***MEADOWDALE: INFORMING COASTAL STREAM RESTORATION***

July 1, 2023

**PRISM Record Number: 22-1754**

**Note that the project milestones and individual task costs below are estimates and subject to change.**

**Project Contacts**

|  |  |
| --- | --- |
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**Whole Project Scope**

The Meadowdale Estuary Restoration Project is the first coastal stream mouth restoration project along the railroad-impacted shoreline of Puget Sound. The restoration project, funded in part by ESRP project #18-1587, replaces an undersized culvert through the railroad embankment with a 128-foot long bridge and excavates a 1.3-acre estuary upstream of the railroad embankment. This regionally significant restoration project presents a unique opportunity to future stream mouth restoration siting and design along the railroad as well as throughout Puget Sound along sediment starved shorelines.

The proposed investigation will focus on the geomorphic and ecological outcomes of the restoration. The stream mouth reconnection and estuary expansion are intended to restore sediment transport and deposition processes to provide improved conditions in the lower stream, estuary, and adjacent nearshore areas. The proposed investigation will document the adjustment of the restored site as fluvial and coastal processes act on it and will inform the sustainability of the design and investment. Understanding the “offsite” benefits to the adjacent nearshore habitats will add information on how stream mouth restoration can improve conditions along sediment starved beaches where feeder bluffs are substantially disconnected through extensive railroad or shoreline armoring stressors.

Investigation of the ecological benefits, notably use by juvenile Chinook Salmon originating in other river systems will be highly informative for future restoration siting and design, and provide key information documenting project benefits to stakeholders, funders, restoration practitioners, and the entire community. Salmon habitat restoration was a significant desired outcome of the restoration and the contributing funding sources. The proposed investigation will inform the return on the investment, thus guiding where and how to work in the future. Assuming juvenile Chinook Salmon use the restored habitats, the proposed investigation can help document the salmon benefits of independent coastal stream mouth restoration. This information is important for land and infrastructure owners along the shoreline who are asked to allow or partner on or even lead restoration. The information is also important for grant funding programs and state, local, tribal, non-profit entities considering future shoreline restoration.

**Agreement Scope**

The Tulalip Tribes and partners will investigate the ecological and geomorphic outcomes of the Meadowdale Park estuary restoration project in Edmonds, WA (RCO project number 18-1259) to inform the siting and design of future coastal stream mouths. The restoration project is the first stream mouth restoration project along the railroad corridor. The restoration included novel elements of excavating a large estuary embayment with room for the site to adjust to fluvial and coastal processes, as well as sea level rise. The proposed investigation will inform the onsite and offsite benefits of restored sediment transport conditions, as well as the sustainability of the estuary design.

**Agreement Milestones**

START DATE: July 1, 2023

END DATE: Work on this project must be completed by November 30, 2025

**Task Summary**

Table 1 – Summary of tasks and costs (pasted from Budget Worksheet)

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Task** | **Match** | **ESRP Amount** |
| 1 | Project Administration | $15,000 | $7,343 |
| 2 | Project Plan |  | $5,843 |
| 3 | Wiki Content |  | $3,906 |
| 4 | Data Collection and Processing | $45,318 | $71,883 |
| 5 | Interim Results Analysis |  | $26,513 |
| 6 | Final Project Report |  | $11,513 |
| 7 | Final Project Presentation |  | $2,668 |
|  |  |  | $10,152 |
|  | **TOTAL** | **$60,318** | **$139,821** |

**TASK 1: Project Management, Progress Reporting & PRISM Final Report**

Project Management will include project reporting including PRISM reports, grant budget management, and assuring all grant requirements are met.

*Deliverables:*

* 1. **PRISM progress reports** that describe accomplishments, project status, and any delays or concerns (Submit 2/yr)

**Target date** – 4/1/2024

**Target date** – 10/1/2024

**Target date** – 4/1/2025

* 1. **PRISM Final Report** – Complete and submit a final report using the final report module in PRISM. This final PRISM report updates the information in PRISM to reflect your completed work and results.

**Target date** – 10/31/2025

**TASK 2 – Learning Project Plan**

**Task 2 Description:**

We will develop a project plan that includes: (1) project goals and objectives, (2) scope and schedule for implementation and deliverables, (3) sampling plan and methods, (4) descriptions of factors affecting accuracy and precision of mapping products, (5) assessment of how the sampling plan will address these factors, (6) descriptions of staff roles and expertise, (7) product descriptions, and (8) estimated costs. This project plan will be completed during the initial phase of our project timeline and will include coordination with project partners and ESRP to develop a clear plan to address the desired project outputs.

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| --- | --- | --- |
| **Sub-Task** | **Summary** | **Target Completion Date** |
| 2A |  |  |
| 2B |  |  |

*Deliverables:*

* 1. **Draft Project Plan** – Send a word document of the draft project plan to ESRP staff for review, minimum of 4 weeks in advance of the anticipated final project plan to allow adequate time for review and revisions.

**Target date** – 12/31/2023

* 1. **Final Project Plan** – Upload a PDF file of the final project plan that incorporates ESRP staff comments to PRISM

**Target date** – 1/31/2024

**TASK 3 – Create Wiki Page Content**

**Task 3 Description:**

Grantee will develop and maintain of a set of wiki pages that describe the project at <https://SalishSeaRestoration.org> including:

* An *effort page* describing the project and links to any web published resources related to the project, including the PRISM project snapshot for the project. If the project is evaluating the effects of restoration actions, this page will include a map of the restoration project and before/after photos. This page will be updated by the grantee as the project progresses (see below).
* A *workgroup page* describing the project proponent.
* A *document page* for, at minimum, the final project report.

*Deliverables:*

**(3.1) Initial Wiki content –** Develop initial wiki pages as described above at the Salish Sea Restoration webpage (<https://SalishSeaRestoration.org>) following guidance therein.

**Target date** – 01/31/2024

(3.2) Upload Interim data summary to wiki and update (see Task 5)

**Target Date –** 7/15/2025

(3.3) Upload Final report to wiki and update wiki project pages to reflect final project findings (see Task 6). All wiki pages developed under Task 3 must be accurate as of the time of project completion.

**Target Date – 1**0/15/2025

(3.4) Upload Final presentation pdf to wiki (see Task 7)

**Target date** –11/30/2025

**TASK 4 – Data Collection and Processing**

**Task 4 Description:**

Data collection and processing will take place for the duration of the project and multiple data collection tasks will be collected during each site visit.

Aerial Imagery - Aerial imagery will be collected three times a year, spring, summer, & fall, at a target tidal elevation of 0’ or less, weather permitting. Imagery will be collected utilizing an Ebee fixed wing drone with a pre-programmed flight path. 8 ground control point (GCP) targets will be surveyed with an RTK GPS for use in orthorectifying the imagery (Casella et al. 2020). Generation of a DSM will be done using Pix4D software which will be imported into ESRI ArcGIS for analysis of changes in elevations across the project site between UAV flights. Additional check of elevations derived from the DSM will be done utilizing RTK GPS transect profiles that are done during or within a week of when the UAV flight was conducted following guidance from Casella et al. 2020 and Long et al. 2016.

RTK GPS Beach Profiles - Nine beach profile transects have been established for the study site. An RTK GPS is used to take point measurements every 3 meters and at locations where the beach slope or surface substrate changes. Beach profiles will be collected 3 times annually after a UAV flight and additional data collection will be conducted after significant climatic events, heavy precipitation and/or wind storms which may significantly alter the beach and estuary configuration. Profile data will be QA/QC and used to produce a DTM utilizing ArcGIS software.

The final profile data will be compared to the UAV imagery derived DSM to help determine the accuracy and precision of the DSM. Comparisons of profile elevations will be conducted to determine profile elevation changes over time. The series of derived DTMs will be analyzed in ArcGIS to evaluate beach elevation and morphological changes over time and to assess volumetric changes in substrate over time utilizing methods outlined in Miller 2011.

Tracking of RFID PIT Tagged Sediment - RFID PIT Tagged sediment has been used to track travel times and distance for different sized sediment classes to determine sediment transport rates and direction of travel, Miller 2011, Miller et al. 2011, & Weaver. 2013, which is important to determine the fate of updrift and stream sediment to the restored estuary embayment. For this study we will utilize RFID PIT tagged sediment ranging in size from 3 to 13 cm in diameter and follow procedures outline in Miller 2011 and Weaver 2013. We will deploy sets of clasts of different sizes at different elevations, locations, and times with respect to tides, storms, and creek discharge to evaluate how the combination of coastal and fluvial processes move materials through the system. Maps of sediment transport trajectories will be generated with the surveys of the located clasts and related to transport mechanisms (e.g., tides, waves, winds, stream discharge) and used to test models.

Analysis of the tagged sediment results will be conducted in coordination with WWU staff and will assess transportation rates and direction of movement based on prevailing winds, precipitation/ streamflow, starting location (stream, beach, tidal elevation), and if we are able to deploy a wave meter, mean wave height.

Sediment Transport Tracking - Sediment tracking will make use of several approaches to quantify rates and processes driving sediment transport, characterize habitat change, and gather important validation data for modeling sediment transport across estuaries, inlets, and beaches. The sediment tracking component of this grant includes collection of:

* Aerial imagery and generation of digital surface models (DSM) via UAV for tracking changes in beach elevations, surface sediment class sizes, and changes in the beach and estuary configuration.
* Beach and estuary embayment RTK GPS profiles to generate and georeference digital terrain models (DTM) and track changes in beach profiles, volume changes, and to classify substrates in aerial imagery s and UAV derived DSMs.
* Tracking of RFID PIT tagged sediment to determine transport dynamics and rate of transport of varying sized clasts across the study area.
* Sediment mapping and classification will be conducted utilizing a combination of substrate type recorded during RTK GPS beach profile surveys as well as supervised classification and machine learning approaches utilizing remote sensed aerial imagery from UAS surveys and time-lapse imagery from fixed cameras.

Biological Data Collection and Analysis - Biological data collection started in February 2021 with fish data collection and will expand to include the collection of plankton samples, invertebrates from fallout traps, juvenile salmon stomach content, and DNA samples of all juvenile chinook caught. All data collection is and will be funded by an EPA NEP grant as match. However, we do not have sufficient funds to process these samples and have added into the application the option of funding the processing and laboratory analysis of the samples. Processing would entail:

* Plankton - processing of approximately 20 plankton samples collected over two years to identify plankton assemblages and proportion inside the estuary and the adjacent shoreline to determine prey field for juvenile salmon.
* Terrestrial Invertebrates - Processing of approximately 60 invertebrate samples from fallout trap to determine the terrestrial invertebrate prey field available to juvenile salmon within the estuary.
* Juvenile Salmon Stomach Content - processing of up to 40 stomach content samples to determine if juvenile salmon are consuming prey from the restored site.
* Juvenile Chinook DNA samples - processing up to 50 DNA samples of juvenile chinook to determine river of origin utilizing the restored system to identify which populations benefit from restoration efforts along this portion of the railroad corridor.

Time-lapse Photography (Match) - A solar powered Erdman Video Systems Mako TL time-lapse camera system has been installed in a tree on the bluff overlooking the shoreline project area. The camera is an 18MP DSLR camera in a weatherproof housing with a cellular modem. The picture interval can be changed remotely as needed and the images are automatically uploaded via cellular network to a webpage on the Erdman website where the images can be easily downloaded. Imagery from the time-lapse camera will be used to make qualitative observations of beach morphology changes and time-stamping events that have caused significant changes in the beach and estuary morphology and for use in the USGS CoSMoS model.

Fish Sampling (Match) - Bi-weekly sampling will be conducted February through June with electrofishing sampling being conducted at low tide in the stream channel, and beach seining at high tie in the estuary and outside nearshore areas.

Invertebrate sampling (Match) - a neuston plankton net will be used to sample plankton during beach seining sampling. Samples will be preserved in buffered formalin in labeled vials.  Fall-out traps will be used to collect terrestrial invertebrates and will be conducted monthly March through June. Samples will be preserved in ethanol in labeled vials.

Juvenile Salmon Stomach Content (Match) - lavage samples will be collected from juvenile salmon during fish sampling efforts and preserved in buffered formalin in labeled vials.

Juvenile Chinook DNA (Match) - Caudal clips will be collected for all juvenile chinook encountered during fish sampling and preserved in ethanol in labeled vials.

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| **Sub-Task** | **Summary** | **Target Start Date** | **Target End Date** |
| 4A | *Beach & Embayment Transects* | 10/19/2020 | 8/31/2025 |
| 4B | *RFID PIT Tagged gravel tracking* | 3/31/2024 | 8/31/2025 |
| 4C | *Aerial imagery acquisition (UAV flights)* | 10/15/2020 | 8/31/2025 |
| 4D | *Sediment mapping and classification* | 10/19/2020 | 8/31/2025 |
| 4E | *Biological Sample Analysis* | 9/1/2024 | 8/31/2025 |
| 4F | *(MATCH) Water quality data logger installation and maintenance* | 2/16/2023 | 11/30/2025 |
| 4G | (MATCH) Time-lapse camera installation and maintenance | 11/20/2022 | 11/30/2025 |
| 4H | (MATCH) Fish sampling | 3/2/2022 | 6/30/2025 |
| 4I | (MATCH) Invertebrate Sampling | 2/1/2024 | 6/30/2025 |
| 4J | (MATCH) Snohomish County Data Collection and Analysis | 2/1/2023 | 8/31/2025 |

*Deliverables:*

**(4.1)** **Data collection log** – Maintain a log which summarizes each data collection event over the course of the learning project and upload a PDF print of that log to PRISM at the completion of each sub-task. Each log entry will include a description of the activities completed, and dates. Data associated with each log entry will be available upon request.

**Target date** – 8/31/2025

**TASK 5 – Interim Results Analysis**

Task 5 Description

Grantee will complete a preliminary analysis of data and results in a draft report that follows the guidance provided in *Attachment B*. The report will include:

* A synopsis of the period of data collection to that point.
* Tabular summary of relevant parameters.
* Any statistical analysis or figures
* A brief discussion of any findings and anomalies.

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| **Sub-Task** | **Summary** | **Target Completion Date** |
| 5A |  | MMDDYY |
| 5B |  |  |
| 5C |  |  |

*Deliverable*:

**(5.1)**  **Interim Results Analysis** – Upload a PDF file containing an interim report of results to PRISM that follows the guidance provided in Attachment B. Update the wiki project page (see deliverable 3.2) to include text describing project progress and either a link to the uploaded file, or text describing the content of the file.

**Target date** – 7/15/2025

**TASK 6 - Final Project Report**

**Task 6 Description**

We will deliver a short summary report in addition to the draft and final learning project report. The short summary report will retail restoration recommendations and guidance for the restoration community. For the final report will follow the guidance provided in *Attachment B,* that will address the subjects identified in the final Learning Plan and will also include the following elements:

* A preferred bibliographic citation for the final report.
* An appendix providing a discussion of lessons learned and a bibliographic citation.
* An appendix describing the final data.
* An appendix describing the image archive provided.

Specific deliverables associated with the final report include:

1. The final report that describes data collection methods, QA/QC results, analysis methods and results, results discussion, and recommendations for design considerations for restoration of an estuary embayment and stream mouth along a sediment starved shoreline. The report will include descriptive statistics of the findings that is geared towards answering the geomorphic and ecological hypothesis in the proposal.
2. A summary of all tabular ecological and geomorphic data collected will be provided in a digital format. If desired, all QA/QC’d data collected as part of the project will be provided in a spreadsheet or database format. Summary statistics for fish sampling and invertebrate data will include, catch per unit effort (CPUE), relative abundances, and assemblage data.
3. All aerial imagery and products derived from it will be provided along with the accompanied metadata.
4. Stream channel, embayment, and shoreline cross-section and profile survey data will be plotted to show the changes at each transect over time and included in the final report and on the wiki page.
5. Post-restoration substrate classification maps and change analysis GIS data layers will be provided. These maps and data layers will document changes in the surface substrate types and distribution over a two-year period providing insight into what sized sediment is being transported to different areas across the site.
6. Time lapse photography and derived metrics of shoreline changes overtime, post-restoration will be provided. This data will help document when significant transport of sediment occurs and allow us to correlate it with site conditions and processes e.g. tidal elevation, waves, stream flooding.
7. Map and GIS layer showing movement of tagged gravel over time and associated metrics e.g. gravel size, distance traveled over time or during episodic event.
8. Continuous water quality data from data loggers. Summary plots of embayment water levels, salinity, and temperature will be generated and incorporated into the final report. QA/QC’d data will also be made available.

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| **Sub-Task** | **Summary** | **Target CompletionDate** |
| 6A | Convene Technical Advisory Group Meeting to meet quarterly | 2/1/2024 |
| 6B | Data analysis | 7/31/2025 |
| 6C | Data analysis write up | 8/31/2025 |

*Deliverables:*

**(6.1)** **Draft Project Report** – Provide a draft report to ESRP staff, a minimum of 4 weeks in advance of the anticipated final report submittal to allow adequate time for review and revisions.

**Target date**- 9/1/2025

**(6.2)** **Final Project Report**  - Attach the final report and written response to comments to PRISM.

**Target date**- 10/15/2025 *[Note: Final report must be submitted prior to advertising upcoming webinar (Deliverable 7.1)]*

**(6.3) Summary Report** – Draft a short summary restoration recommendations and guidance report for small coastal streams along the waterfront railroad corridor. Attach to PRISM and wiki.

**Target date** – 10/15/2025

**TASK 7 - Final Project Presentation**

**Task 7 Description**

Grantee will provide a professional presentation of results via an ESRP-hosted seminar or webinar, providing sufficient time (typ. two weeks advance) for the ESRP team to invite guests. The length of the presentation will be 45 minutes with 15 minutes for questions (1 hr total) unless otherwise agreed upon. The final project presentation will occur after delivery of a final project report.

In addition, the study findings will be communicated via presentations at technical conferences, and to restoration planning groups that are interested. Potential audience groups include:  Lead Entities, Snohomish MRC, Snohomish Technical group, and PSEMP Nearshore Working Group.

*Deliverables*:

**(7.1)** **Presentation Title, planned webinar date and venue (if applicable) of the presentation,** delivered by e-mail to ESRP Science Manager at least two weeks prior to the presentation and after the Final Project Report (Deliverable 6.2) is complete.

**Target date** – 10/15/2025

**(7.2)** **Presentation** - Delivery of the presentation. WDFW may record the presentation for use at its discretion.

**Target date** – 11/20/2025

**(7.3)** **PowerPoint Slides** - A copy of the PowerPoint presentation used in the final presentation, uploaded to PRISM and to <https://salishsearestoration.org> as a presentation file, linked to the wiki project page.

**Target date** – 11/30/2025



**Summary of Deliverables**

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| --- | --- | --- | --- |
| **#** | **Deliverable** | **Target Completion Date** | **Notes** |
| 1.1 | PRISM Progress Reports (**2/yr)** | 4/1/2024  10/1/2024  4/1/2025 |  |
| 1.2 | PRISM Final Report | 10/31/2025 |  |
| 2.1 | Draft Learning Plan | 12/31/2023 |  |
| 2.2 | Final Learning Plan | 1/31/2024 |  |
| 3.1 | Wiki page initial content | 1/31/2024 |  |
| 3.2 | Wiki page interim update | 7/15/2025 |  |
| 3.3 | Final wiki content and final report uploaded to Wiki | 10/15/2025 |  |
| 3.4 | Final presentation uploaded to wiki | 11/30/2025 |  |
| 4.1 | Data collection log | 8/31/2025 |  |
| 5.1 | Interim Data Summary | 7/15/2025 |  |
| 6.1 | Draft Project Report | 9/1/2025 |  |
| 6.2 | Final Project Report | 10/15/2025 |  |
| 6.3 | Restoration Recommendation and Guidance Summary Report | 10/15/2025 |  |
| 7.1 | Presentation Announcement | 10/15/2025 |  |
| 7.2 | Presentation | 11/20/2025 |  |
| 7.3 | PowerPoint uploaded to PRISM | 11/30/2025 |  |
|  | Agreement End Date | 11/30/2025 | All expenditures must be prior to this date. |

**Attachment B: GUIDANCE FOR COMPLETING PROJECT PLAN, INTERIM RESULTS AND FINAL REPORT**

**TASK 2 – Learning Project Plan**

**The grantee will develop a project plan, minimally including:**

* Clearly defined project goals and objectives.
* Conceptual basis and rationale for the project approach
* Sampling plan for data collection including reference sites (if applicable)
* Planned data analyses including hypotheses (if applicable)
* A description of the products for this project and anticipated delivery schedule
* A description of the staff expertise required to complete the project and how that expertise will be secured
* This may be organized into the following sections: **Introduction**, **Methods**, **Timeline**

**If this is a project evaluating the effects of restoration, this learning plan should include the following additional components**

* A clear description of the restoration actions and when they occurred
* Hypotheses to be tested and parameters to be compared through quantitative monitoring
* Identification of control or reference sites (if applicable).
* Descriptions of temporal and spatial patterns that may affect the accurate and precise measurement or estimation of parameters.
* A clear sampling plan that includes frequency, duration, intensity and the planned methods of data analysis.
* A scope and schedule describing how qualitative or quantitative observations will trigger management actions or reporting (if applicable).

**TASK 5 – Interim Results Analysis**

The Grantee will complete a preliminary analysis of data, resulting in a draft report of results. That report of results should include:

* A synopsis of the period of data collection
* Tabular summary of relevant parameters.
* Any statistical comparisons, including stated assumptions, consistent with the project goals and objectives (if useful and meaningful at the time of analysis).
* Figures providing useful visual representation of those comparisons.
* A brief discussion of any findings and anomalies.

This work is intended to be an unformatted or lightly formatted product in preparation for a final project report, perhaps delivered as a simple memo, that provides updates on ongoing observations without creating a substantive additional effort. These interim results are not anticipated to occur more than once a year (at most) for any one subject.

**TASK 6 - Final Project Report**

The Grantee will deliver a draft and final learning project report consistent with specifications found in the Learning Plan, the submitted budget, and previous tasks. That report will provide sufficient information such that a scientifically trained reader could replicate the procedures and analyses. The report will be formatted as a scientific paper (Introduction, Methods, Results, Discussion) unless otherwise agreed upon. The report will address the subjects identified in the final Learning Plan and also include the following elements:

* A synthesis or executive summary of the project and findings, paraphrasing critical sections of the report, while using language and terms that are easy to understand for broad audiences. The synthesis will include (for example as a bulleted list) 1. Implications for future restoration and 2. Key uncertainties.
* A preferred bibliographic citation for the final report.
* An appendix describing the final data as described in Deliverable (6.3).
* An appendix describing the image archive provided as Deliverable (6.4).