

**Nooksack Indian Tribe  
NPLCC Final Progress Reporting  
Agreement F14AC00555  
March 28, 2016**

**1. ADMINISTRATIVE INFORMATION:**

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P.O. Box 157  
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**Project Title:** Nooksack River Climate Change Vulnerability Assessment,  
Restoration Planning, and Adaptation Plan

**Agreement Number:** F14AC00555

**Date:** March 28, 2016

**Project Duration:** August 15, 2014 through December 31, 2015

**2. PUBLIC SUMMARY:**

Climate change has altered and will continue to alter the hydrologic systems, Pacific salmon habitat, and survival of salmon in the Nooksack River watershed. Past and future climate change in combination with impacts from forest practices and land use in the watershed will continue to degrade fish habitat and reduce salmon stocks in the river. Tribal groups are dependent on Pacific salmon for cultural, subsistence, and commercial uses, and continued climate change will threaten the ability of tribal members to harvest salmon. Tribes are place-based and cannot move to where salmon will survive in the face of climate change. Actions must be implemented that facilitate salmon survival and recovery with legacy impacts and the additional impacts of continued climate change. The purpose of the Tribe's overall climate change project is to evaluate the effect of climate change on glacier ablation and river flow regimes, temperature, evaluate impacts on fish, conduct a vulnerability assessment, plan salmon habitat restoration, and prepare an adaptation plan for salmon habitat and salmon recovery. Funding from this NPLCC grant was applied to the climate change impacts and vulnerability assessment, and adaptation plan preparation tasks for the South Fork Nooksack River as a component of the Tribe's overall climate change project. The overall project costs were leveraged by other funding sources including EPA, BIA, NWIFC, and ATNI grant funding.

### 3. EXECUTIVE SUMMARY:

#### **Overall Climate Change Project Objectives:**

1. Evaluate the effect of climate change on glacier ablation and altered melt contributions to the Nooksack River (**other funding**).
2. Evaluate the effect of climate change on river hydrology (**other funding**).
3. Quantify the effects of climate change and altered river hydrology on physical fish habitat and fish ecology (**other funding**).
4. Assess climate change impacts on fish and fish biology and inform salmon habitat restoration actions aimed at perpetuating all nine salmonid species in the Nooksack River basin in the face of climate change (**partially funded by NPLCC funding**).
5. Conduct a vulnerability assessment that will ultimately reduce sensitivity, reduce exposure, and increase adaptive capacity of salmon to climate change impacts (**partially funded by NPLCC funding**).
6. Prepare an adaptation plan that can be directly integrated into management practices (**partially funded by NPLCC funding**).

**Management Objectives:** The proposed tasks under this grant funding will address Focused Activity 4 of NPLCC Implementation Plan and specifically Action 4.4 as follows:

1. Act on the assessment of impacts of climate change on Nooksack River hydrology (Priority Topic A) developed from associated but independently funded project and recent climate change assessments made by CIG,
2. Conduct an impacts assessment/vulnerability assessment for salmon (Priority Topic D),
3. Evaluate existing salmon habitat restoration plans and prioritize those plans and tools based on robustness in the face of climate change (Priority Topic D).
4. Work with decision-makers to understand how this information can be used and how scientists can deliver the information so it is relevant (Guiding Principles and Action 4.4 Objective),
5. Assist one or more partner entities with incorporating climate change information into habitat conservation and restoration planning (Guiding Principles and Action 4.4 Objective),
6. Assist decision-makers and managers with incorporating climate information into their planning efforts and implementing adaptation actions (Guiding Principle and Action 4.4 Objective), and
7. Inform managers of other organizations and jurisdictions, as well as other river basins in the NPLCC geographic areas on the process of conducting climate change vulnerability assessment and adaptation planning focused on Pacific salmon and salmon restoration planning (Guiding Principles and Action 4.4 Objective).

**How goals and objectives were met:** As indicated, work towards meeting the project objectives have been funded by a variety grants from EPA, BIA, ATNI, and NWIFC. Work partially funded by

this grant included 1) assess climate change impacts on fish and fish biology and inform salmon habitat restoration actions aimed at perpetuating all nine salmonid species in the South Fork Nooksack River (SFNR) basin in the face of climate change, 2) conduct a vulnerability assessment that will ultimately reduce sensitivity, reduce exposure, and increase adaptive capacity of salmon to climate change impacts, and 3) prepare an adaptation plan that can be directly integrated into management practices. These goals were components of the Tribe's overall climate change project. Work specifically funded by the NPLCC funding was directed at leading the EPA-ORD climate change pilot research project qualitative assessment and public outreach at several meetings, conferences, and workshops including: the 2014 PNW Climate Science Conference (Seattle), Whatcom County Public Utility District #1 (Bellingham), Tribal Climate Change Conference, EPA Climate Change and Stream Temperature Impacts (Portland), ITEP Tribal Climate Change webinar, Whatcom Irrigators workshop, NWIFC Habitat Conference (Lummi Nation), 2015 National Adaptation Planning Conference (St. Louis, MO), Qualitative Assessment webinar (EPA), 2015 Salmon Recovery Conference, 2015 PNW Climate Science Conference, and WRIA 1 Watershed Management staff team. The climate change impacts, vulnerability assessment, and adaptation planning technical work was conducted based on the Tribe's lead in preparing the *Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River*, WA, Draft Final, September 2015 (EPA-ORD, Nooksack Indian Tribe, and Tetra Tech, Inc. 2016). As such, the work plan components explicitly addressed by this funding agreement were met by the events and document itemized above.

**Problems and/or delays:** Early in the execution of the work covered by this funding agreement, the requirement of a Data Management Plan was discussed. However, no data was collected while executing these work plan components and as such, a plan was not deemed necessary. All of the work specified in the funding agreement was accomplished by December 31, 2015.

**Achievements:** The Tribe has initiated a novel and comprehensive climate change project that involves assessing existing legacy impacts; glacier ablation studies; river basin hydrologic modeling for flow, temperature, and sediment; climate changes impacts assessments; vulnerability assessment, and adaptation planning for salmon habitat and salmon recovery. We are in various stages of accomplishing the goals and objectives of our overall project listed above. However, we have completed several reports on our work previously submitted to the grantor in early January 2016. Of greatest note is our technical lead on EPA-ORD Climate Change Pilot Research Project that was completed in support of the temperature TMDL be prepared for the South Fork Nooksack River as cited above. Finally, we have presented at least 12 meetings, conferences, and workshops over the course of our grant agreement term.

**Lessons learned and accomplishments:** We have initiated and are partially through accomplishing goals and objectives of the Tribe's comprehensive and novel climate change project. There are many "moving parts", technical tasks, contractors, and collaborators, to our project and coordinating all this work has created administrative strain and stress. However, we

continue to succeed. Our major accomplishment is the technical lead we provided on the EPA-ORD Climate Change Pilot Research Project that was completed in support of the temperature TMDL prepared for the South Fork Nooksack River as cited above.

**Contributions:** The primary contribution that was funded by this grant agreement was the technical lead and co-authorship on the EPA-ORD Climate Change Pilot Research Project that was completed in support of the temperature TMDL be prepared for the South Fork Nooksack River as cited above.

#### **4. PURPOSE AND OBJECTIVES:**

The work conducted and funded by this NPLCC grant involves the vulnerability assessment, restoration planning, and adaptation plan for salmon and salmon habitat in the face of climate change. These project tasks are part of a larger climate change project being conducted by the Nooksack Indian Tribe that includes: 1) evaluation of glacier ablation and alteration of melt contribution to the Nooksack River, 2) assessment of changes to the hydrologic regime of the Nooksack River including flow, sediment, and temperature, 3) calculation of altered instream flows and physical fish habitat, 4) climate change impacts and vulnerability assessment, 5) fish habitat restoration planning, and 6) preparation of an adaptation plan. This NPLCC and ATNI funding was directed at tasks 4 through 6 above. Funding for tasks 1 through 3 was provided by EPA, BIA, and NWIFC.

Recent climate change trends and future climate change scenarios suggest that streamflow dynamics in regard to timing, magnitude, and temperature will be adversely affected as a result of continued climate change. Climate change will affect precipitation timing, amounts, and intensities; snow accumulation and melt dynamics; alter glacier melt contributions to summer low flows and temperature modulation; adversely impact fish habitat and survival. These likely impacts will exacerbate legacy impacts caused by land management. Of particular interest to the Nooksack Indian Tribe and Lummi Nation is how changes in flow will effect survival of salmonids in the Nooksack River that both groups rely on for subsistence, cultural, ceremonial, and commercial uses. Thus, there is a need to address the impacts of climate change on the hydrology of the Nooksack River basin and associated impacts on fish habitat (vulnerability assessment), in order to inform natural resource managers on the habitat-restoring needs of salmon in the face of climate change. The adaptation plan supports restoration planning by building resistance, enhancing resilience, and facilitating transitions of salmon in the face of climate change. The salmon vulnerability assessment, adaptation plan, and fish habitat restoration planning project comprise a pilot that can be applied in similar watersheds with similar limiting factors by other Tribes such as Lummi Nation, Sauk-Suiattle, Upper Skagit, Snoqualmie, Nisqually, Quinault, Hoh, and Lower Elwha Tribes. We have actively engaged the Stillaguamish Indian Tribe by organizing and facilitating four inter-Tribal climate change information exchange meetings in order to inform them on the SFNR qualitative assessment and for them to inform us on their novel approach to floodplain management.

The Nooksack River watershed supports nine species of salmonids including populations of Chinook (spring and fall, threatened), riverine sockeye, chum, pink (even- and odd-year), and coho salmon, steelhead/rainbow (threatened), cutthroat, and bull trout (threatened), and Dolly Varden (WRIA1 SRB 2005). The abundances of two spring Chinook populations are critically low, on the order of 100-300 natural-origin spawners for each population. The populations comprise two of 22 independent populations in the Puget Sound Chinook ESU's; both populations are considered essential for recovery of the ESU (WRIA1 SRB 2005; WDFW 2002). The work funded by this grant supports the recovery of these species in the face of climate change.

## 5. METHODS, ORGANIZATION AND APPROACH:

**Climate Change Impacts Assessment** – An assessment of climate change impacts was developed based on other work being accomplished in the Tribe's overall climate change project as well as a contemporary literature review, such as Climate Impacts Group (CIG, University of Washington) recent literature updates. Changes to the physical environment as a result of climate was evaluated from the results of the glacier ablation, watershed hydrology, and physical habitat investigations work plan components covered by existing funding as well as the EPA-contracted work accomplished by Tetra Tech, Inc. on the climate change pilot research project (Tetra Tech, Inc. 2014, *Quantitative Assessment of Temperature Sensitivity of the South Fork Nooksack River under Future Climates using QUAL2Kw*). This information includes: glacier ablation, altered river hydrology, changed sediment dynamics, and altered physical habitat associated with various climate change scenarios. We evaluated conditions of natural resources of value to the Tribe through consultation with George Swanaset Jr. who is a tribal member and who directs the Tribe's cultural resources department. Further, we accessed the TEK knowledge base contained by the Northwest Indian Fish Commission, an organization that represents the natural resource interests and concerns of Pacific Northwest Tribes. Also, we applied and/or implemented the draft document "Guidelines for Considering Traditional Knowledges in Climate Change Initiatives" recently prepared by the Advisory Committee on Climate Change and Natural Resource Science. In this sense, we used TEK to determine pre-European fish abundance and harvest levels and how such have declined since. This knowledge helped the Tribe to further assess the likely impacts of climate change on fish abundance and harvest levels.

**Vulnerability Assessment** - A vulnerability assessment of salmon in the South Fork Nooksack River (SFNR) watershed was accomplished by integrating TEK (see above) and by applying the results of a separate on-going project tasks that evaluated the impacts of climate change on glacier ablation and altered hydrology, including altered instream flows. The primary methods of assessing fish and fish habitat climate change vulnerability was contained in Beechie et al. (2102) *Restoring salmon habitat for a changing climate*. Applicable work towards the vulnerability assessment was accomplished through a cooperative pilot research project being accomplished by the Nooksack Indian Tribe, EPA Research and Development (Klein 2012, 2013), and Tetra Tech (2013). The methodology for the vulnerability assessment is detailed in "EPA

Region 10 Climate Change and TMDL Pilot - Proposed Methodology for Evaluating Climate Change on Endangered Species Act Recovery Actions” (Tetra Tech 2013). The Nooksack Indian Tribe substantially contributed to this Tetra Tech document. This pilot research project resulted from Nooksack Indian Tribe comments provided on the South Fork Temperature TMDL being conducted by EPA and DOE. The Tribe’s comments focused on the need to include climate change, upland watershed processes, and legacy impacts in the traditional TMDL.

The vulnerability assessment was based on the evaluation of changed physical habitat (streamflow, temperature, stream morphology) due to climate change following Tetra Tech (2013) and Beechie et al. (2012). Methods described by these sources include:

1. Identify projected climate change risks
2. Evaluate impacts of climate change per salmonid species
3. Evaluate impacts of climate change per life history stage
4. Evaluate climate change impacts per scenario
5. Evaluate climate change impacts per restoration action
6. Inventory existing stressors and legacy impacts, past restoration actions, and current projects
7. Evaluate effectiveness of restoration actions
8. Evaluate political, social, and practicable feasibility

The Tribe provided the technical expertise to conduct the vulnerability assessment steps identified above. The vulnerability assessment focused on an evaluation of changes in the runoff hydrograph and temperature regimes of the river in the face of climate change and subsequent impacts to salmon habitat, salmon ecology and survival, and the Tribe’s reliance on salmon for cultural, ceremonial, subsistence, and commercial purposes.

**Fish Habitat Restoration Planning** – The salmon recovery plan for the Nooksack River watershed was evaluated in regard to the effectiveness of restoration actions in the face of climate change following Beechie et al. (2012), Klein (2012, 2013), Tetra Tech (2013). Recommendations for modifications of the plan taking climate change into consideration were made.

**Adaptation Plan** - Upon completion of the vulnerability assessment, the adaptation plan was developed for salmon in the SFNR watershed that focused on developing fish habitat restoration plans that are robust in the face of climate change. The WRIA 1 Salmon Recovery Plan (WRIA 1 2005) was reviewed and strategies identified that could be modified to be more effective in the face of climate change. Adaptation planning applied the methods of Beechie et al. (2012), Klein (2012, 2013), Tetra Tech (2013), and Glick et al. (2011). As applied in this methodology, Beechie et al. (2012) identify four over-arching questions. The primary question is “Do climate change predictions alter restoration plans?” To answer that question, a subset of guiding questions needs to be considered:

1. What habitat restoration actions are necessary for recovery of local salmon populations?
2. Do future stream flow and temperature scenarios alter the types of habitat restoration actions that are necessary for recovery?
3. Does the restoration plan or action ameliorate a predicted climate change effect on stream flow or temperature?
4. Will the restoration plan or action increase habitat diversity and salmon population resilience?

In addition, the adaptation planning process involved evaluation of the effectiveness of the existing salmon recovery plan to address climate related stressors to fish such as altered sediment dynamics, stream temperatures, drought, and wildfire. Such an evaluation was based on contemporary literature sources such as that recently developed by the USDA Forest Service (e.g., Dave Peterson).

The plan as contained in the **Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River**, presented the results of the vulnerability assessment; describe results of reviewing and developing restoration strategies and plans, monitoring and adaptive management procedures, and how to reduce the impact of climate change on the Tribe's ability to harvest salmon in the Nooksack River. The vulnerability assessment and adaptation plan were developed as a pilot for other Tribal groups, public natural resources management agencies and managers to apply in similar watersheds with similar environmental stressors that affect fish, such as Lummi Nation, Sauk-Suiattle, Upper Skagit, Snoqualmie, Nisqually, Quinault, Hoh, and Lower Elwha Tribes. At least 12 presentations were made to various stakeholder groups, meetings, conferences, and workshops symposia on methods and the results of this project. We have actively engaged the Stillaguamish Indian Tribe by organizing and facilitating four inter-Tribal climate change information exchange meetings in order to inform them on the SFNR qualitative assessment and for them to inform us on their novel approach to floodplain management.

**Geographic Extent** – The vulnerability assessment and adaptation plan was prepared with focus on the SFNR. However, as indicated, this pilot project can be applied to all watersheds that drain into Puget Sound.

**Expected Outcomes** – The portion of the overall Nooksack Indian Tribe's climate change project funded by this NPLCC grant will include preparation of 1) impacts assessment, 2) vulnerability assessment, 3) adaptation plan, 4) updated salmon habitat restoration that directly takes climate change into consideration, and 5) project information dissemination to other tribes, government agencies, and other stake holder and public interest groups in the form of articles, conference presentations, and workshops. Our work has been captured in the **Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River** that the Tribe took the technical lead on.

**Metrics to Evaluate Vulnerability** - There are several metrics that may be applied to the vulnerability assessment and include:

- Projected decrease in proportion of glacier mass and aerial extent,
- Altered river hydrograph in regard to flow timing, magnitude, and durations (i.e., shape of the hydrograph) as compared to the existing condition,
- Altered physical habitat available to fish as a result of the altered hydrology of the rivers by comparing physical habitat available under current conditions with that under various climate change scenarios, and
- Shifts in the abundance of and harvest levels of fish of importance to the tribe under various climate change scenarios,

By applying these metrics to altered conditions under various climate change scenarios and comparing those to the current conditions, and integrating with Tribal expectations of fish abundance and harvest levels provided the information on the degree of vulnerability of aquatic resources to climate change.

## **6. PROJECT RESULTS:**

As a result of this NPLCC funding, we were able to assess climate change impacts on the hydrology of the SFNR, conduct a vulnerability assessment, and prepare an adaptation plan for salmon recovery and restoration planning taking climate change into consideration. This work involved an effective collaborative effort between the Tribe, EPA-ORD, EPA Region 10, Ecology, and Tetra Tech, Inc. As a result of this work, we provided the technical work for and were senior authors on the EPA-ORD **Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River** project report in the final stages of EPA publishing. Further, as indicated, we have presented at least 12 meetings, conferences, and workshops over the course of our grant agreement term. We have actively engaged the Stillaguamish Indian Tribe by organizing and facilitating four inter-Tribal climate change information exchange meetings in order to inform them on the SFNR qualitative assessment and for them to inform us on their novel approach to floodplain management.

## **7. FINDINGS AND CONCLUSIONS:**

Work accomplished under this grant involved providing the technical expertise and the analysis of the Tribe in preparing the **Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River**. This work involved assessing climate change impacts to the physical environment (Section 5.1), evaluating climate change impacts on each salmonid species (Section 5.2), evaluation of existing salmon recovery actions per the Nooksack River salmon recovery plan (Section 5.3), and making specific recommendations on the tools and methods to be applied by river reach and watershed in

regard to salmon recovery, habitat restoration planning, and water quality improvement in the face of climate change (Sections 5.3 and 5.4). Conclusions were presented in Section 5.4.

#### 8. LESSONS LEARNED AND RECOMMENDATIONS:

We have initiated and are partially through accomplishing goals and objectives of a comprehensive and novel climate change project. There are many “moving parts” to our project and coordinating all this work has created administrative strain and stress. However, we continue to succeed. Our major accomplishment is the technical lead we provided on the EPA-ORD Climate Change Pilot Research Project that was completed in support of the temperature TMDL prepared for the South Fork Nooksack River as cited above. This project was planned and executed as a pilot that can be applied to all other tributary watersheds to Puget Sound. We have provided assistance to the Stillaguamish Tribe on this pilot as the SFNR and the Stillaguamish River have very similar landscape characteristics and water quality impairments.

#### 9. MANAGEMENT APPLICATIONS AND PRODUCTS:

Our work under this funding and resulting ***Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River*** has direct application to other tributary watersheds to Puget Sound. The EPA-ORD pilot research project has direct management applications to assessing climate change, evaluating vulnerability of fish and habitat restoration to climate change, and an adaptation plan for fish recovery and restoration planning that can be applied to all watersheds tributary to Puget Sound.

#### 10. PUBLICATIONS AND OUTREACH:

Our work under this funding resulted in the ***Qualitative Assessment: Evaluating the Impacts of Climate Change on Endangered Species Act Recovery Actions for the South Fork Nooksack River***. Further, we initiated an effective public outreach program by presenting at several meetings, conferences, and workshops including: the 2014 PNW Climate Science Conference (Seattle), Whatcom County Public Utility District #1 (Bellingham), Tribal Climate Change Conference, EPA Climate Change and Stream Temperature Impacts (Portland), ITEP Tribal Climate Change webinar, Whatcom Irrigators workshop, NWIFC Habitat Conference (Lummi Nation), 2015 National Adaptation Planning Conference (St. Louis, MO), Qualitative Assessment webinar (EPA), 2015 Salmon Recovery Conference, 2015 PNW Climate Science Conference, and WRIA 1 Watershed Management staff team.

**11. SIGNATURE:**

We have successfully executed the approved work plan pursuant to this NPLCC funding. This Final Progress Report presents the documentation of our work under this funding.

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Oliver John Grah  
Water Resources Program Manager  
Nooksack Natural Resources  
Nooksack Indian Tribe

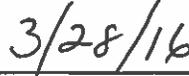
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Oliver John Graham  
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Date