

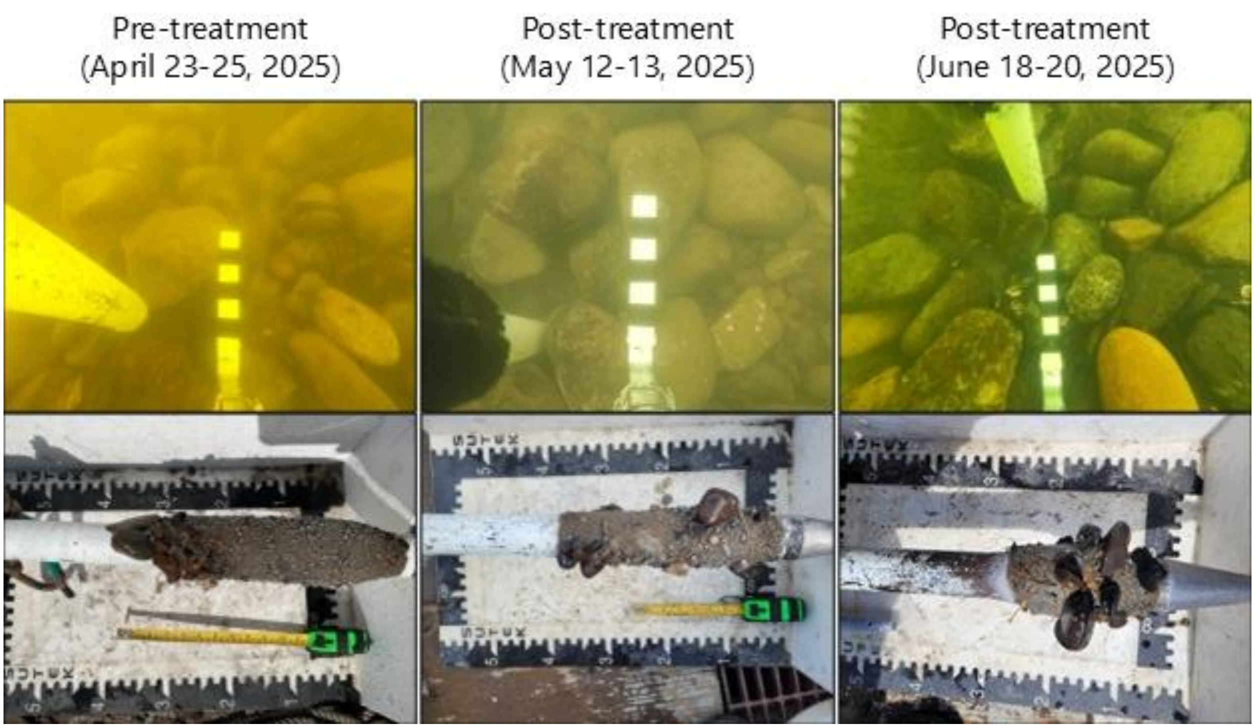

Figure 4.2 Comparison of substrate conditions at Site 7 during each sampling event.

5 CONCLUSION AND RECOMMENDATIONS

The combination of underwater imagery and freeze core sampling allowed for detailed evaluation of the surficial and subsurface composition of the substrate. Sampling was conducted prior to and following the restoration effort that took place in May 2025 to evaluate changes in substrate composition, hence assessing the effectiveness of the restoration treatment. The data and observations suggest that the restoration method was relatively ineffective at producing the desired substrate conditions. Key factors limiting the effectiveness of the treatment included: the restoration technique was limited by depth; there was spatial uncertainty in exactly where the cleaning techniques were being applied and to what intensity; limited ability of the sled to penetrate into an armored or embedded substrate; insufficient proportion of coarse gravels and cobbles in the substrate mixture, limiting the ability of the sled to vertically sort the sediment and produce a surficial layer composed of coarse grains. Of the limitations above, the greatest limiting factor appeared to be that most locations within the treatment area contained an insufficient proportion of coarse grains and excessive amount of sand.

NHC recommends the following items be considered to advance the NWSRI towards its goal of effectively restoring spawning and incubation habitat to promote natural recruitment in the Nechako River:

- Should the focus of the NWSRI remain on improving habitat on the Lower Patch spawning pad, additional restoration methods should be investigated that are not depth-limited or at least have an operational range of up to 3 m of depth. Such methods may include an excavator or winch operating the sled from a barge or temporary working platform.
- It is also considered critical that future restoration efforts make use of high-accuracy spatial positioning systems to be able to resolve, with greater certainty, which areas were treated and with what intensity. More accurate spatial positioning may be particularly important when improvements in physical habitat are considered relative to localized egg detection and spawn monitoring data.
- While previous studies (NHC, 2014, 2016a, 2018, 2023a) indicate that the quality of restored substrate within the center and southern portions of the Lower Patch are unlikely to persist due to frequent exposure to sand transport, additional study would be required to more precisely define the duration of which restored substrate may remain biologically functional before becoming overwhelmed with sand. Should restoration efforts continue to be focussed on the Lower Patch, it is recommended that supplementary measures be considered to both better define and prolong the longevity of restored substrates, including the possible use of a sediment trap immediately upstream; see NHC (2023b) for preliminary feasibility assessment.
- The effectiveness of mechanical remediation of exiting substrate on the Lower Patch (using the tools to date) appears to be limited due to the insufficient proportion of coarse gravels and cobbles and high sand content contained within the bed sediment mixture. Two recommendations stem from this finding:

- Should remediation of existing substrate remain the NWSRI's preferred approach, it is recommended that additional remediation techniques be investigated that can effectively remove and displace the sand contained within the sediment mixture (e.g., specialized dredge).
- A more effective approach may be to shift the focus from remediation or cleaning of existing substrate to placement of additional spawning substrate to effectively coarsen the composition of the surficial sediment mixture. Should this approach be selected, NHC recommends further study be conducted prior to implementation, including: sediment transport and substrate monitoring at candidate sites; sediment tracer studies to assess gravel mobility; and numerical modelling to assess potential increases in flood risk associated with the substrate placement.

6 REFERENCES

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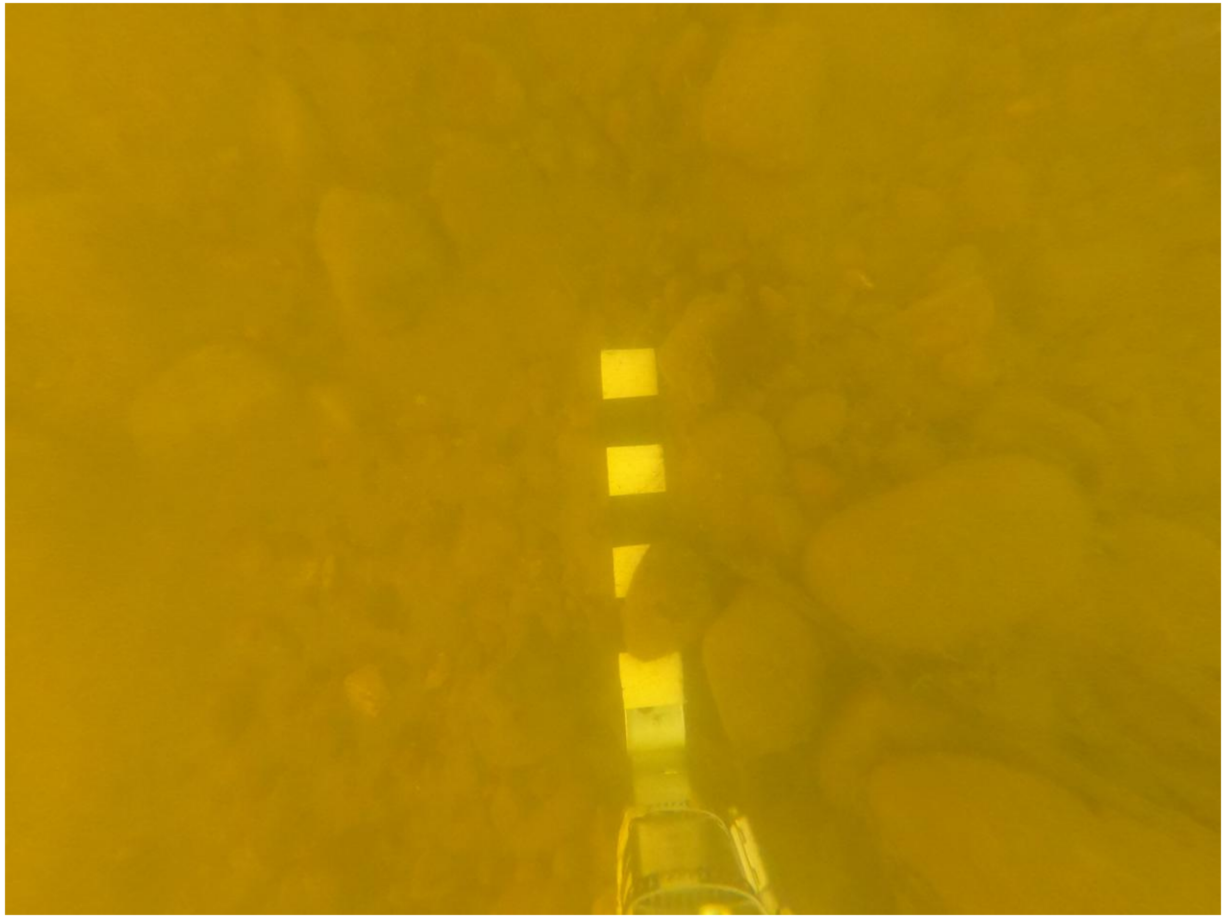
CLOSURE

NHC would like to thank the British Columbia Conservation Foundation and the BC Ministry of Water, Land and Resource Stewardship for initiating this study, as well as the Nechako White Sturgeon Restoration Advisory Group, Carrier Sekani Tribal Council, and Freshwater Fisheries Society of BC for the support provided during the project.

Please do not hesitate to contact Andre Zimmermann (azimmermann@nhcwater.com) or Simon Gauthier-Fauteux (sgauthierfauteux@nhcwater.com) by email or telephone (604.980.6011) if you would like to discuss any aspect of this report.

APPENDIX A

PRE-TREATMENT SAMPLING RESULTS




SITE 1
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FLOW
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Substrate Condition
Good
Moderate
Poor
Lower Patch
Treated Area (May 5-10, 2025)
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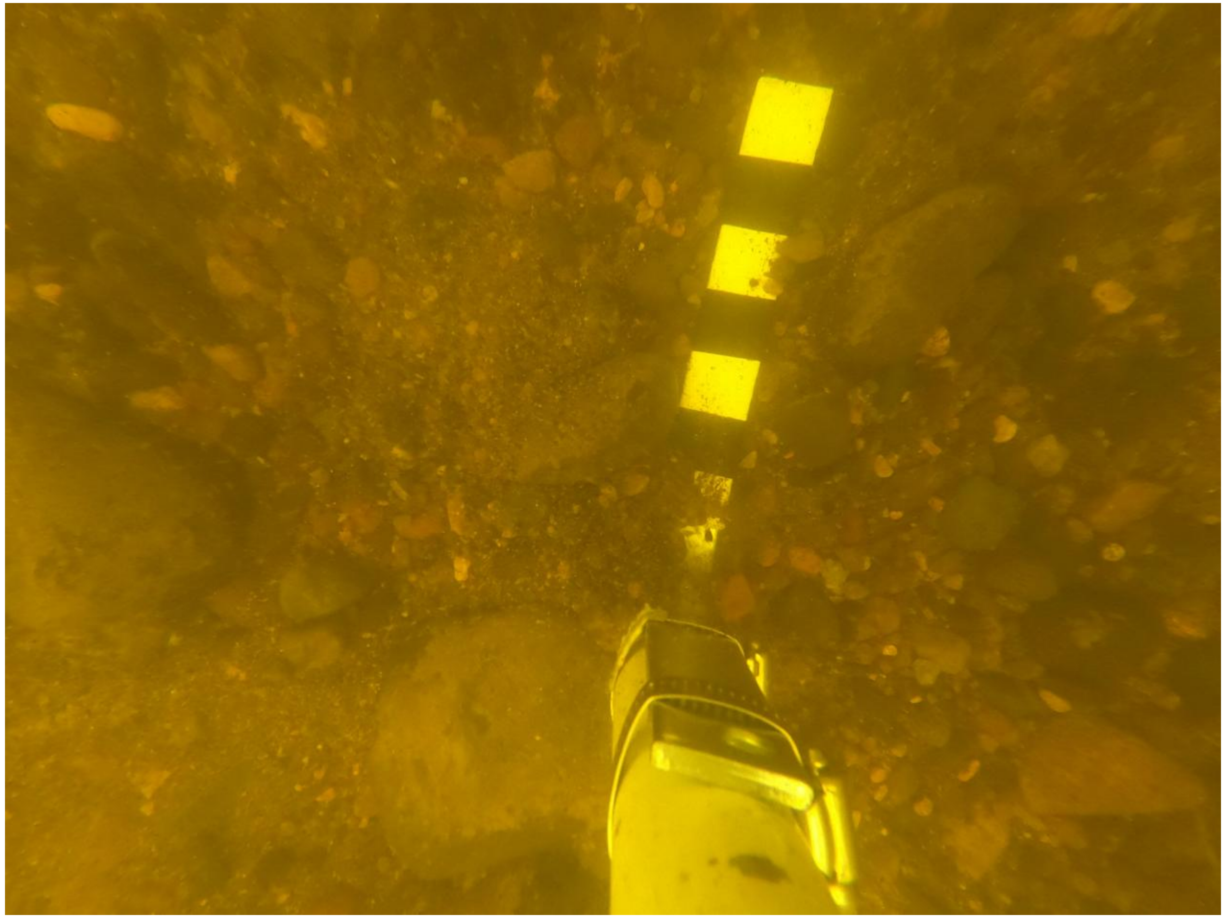


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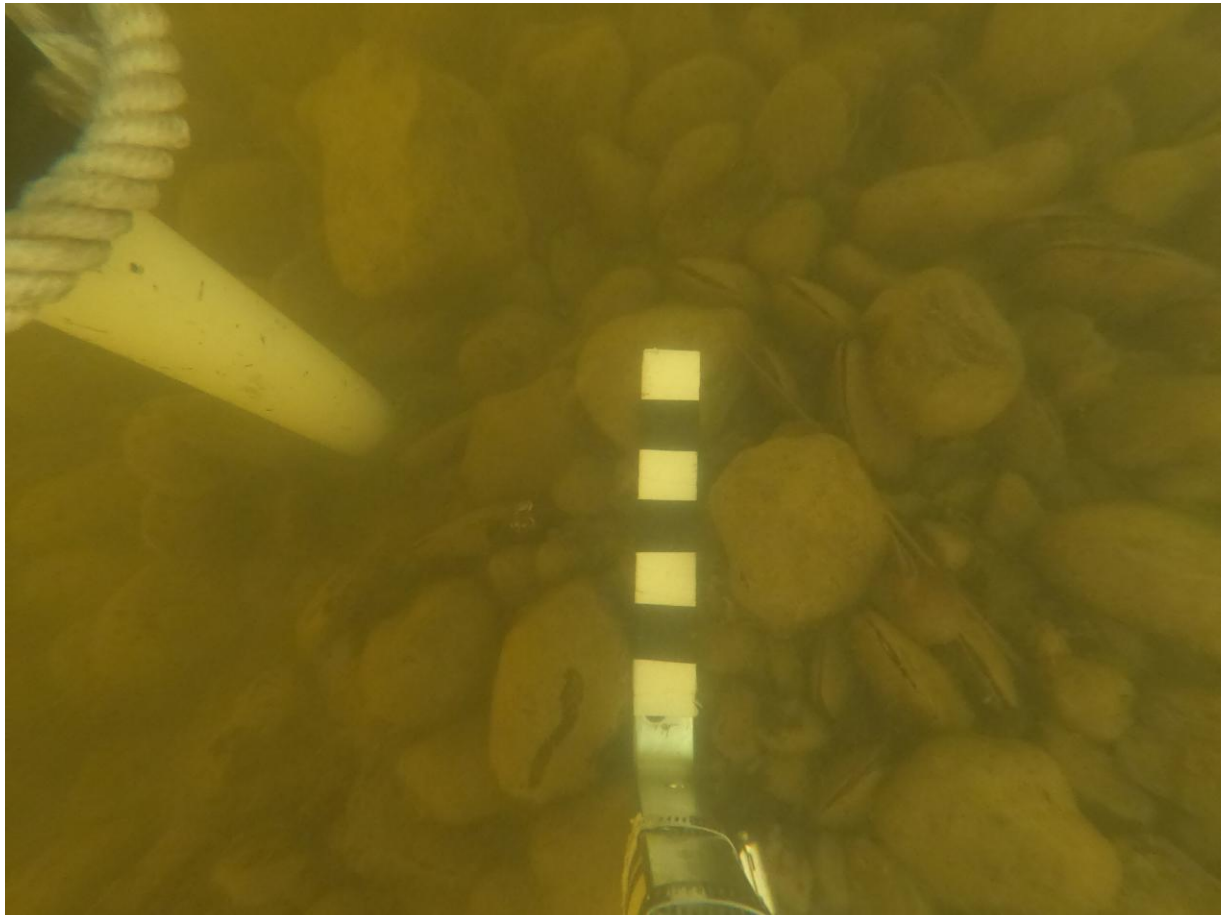


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Lower Patch
Treated Area (May 5-10, 2025)
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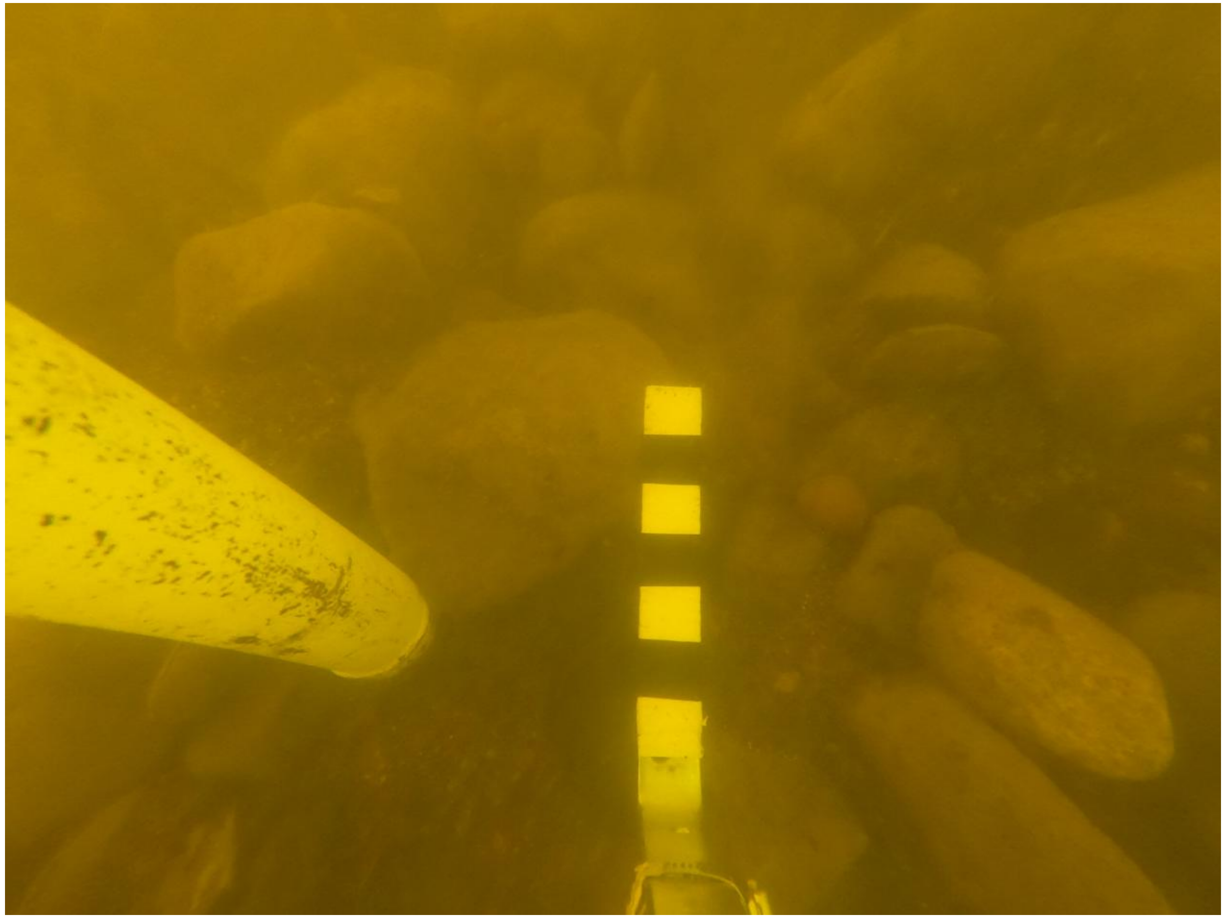


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Substrate Condition
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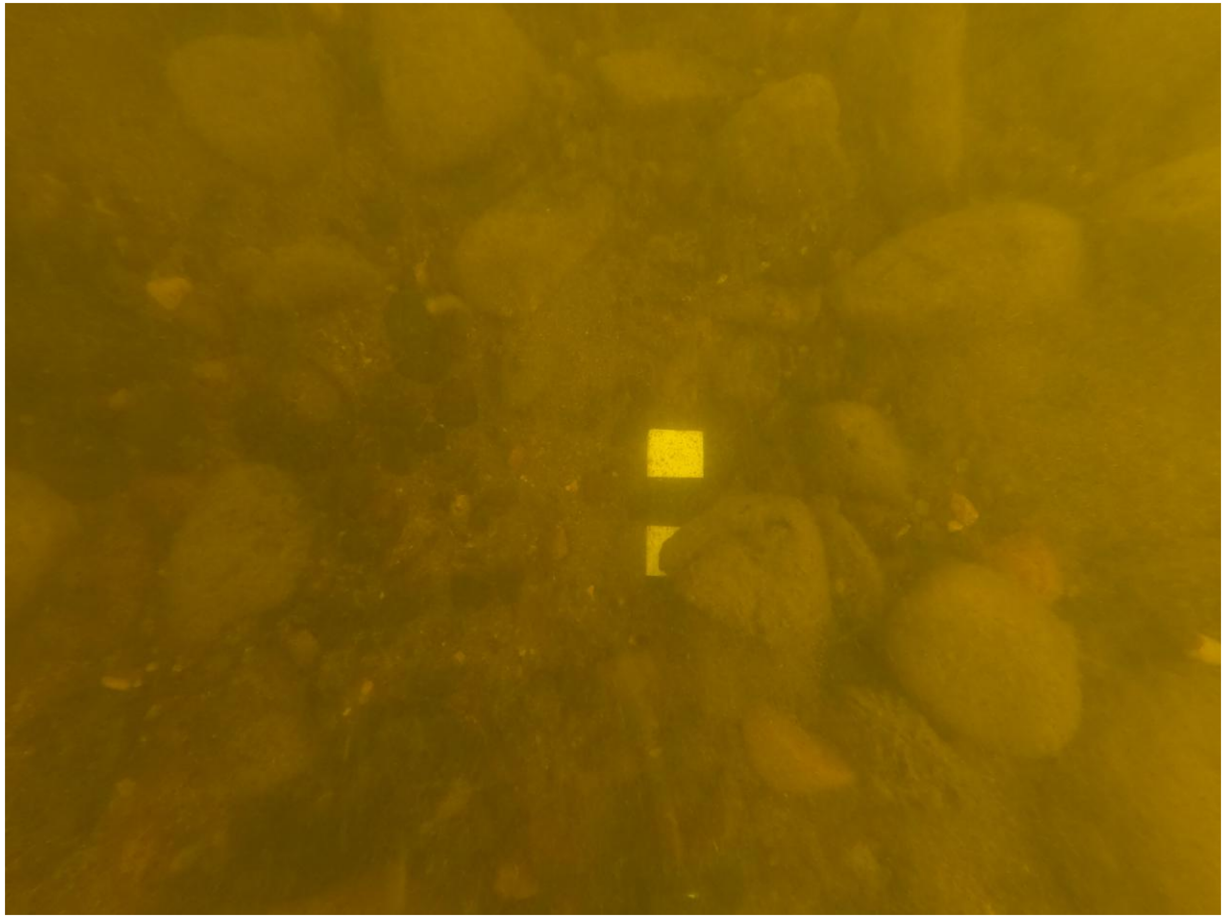

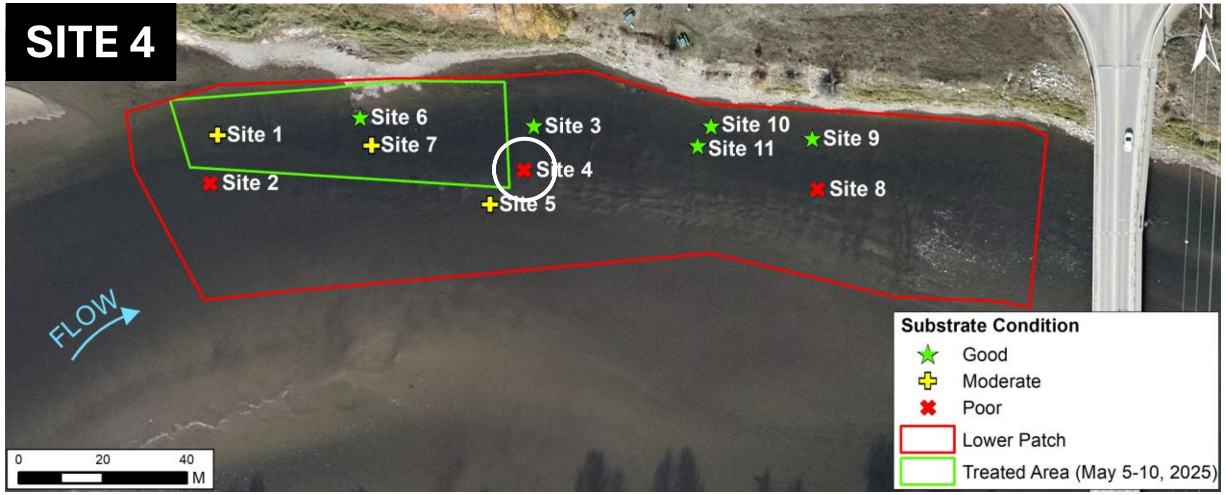
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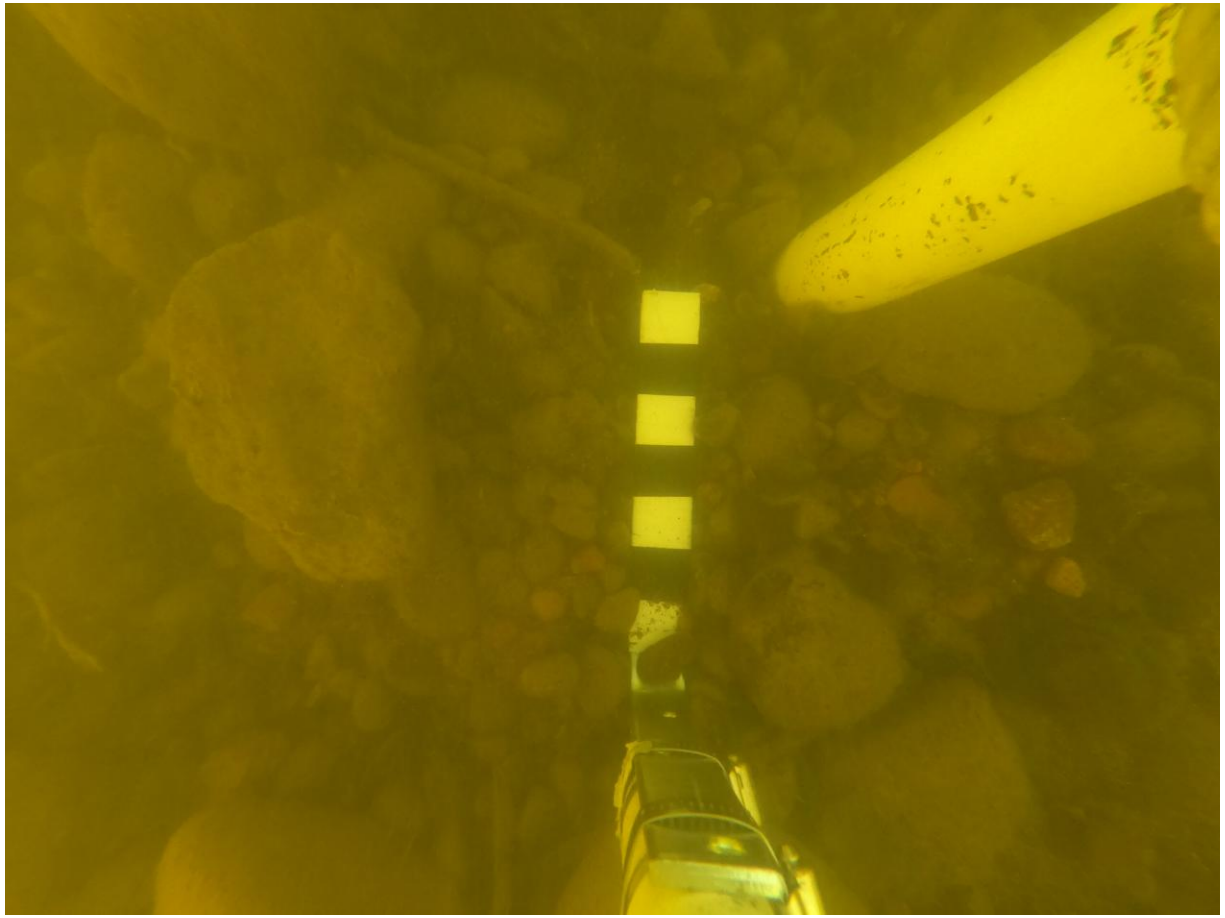


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Treated Area (May 5-10, 2025)
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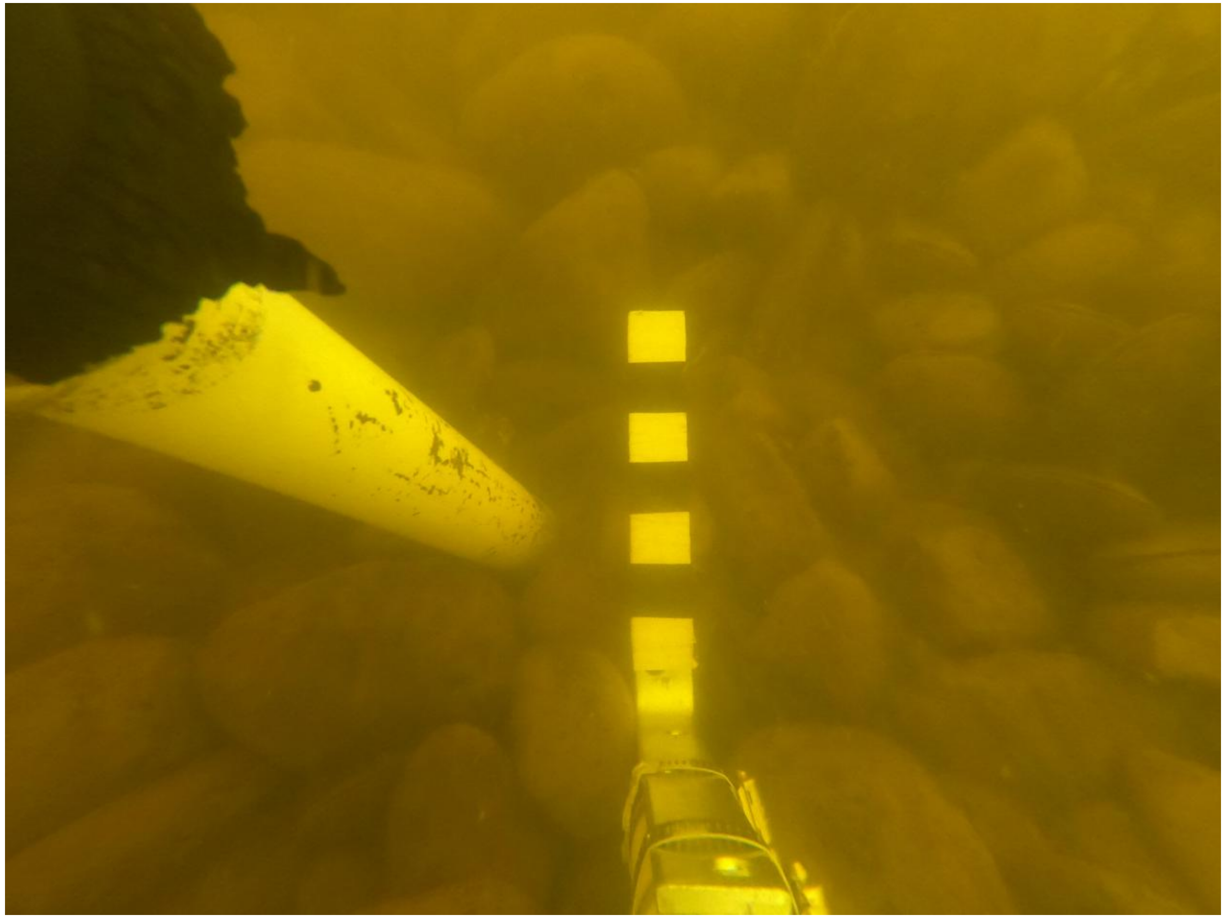


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Treated Area (May 5-10, 2025)
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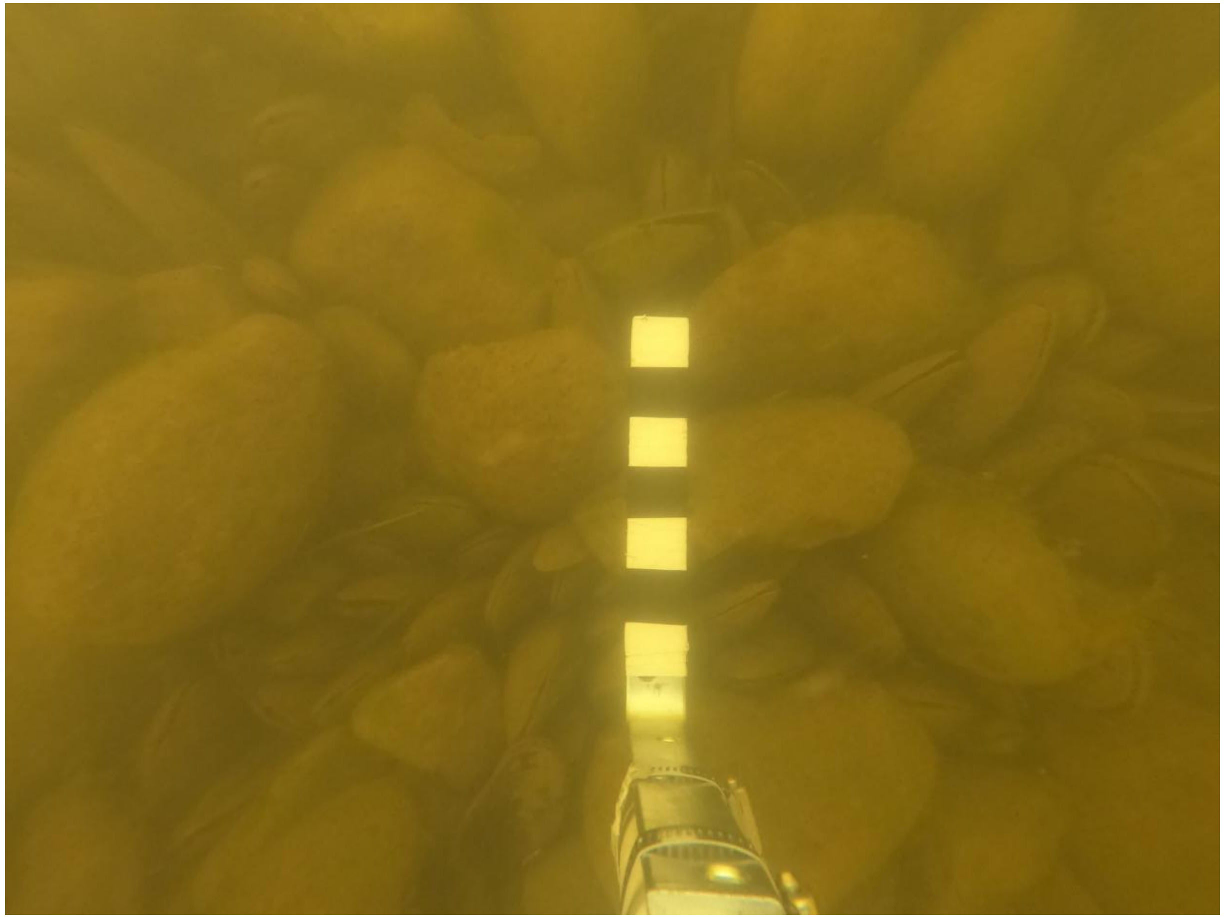


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Substrate Condition
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Lower Patch
Treated Area (May 5-10, 2025)
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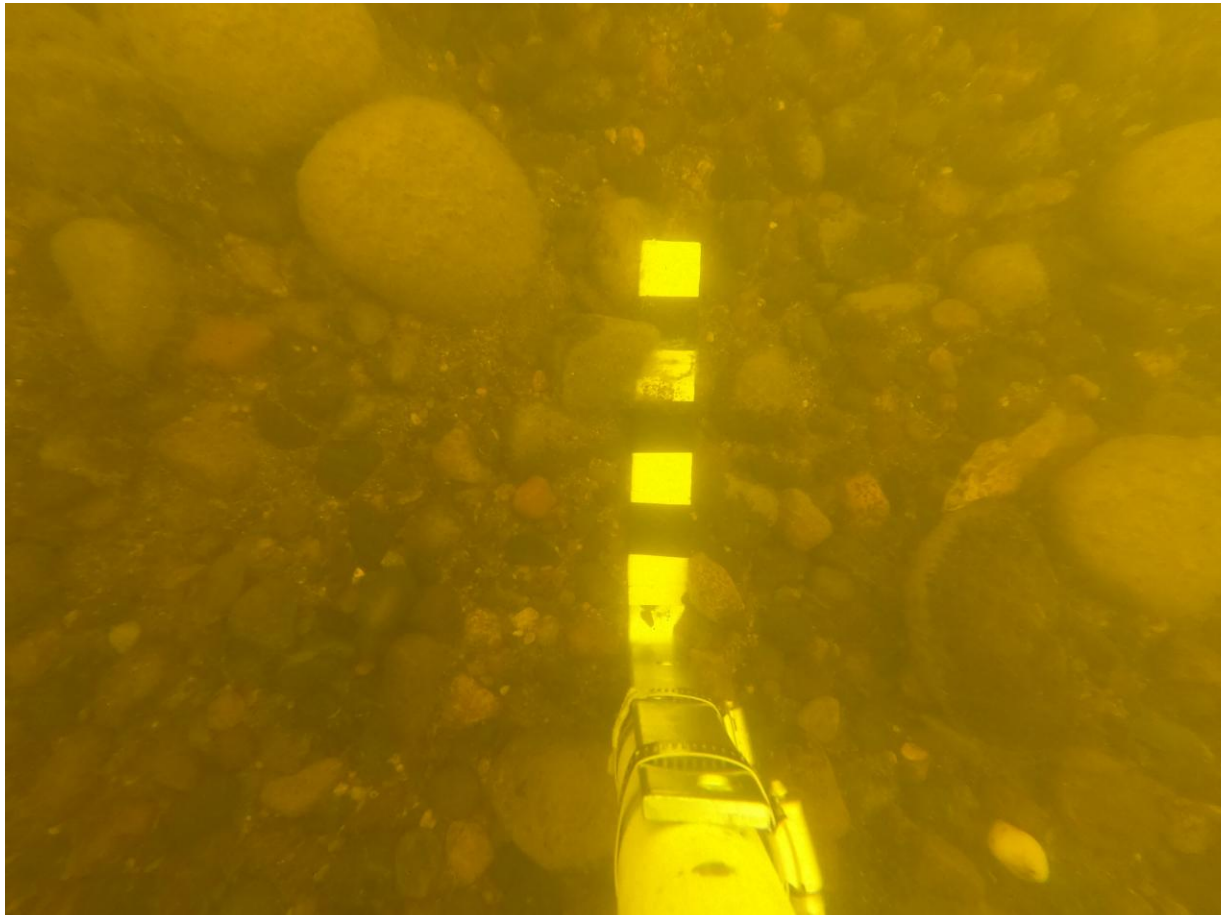


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FLOW
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Substrate Condition
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Lower Patch
Treated Area (May 5-10, 2025)
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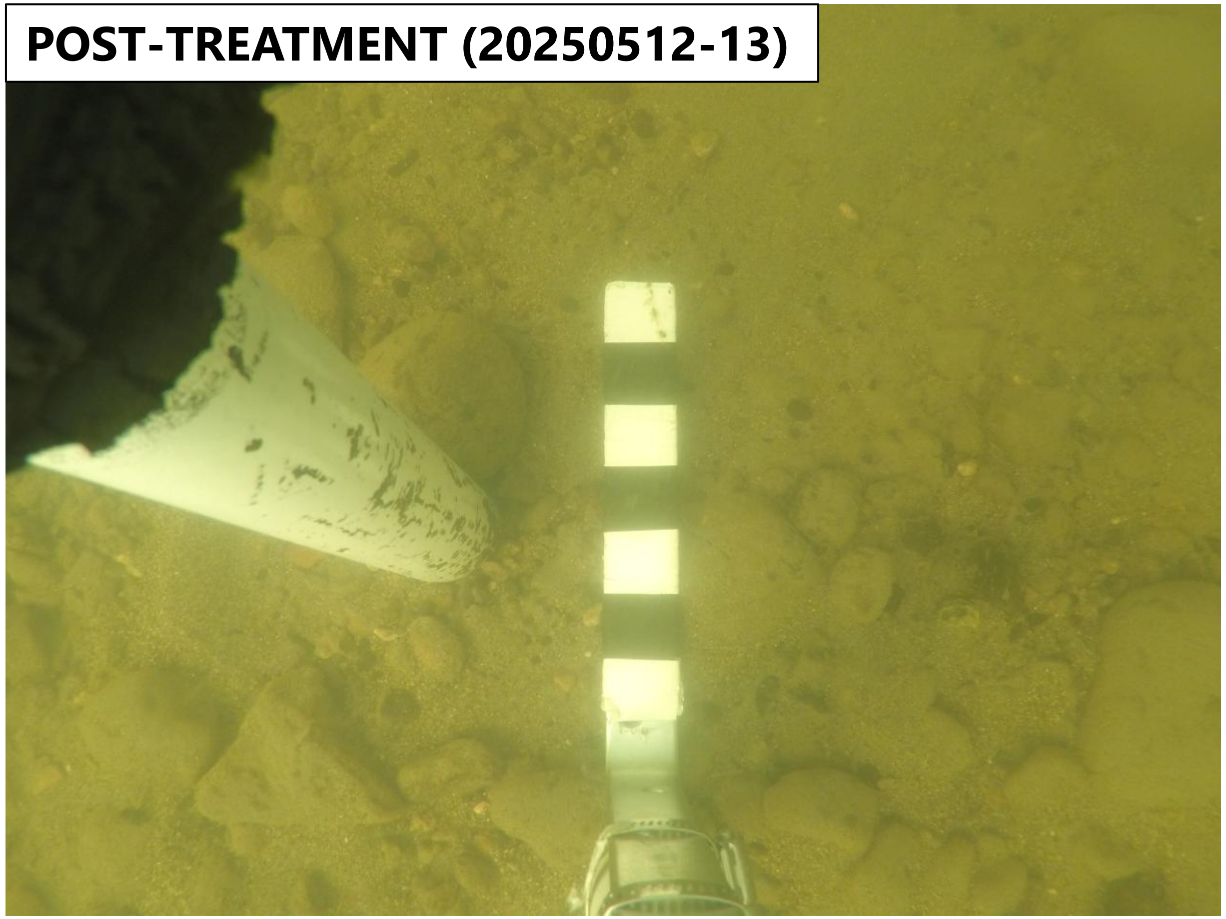
APPENDIX B

POST-TREATMENT SAMPLING RESULTS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Site 19
Site 20
Site 21
FLOW
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Substrate Condition
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Lower Patch
Treated Area (May 5-10, 2025)


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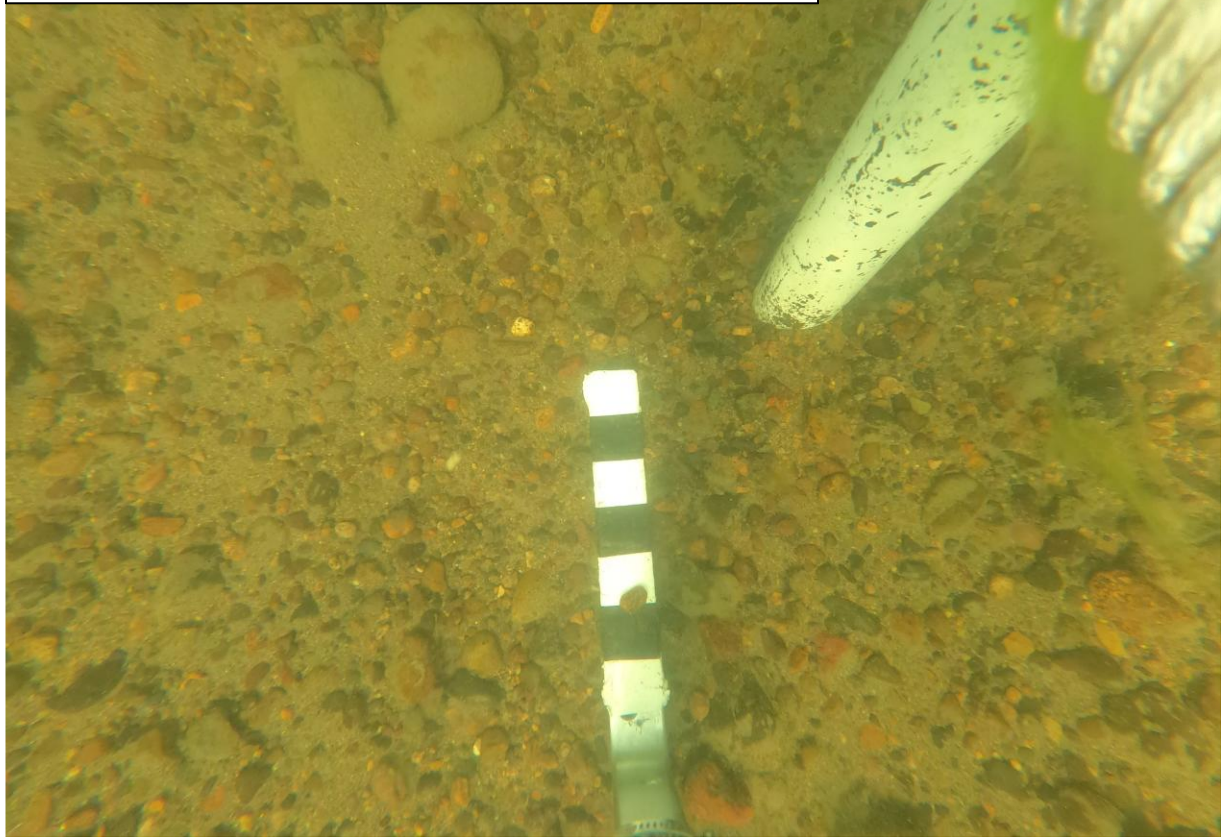
POST-TREATMENT (20250619-20)



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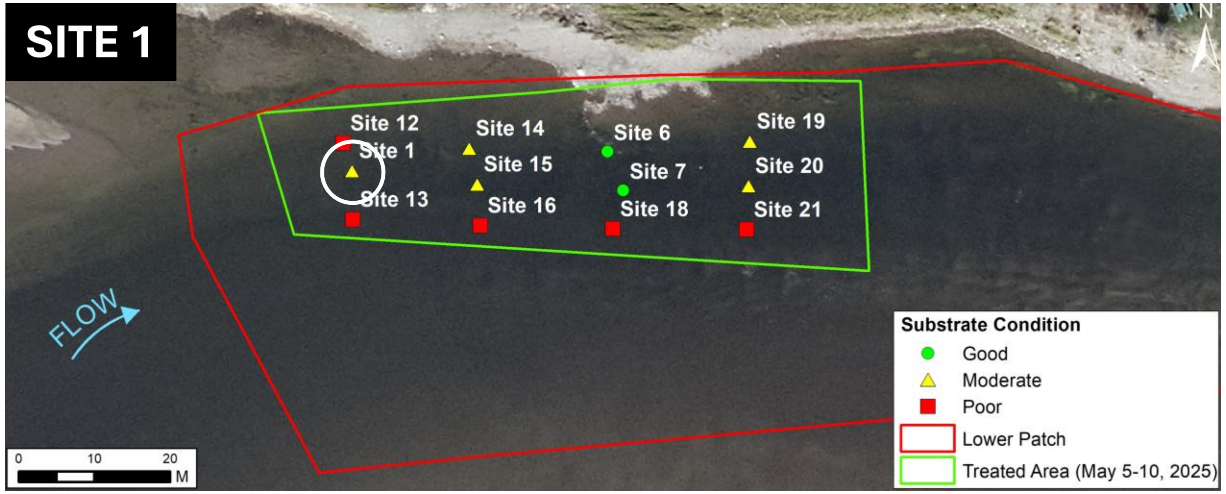

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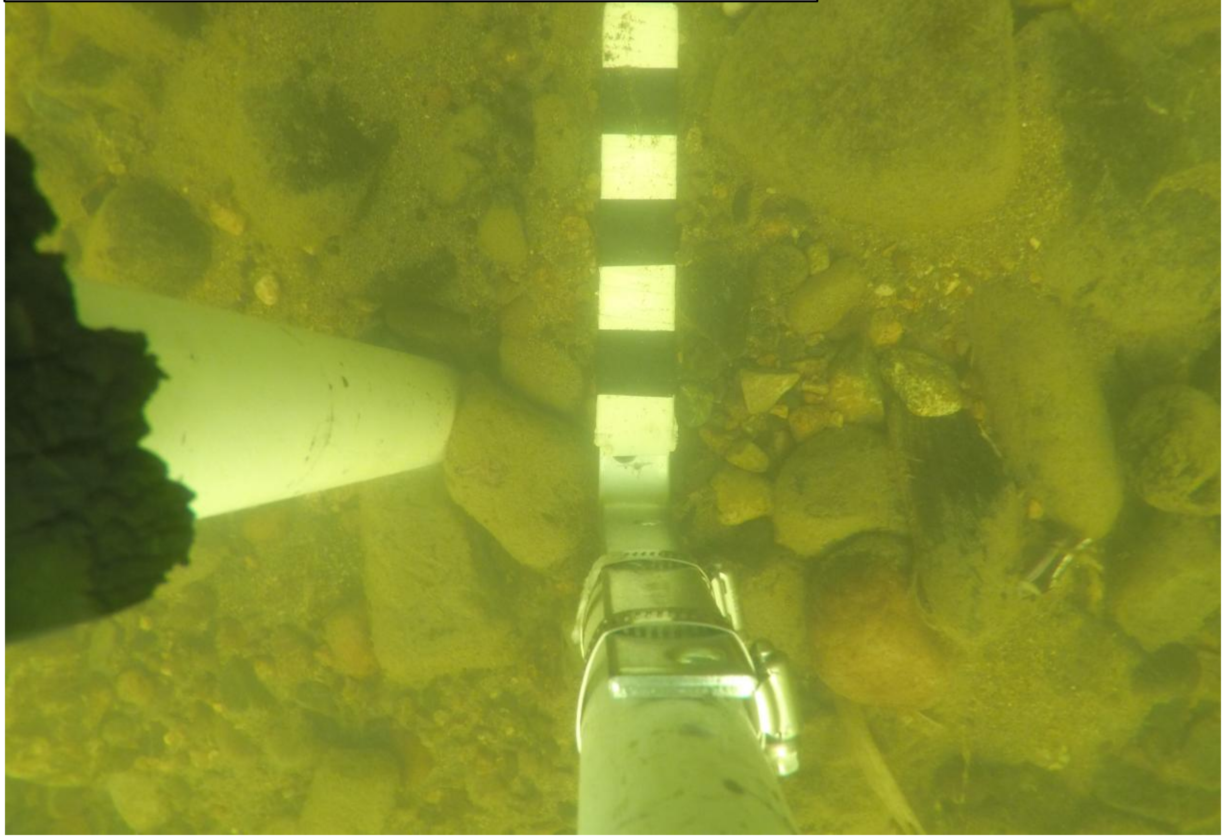

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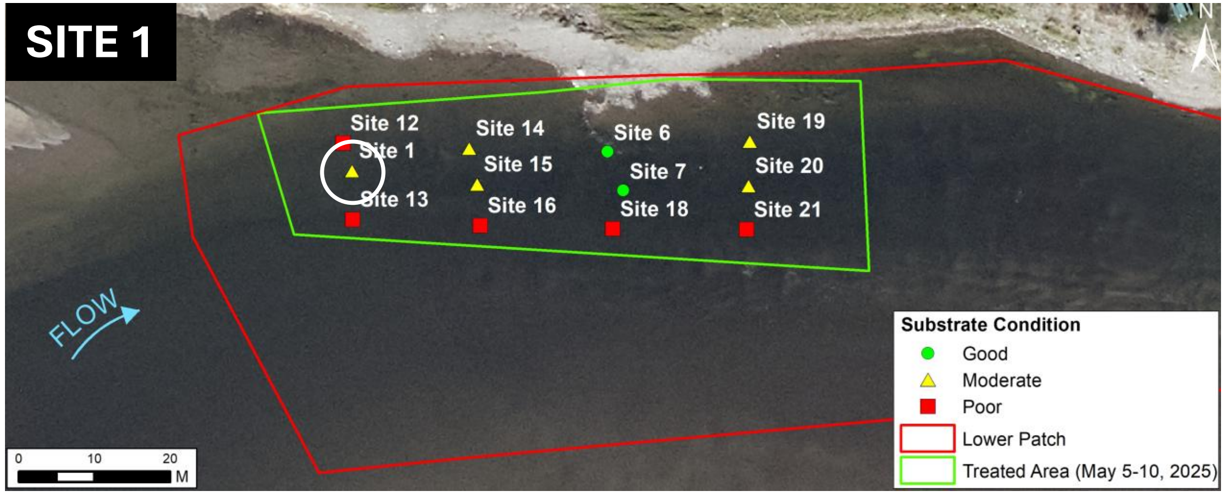

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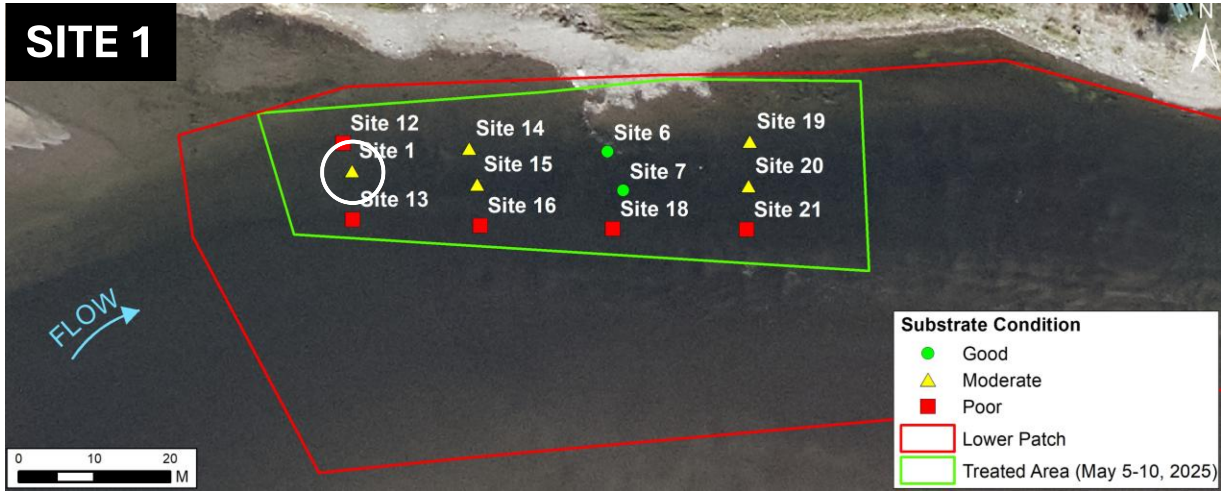

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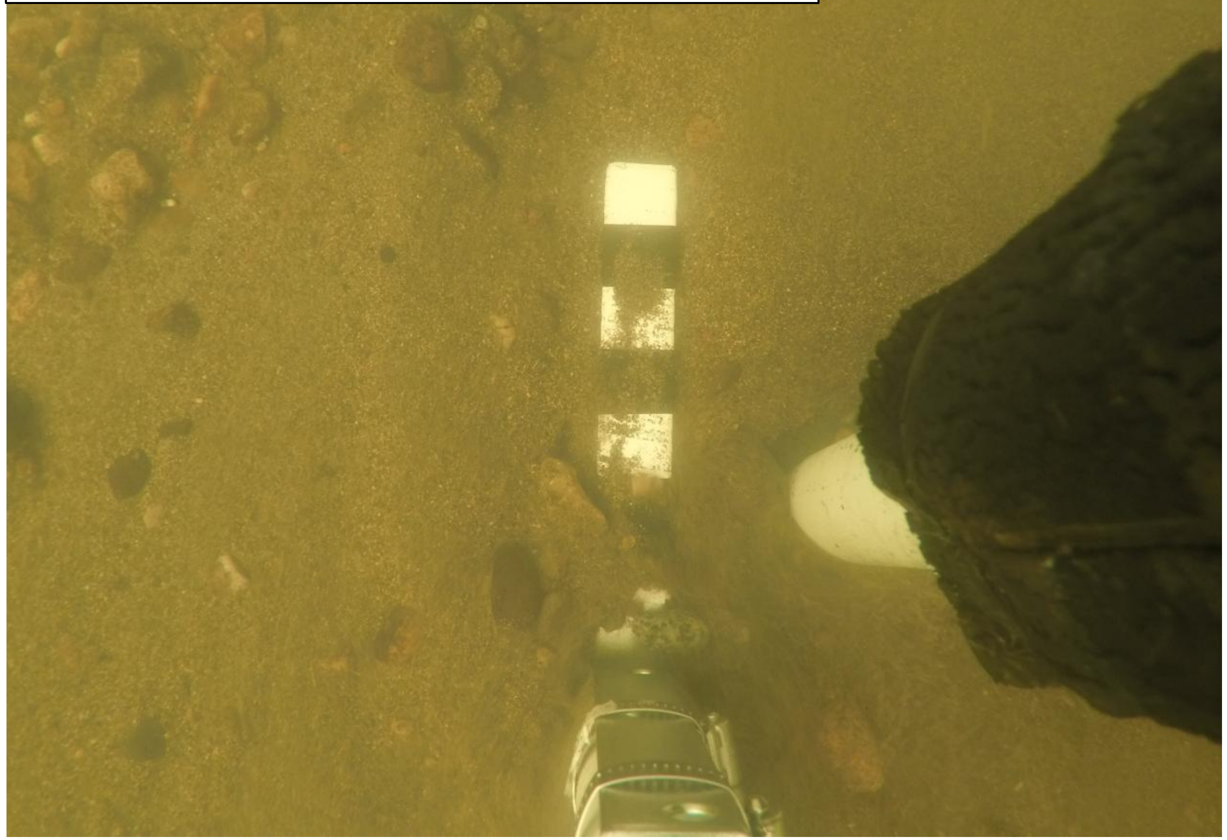

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SITE 13

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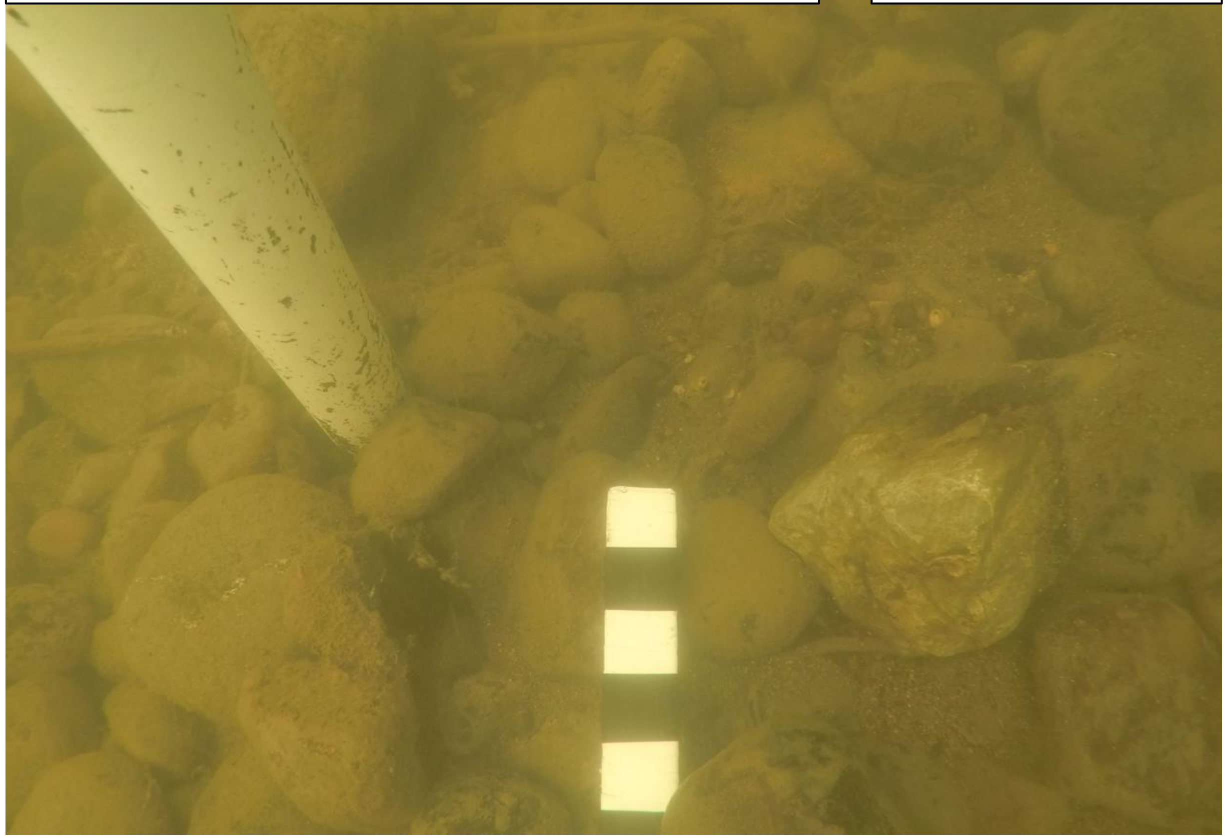
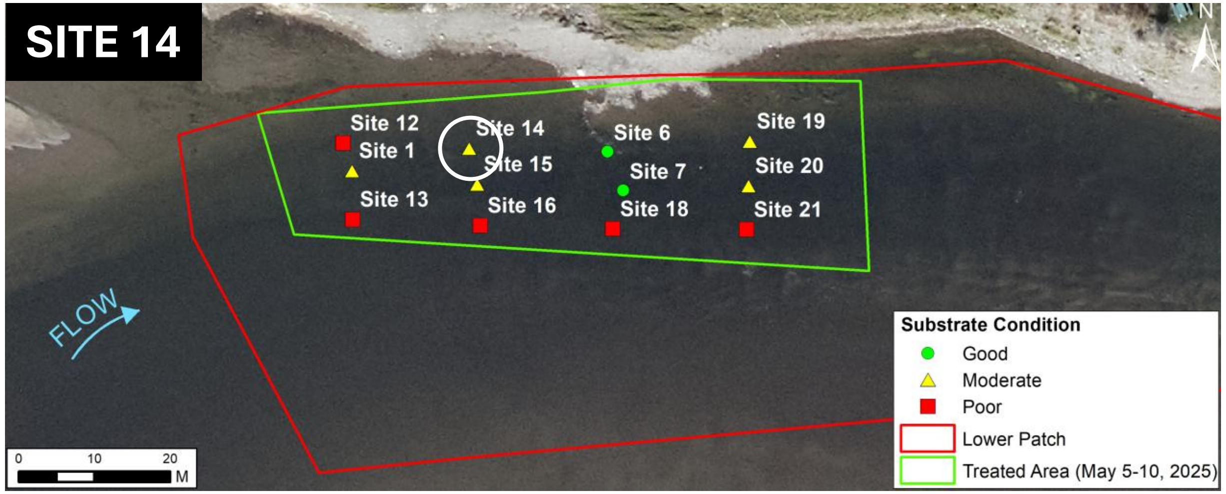
Sample 1 of 2





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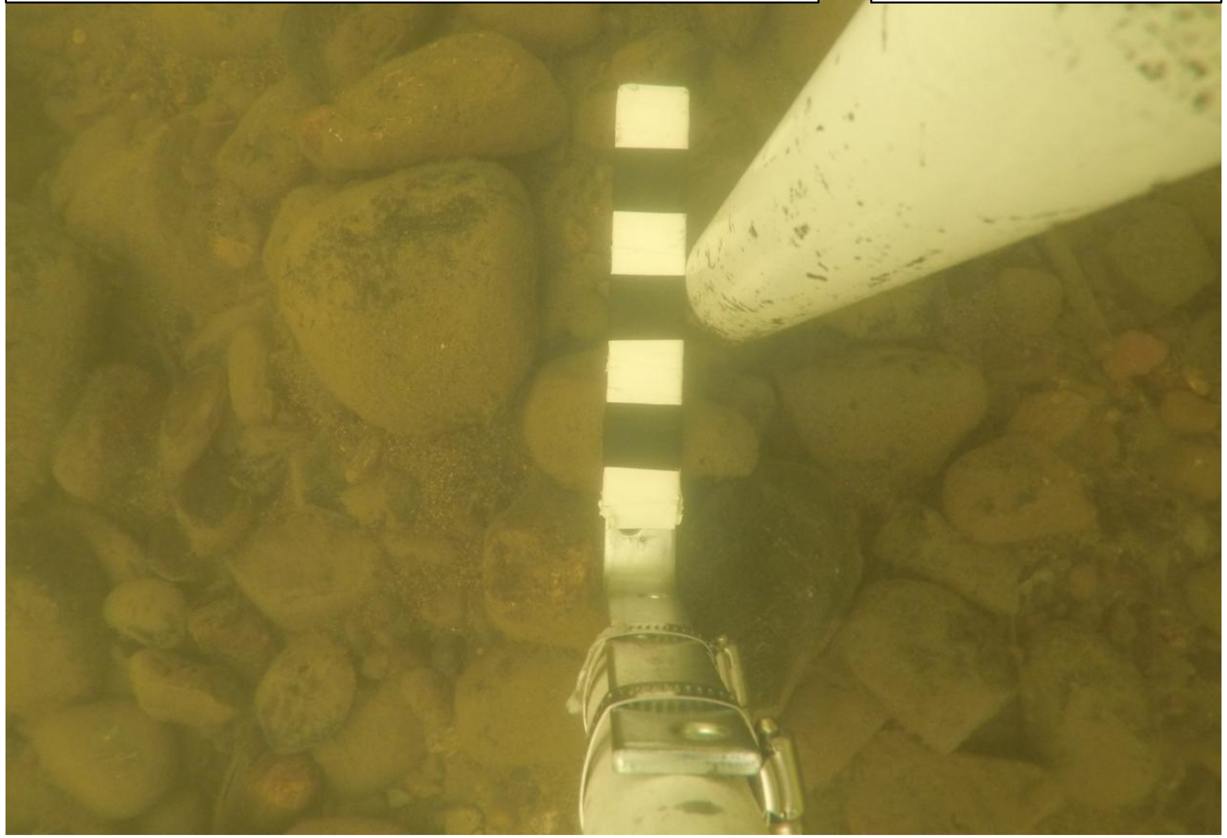

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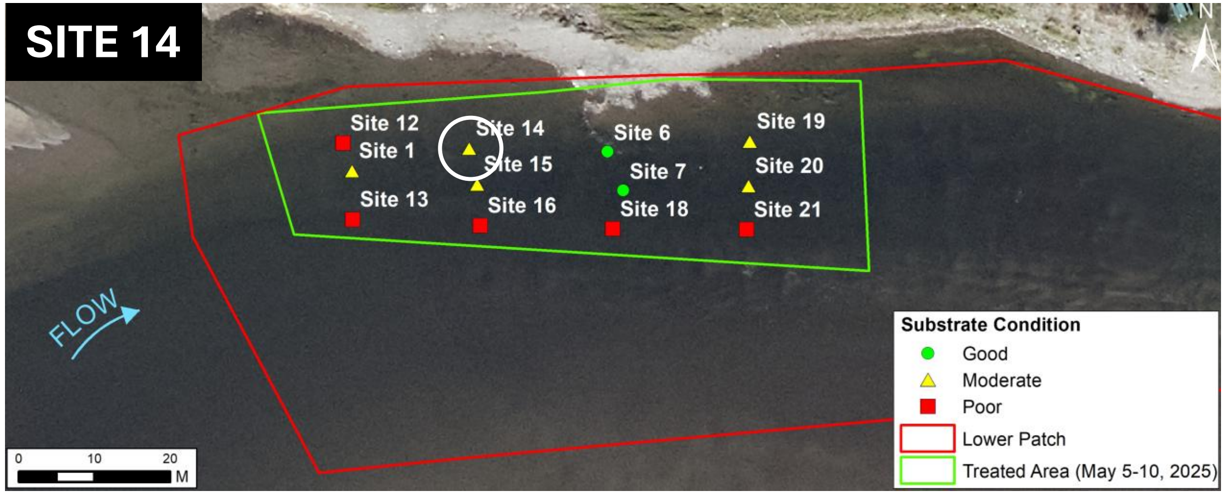

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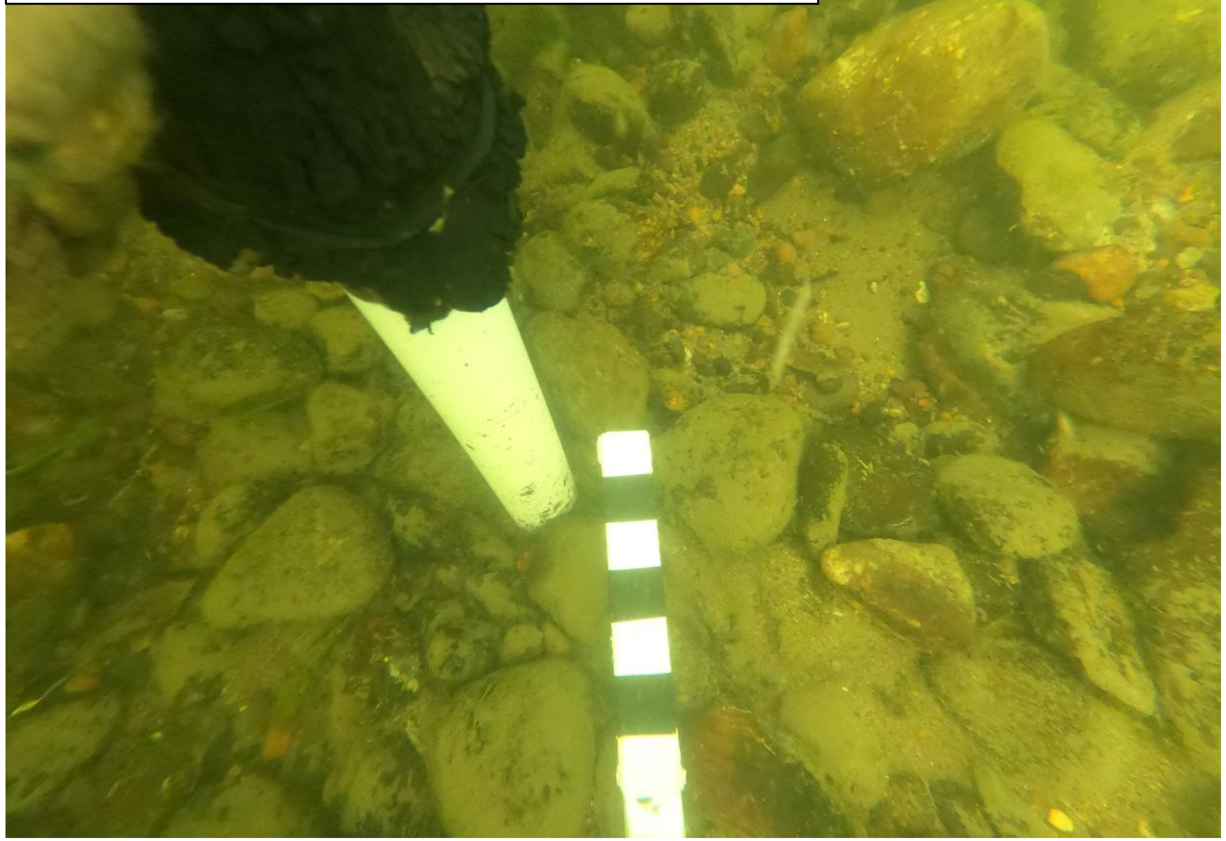

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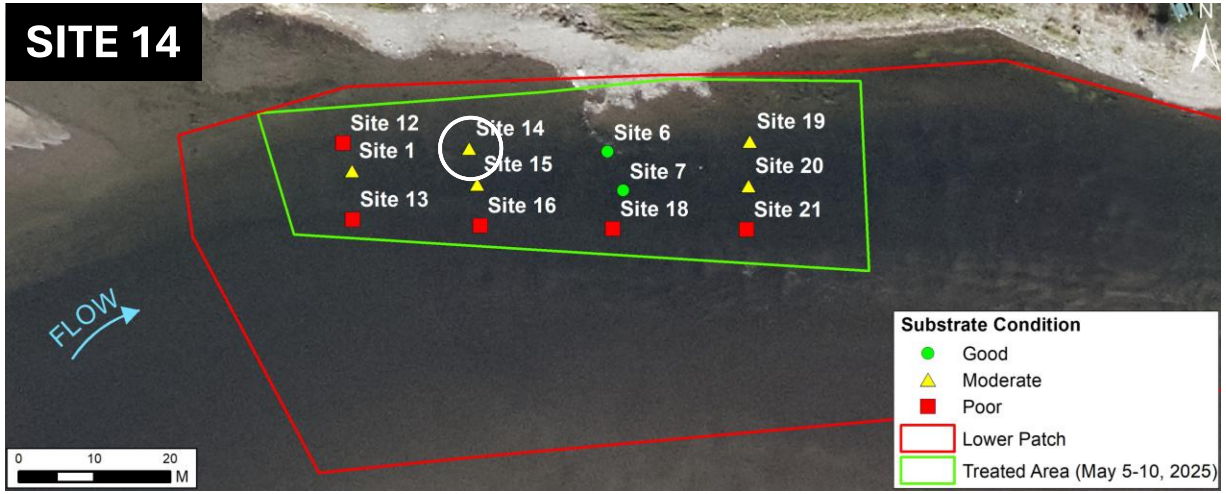

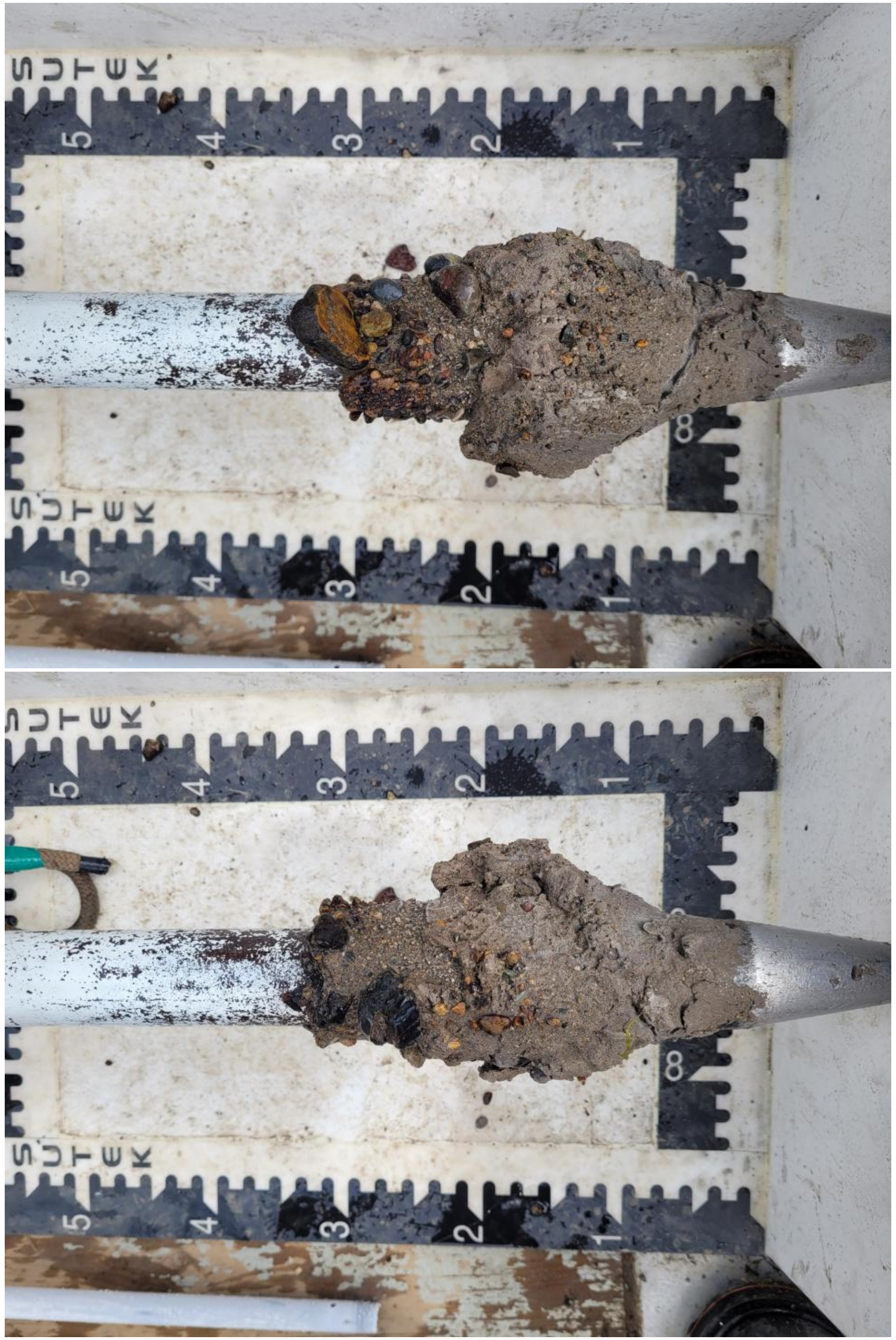


POST-TREATMENT (20250512-13)


SITE 15
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Site 21
FLOW
Substrate Condition
Good
Moderate
Poor
Lower Patch
Treated Area (May 5-10, 2025)
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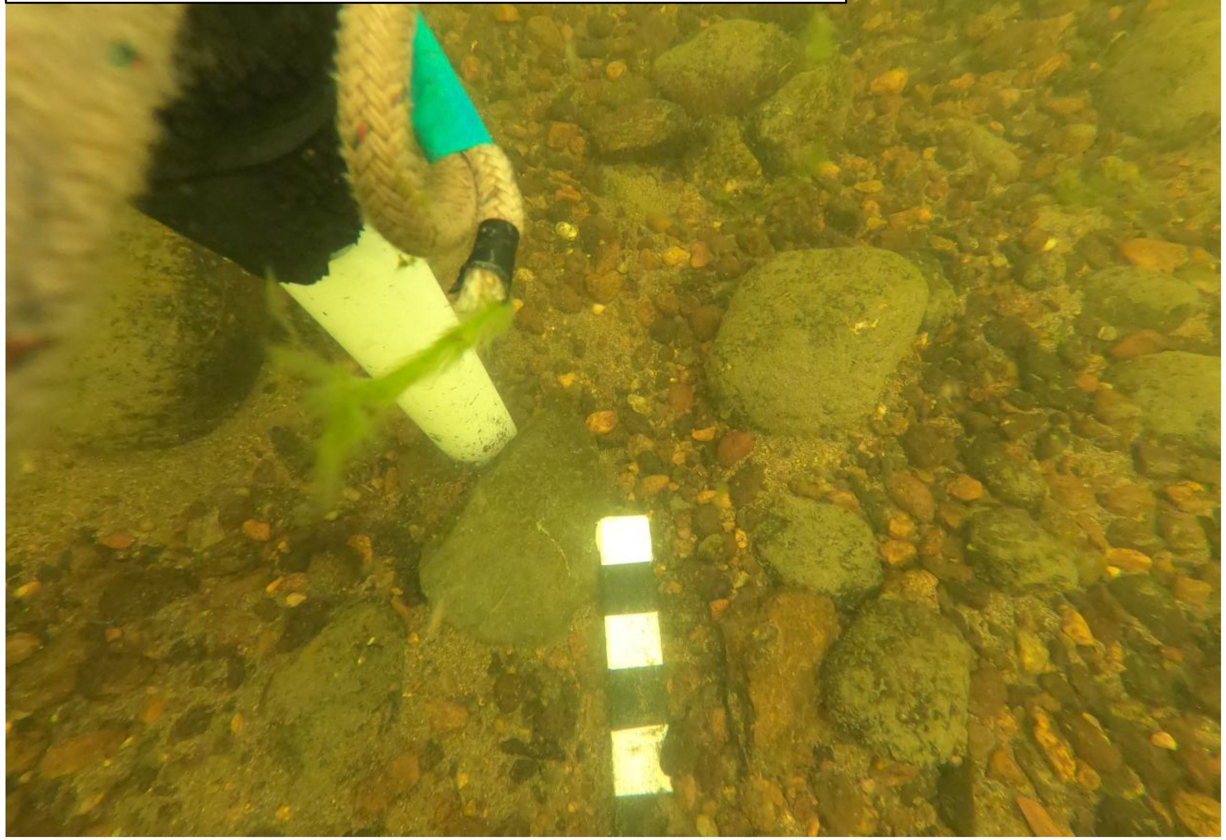
POST-TREATMENT (20250618-20)



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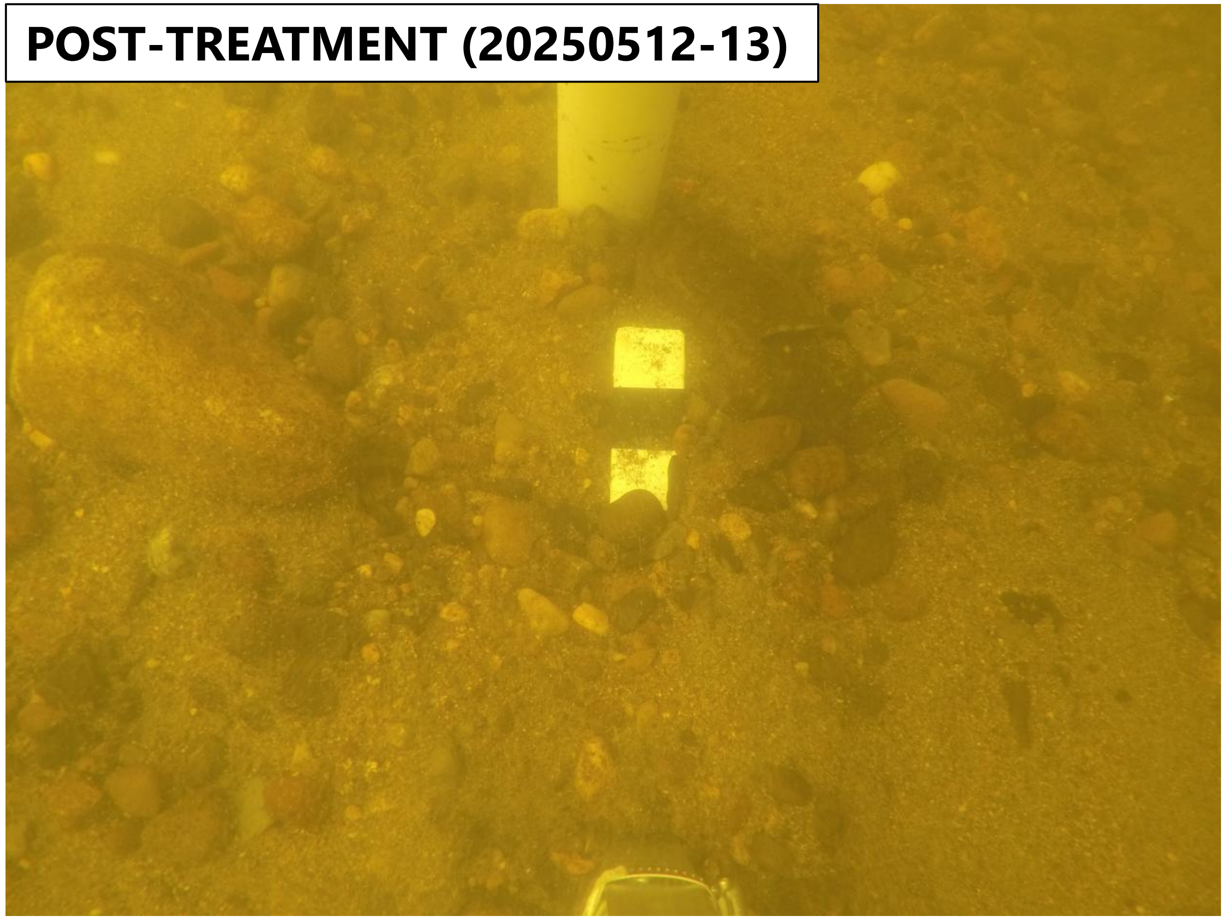

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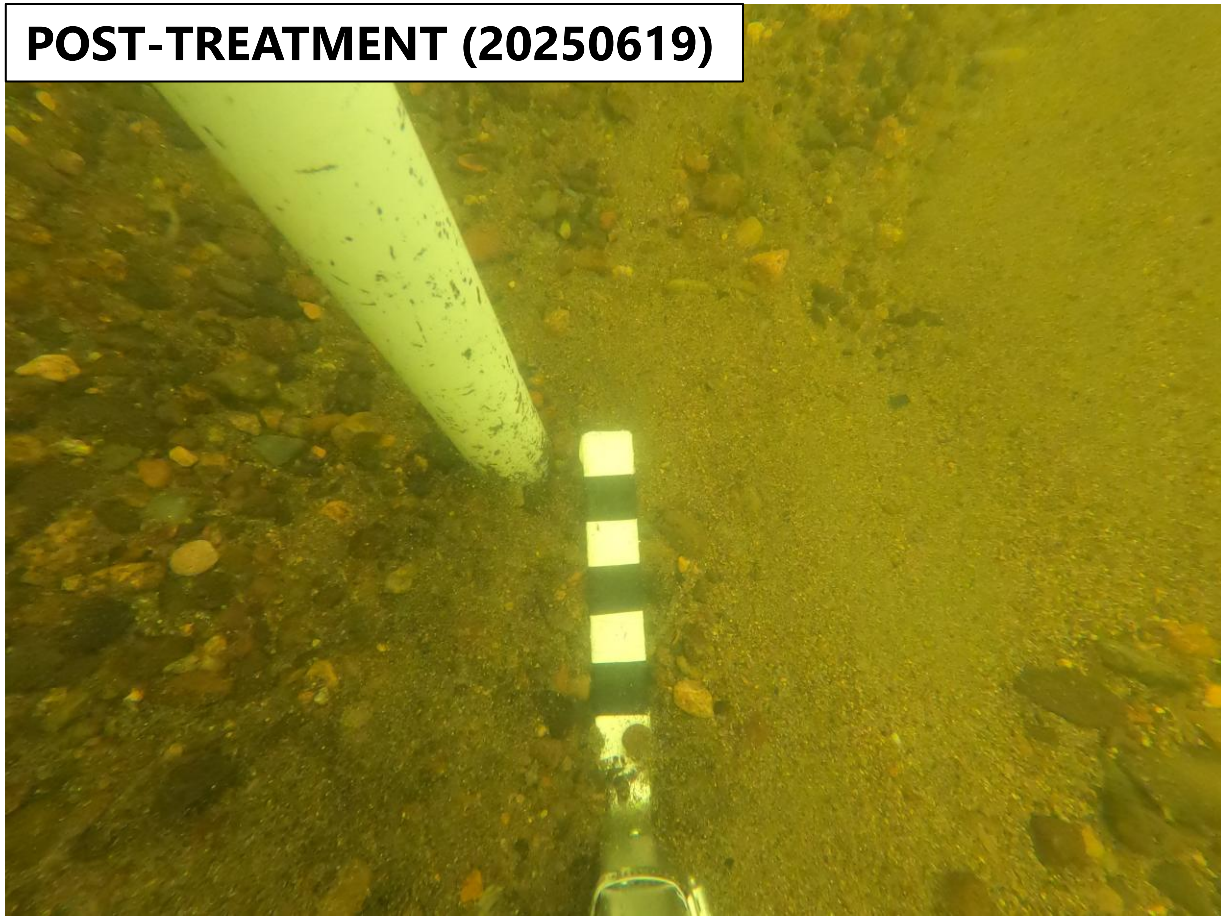
POST-TREATMENT (20250619)


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FLOW
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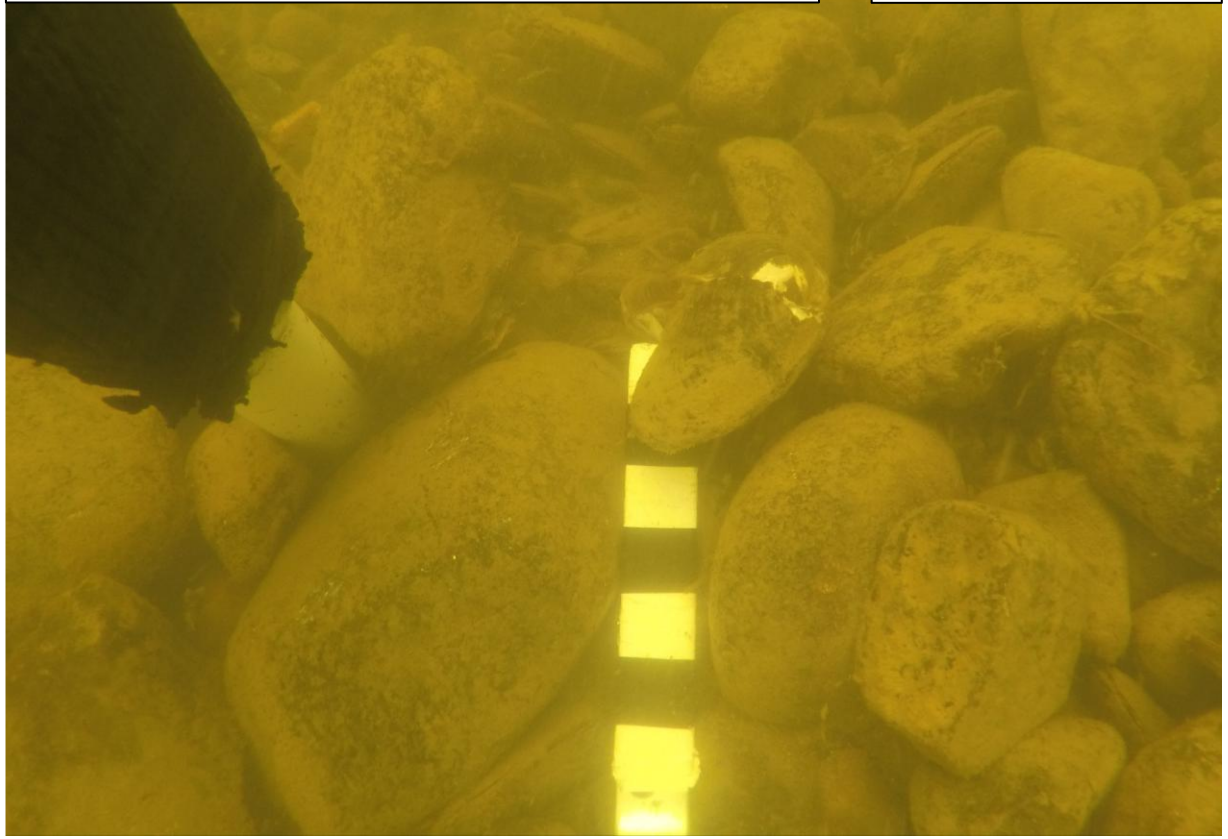
M
Substrate Condition
Good
Moderate
Poor
Lower Patch
Treated Area (May 5-10, 2025)

PRE-TREATMENT (20250423-25)

POST-TREATMENT (20250512-13)

Sample 1 of 2



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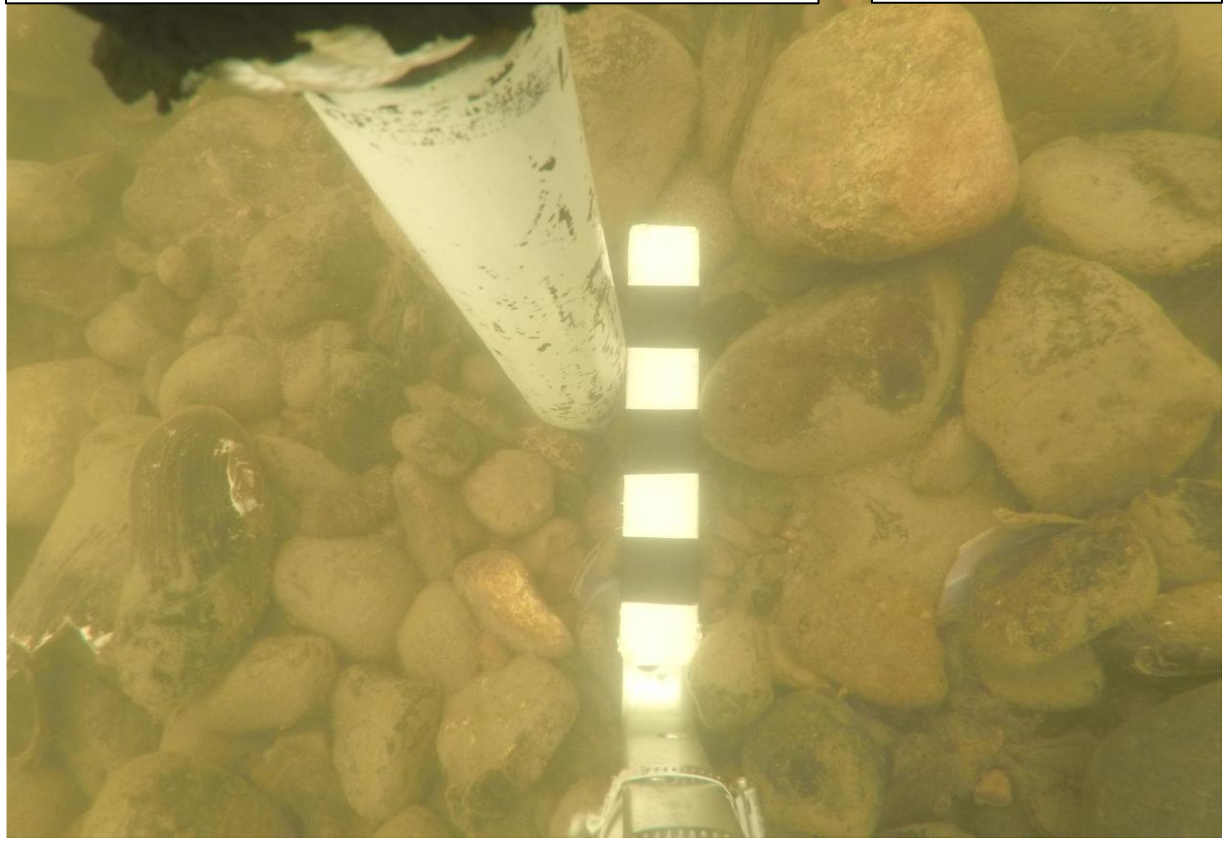

POST-TREATMENT (20250619-20)

POST-TREATMENT (20250619-20)

Sample 2 of 2

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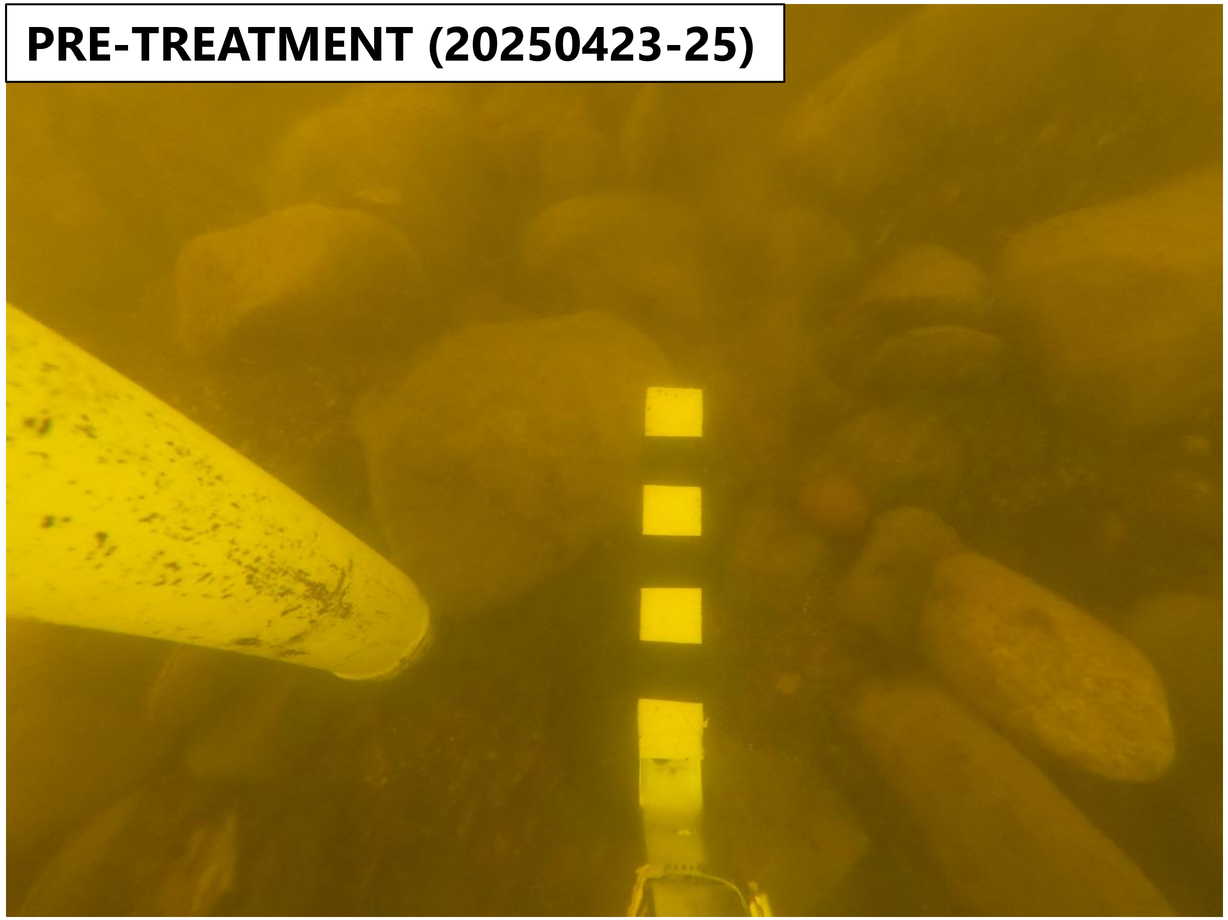

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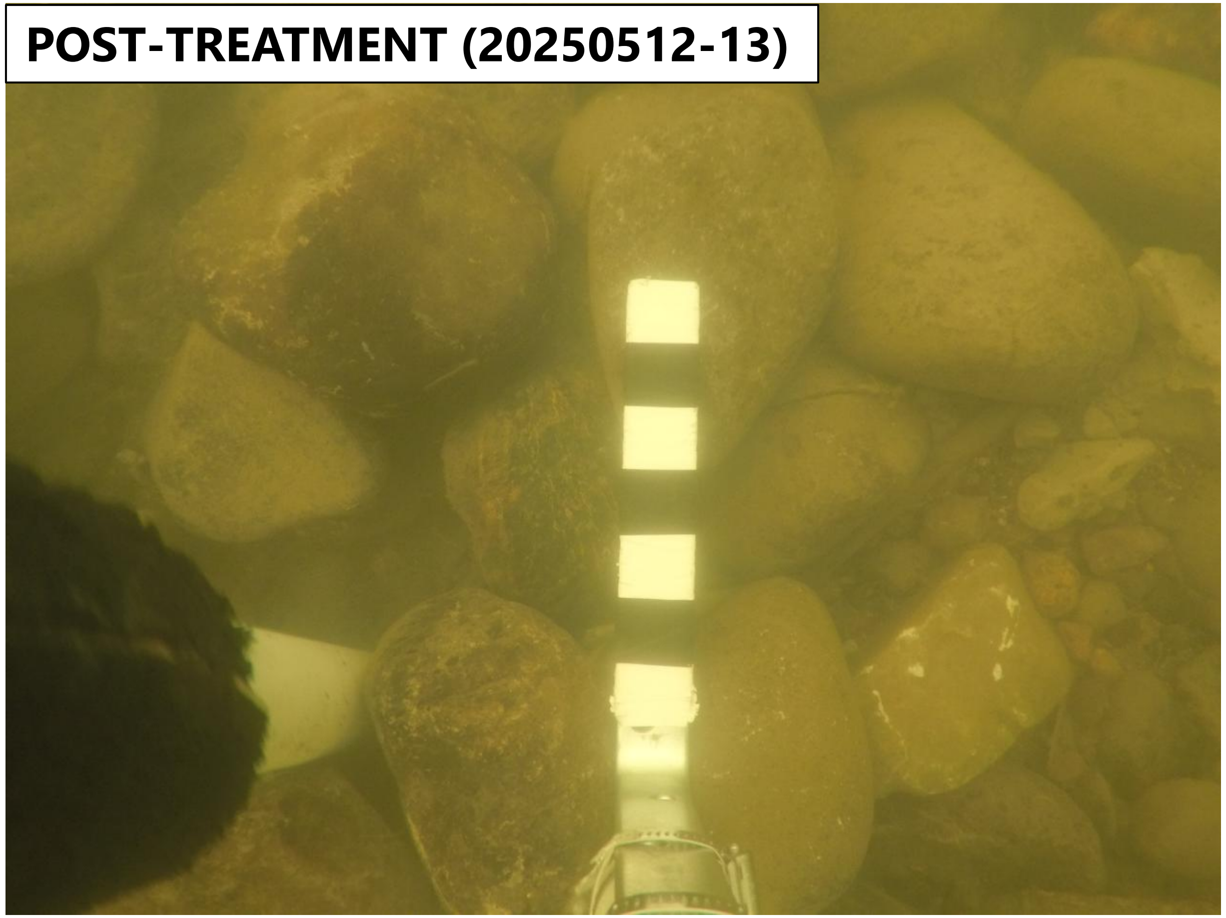

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POST-TREATMENT (20250619)

SITE 7

POST-TREATMENT (20250512-13)

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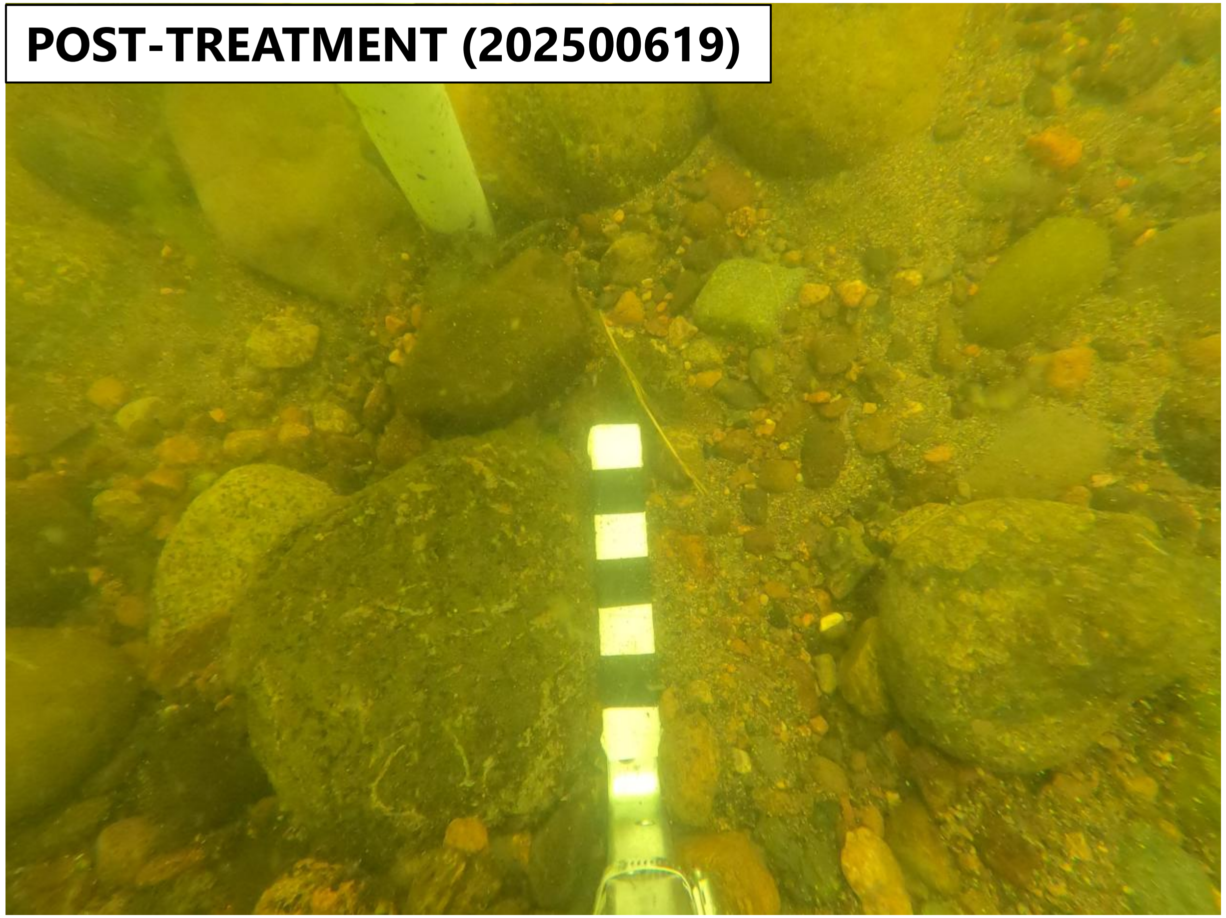

SITE 18

POST-TREATMENT (20250512-13)


POST-TREATMENT (20250619)


SITE 19
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Site 21
FLOW
Substrate Condition
Good
Moderate
Poor
Lower Patch
Treated Area (May 5-10, 2025)
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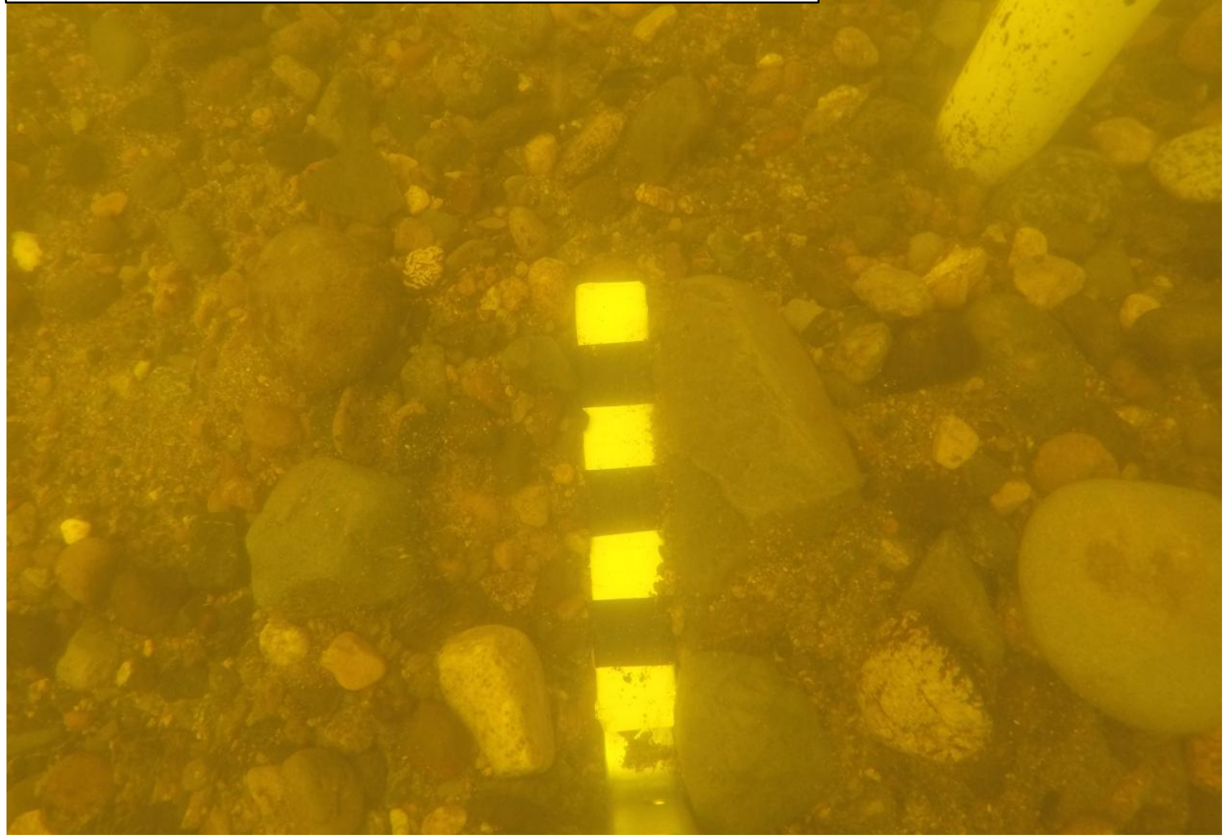
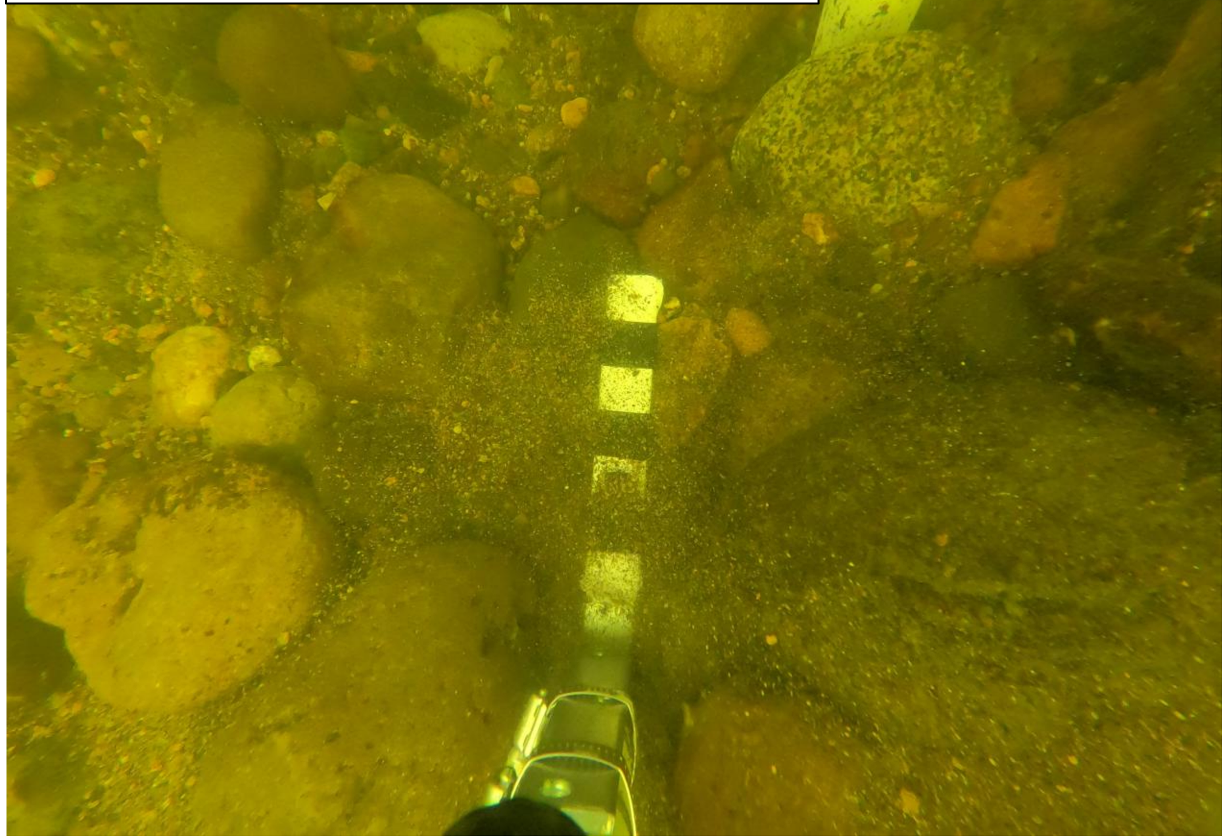
M

POST-TREATMENT (20250512-13)



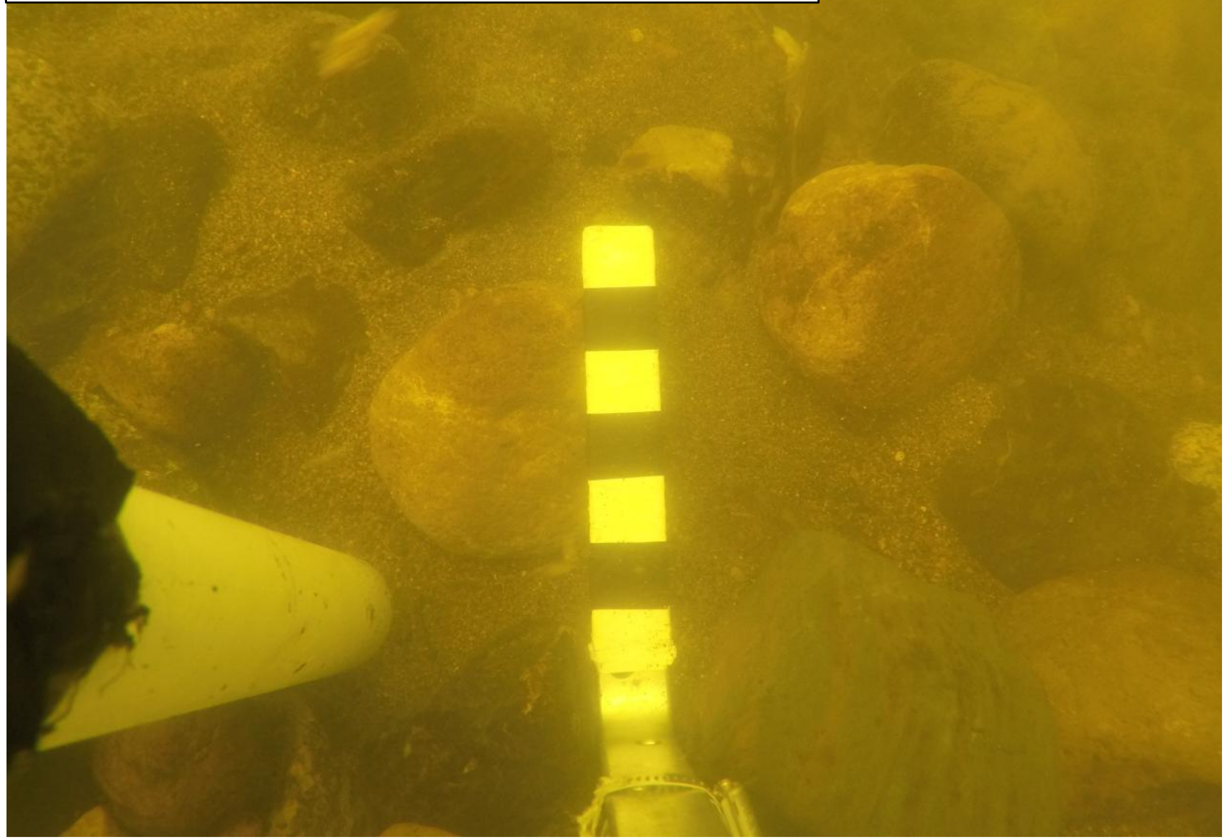
SITE 20

POST-TREATMENT (20250619-20)



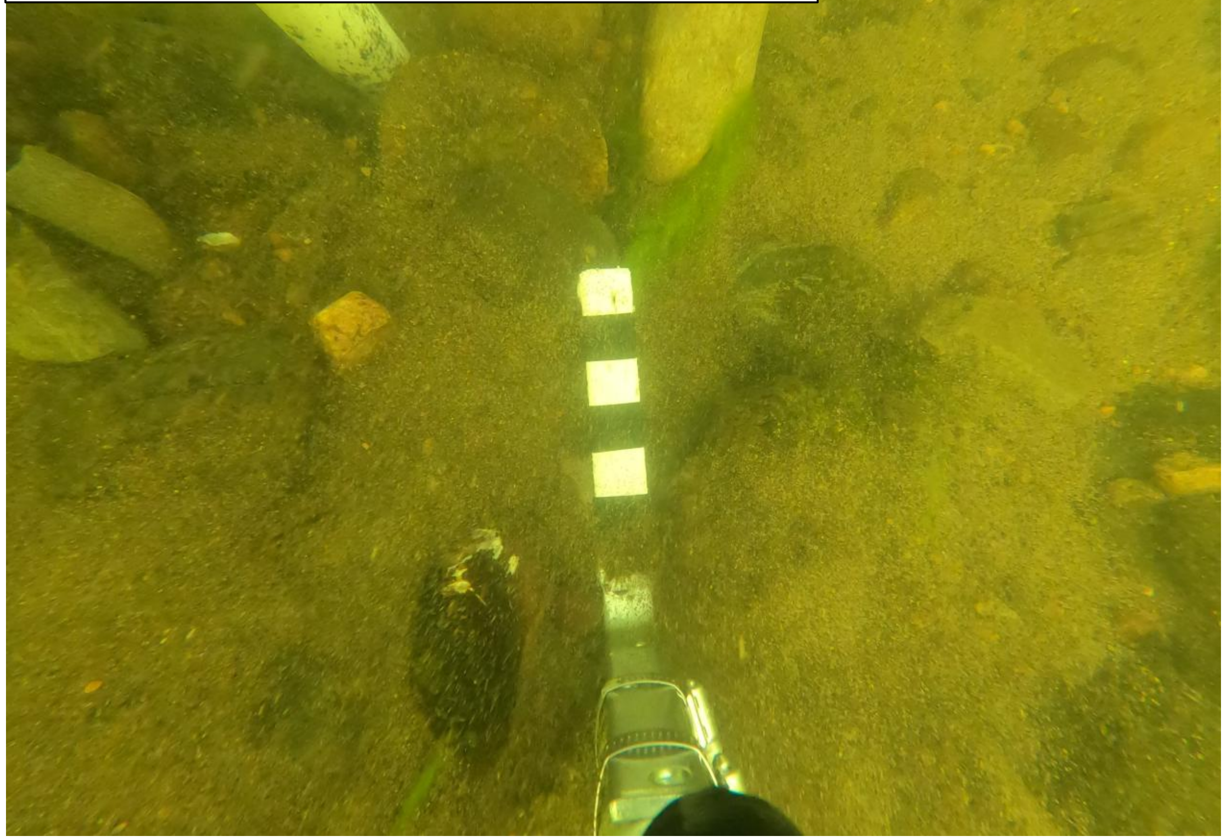
SITE 20

POST-TREATMENT (20250512-13)



SITE 21

POST-TREATMENT (20250619-20)



SITE 21