Oregon Department of Transportation

Research Stage 1 Problem Statement

Number 26-41 – "Developing a Practical Framework for Flood Hazard Assessment Under Climate Change"

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Extreme flooding events pose significant risk to transportation assets such as bridges, culverts, and other hydraulic structures. This risk is further exacerbated by changing climate, which has been shown to increase the frequency and intensity of extreme precipitation events. Furthermore, the nonstationary nature of climate change renders existing design and evaluation methods ine;ective, as hazard statistics drawn from past events are no longer reliable in a changing climate. The goal of this research is to develop a practical framework for flood hazard assessment under climate change, particularly in the context of bridge scour risk in rural areas and climate-informed design for culverts and storm drainage systems. The developed framework will align closely with existing analysis protocols at ODOT while incorporating the impacts of climate change and their uncertainties under various future scenarios.

2. What **final product or information** needs to be produced to enable this research to be implemented?

To facilitate practical implementation, the anticipated final products from this research are outlined below.

- The study will provide a comprehensive review of flood intensity measures pertinent to the design and evaluation of transportation assets and hydraulic structures within transportation systems. Examples include inundation depth and flow discharge with di;erent return periods.
- The study will deliver a hydrologic model that can (a) match intensity statistics currently used in design and evaluation, which does not consider climate forcing, and (b) incorporate future climate change e;ects based on di;erent downscaled temperature and precipitation projections.
- Using the hydrologic model, the research will develop a streamlined framework to estimate flood intensity measures for structural design and evaluation, taking into account climate change e;ects and their local impacts in Oregon. This framework will be applied in pilot studies assessing climate risks to a selected set of transportation structures.

To incorporate climate change information, the research will adhere to the general concepts and methodology established in NCHRP Project 15-61. The pilot study will update and expand upon the existing preliminary studies conducted by ODOT, as documented in NCHRP Project 15-61a.

3. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

Name	Title	Email	Phone
Payman Abbaszadeh	Assistant Professor, Portland State University	pabbaszadeh@pdx.edu	503-725-5499
Wesley Nickerman	Senior Bridge Hydraulic Engineer, ODOT	Wesley.A.NICKERMAN@odot.oregon.gov	541-239-7068

Name	Title	Email	Phone
Kira Glover-Cutter	Research Analyst and Coordinator, Geo/Hydro/Environmental Science and Engineering, ODOT	Kira.M.GLOVER-CUTTER@odot.oregon.gov	971-701-0051

4. Decision making lenses

Please complete the following three sections. Your answers to these questions will be applied on a programmatic basis to support agency decisions. Answering yes to the questions below is not required. Resolving a narrowly focused technical research problem may meet agency needs without answering yes to any of the following questions. The ODOT Research Section will seek a balanced portfolio some projects will answer yes to one of the three categories below (e.g. climate, equity, and/ or safety) and other projects in a di;erent category.

We are looking for an overall program balance and no one project is expected to balance all categories. Generally, a research problem statement is expected to be able to answer yes with clear and verifiable information in only one of the three categories below, some projects may be able to answer yes in two or even three categories. Some projects (i.e. needs focused on specific elements of infrastructure design), may have no yes answers but may still be high value research need.

Climate

Oregon recognizes the climate crisis and makes systemic changes to reduce emissions caused by travel. Every mile driven in Oregon is powered by a clean source of fuel. We seek research that supports construction and maintenance operations are carbon neutral and investments in mobility that support travel by low and no emission modes. While every research project may not result in a reduction in emissions, transportation investments overall support emission reductions to achieve state goals. Oregon envisions a transportation system that is resilient in the face of seismic and climate events and impacts to the degradation of the natural environment are reduced. Our vision includes a transportation infrastructure is built in a way that avoids impacts on key habitat and results in better environmental conditions for wildlife and native vegetation. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4f. Will addressing the **transportation issue** identified as a need in Question 1 develop, or validate methods for the estimation, measurement, or monitoring of transportation generated greenhouse gasses (GHG)?

☐Yes ☒No ☐Unsure

4g. If climate or GHG is not the focus of this **transportation issue** identified in this problem statement, will the research apply a GHG analysis to transportation infrastructure, planning, operations, maintenance, or materials?

☐Yes ☒No ☐Unsure

4h. Will the addressing the **transportation issue** include development or testing of construction practices, methods, or materials to establish potential reductions in greenhouse gas emissions?

☐Yes ☒No ☐Unsure

4i. Will the solving the **transportation issue** in question 1 study or support the reduction of vehicle miles traveled and single occupancy vehicle travel or support transition to electric vehicles (or other types of zero emission vehicles) or low-carbon alternative fuels?

☐Yes ☒No ☐Unsure

4j. Will the solving the **transportation issue** in question 1 lead to work that will support, measure, monitor, transportation system resilience in response to expected climate events, e;ects, or natural disasters in general?

☒Yes ☐No ☒Unsure

4k. Will the solving the **transportation issue** in question 1 lead to work that may result in better environmental conditions for wildlife and native vegetation ?

☐Yes ☒No ☐Unsure

4l. If you answered yes to any of the climate questions above or can provide alternative details related to climate, please provide additional information:

- 4j: This research will focus on enhancing resilience to extreme floods, which may become more frequent and intense due to climate change yet contain high uncertainty at the regional or local level. If successful, the research will enable ODOT to explore di;erent scenarios, options, and trade-o;s when planning for the climate resilience of transportation infrastructure.

Equity

Equity can have many dimensions and impacts relating to communities, and transportation. It is important that problem statement proposals clearly explain in what capacities are equity dimensions or impacts being examined within problem statements. It is a goal of the OTP to "Improve access to safe and aJordable transportation for all, recognizing the unmet mobility needs of people who have been systemically excluded and underserved. Create an equitable and transparent engagement and communications decision-making structure that builds public trust". Proposed research may have the intent of studying elements of this goal or apply analysis to specific transportation topics to ensure the resulting research recommendations is consistent with our equity goals. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan and Oregon Transportation Plan.

4a Is the **transportation issue** identified as a need in Question 1 specifically focused on transportation equity?

☐Yes ☒No ☐Unsure

4b If the **transportation issue** is not focused on transportation equity, will the primary topic be assessed for equity benefits or impacts within the research project?

☐Yes ☒No ☐Unsure

4c Is the implementation of potential findings from this research likely to directly involve participation from an identified group that would benefit from an equitable process or outcome?

☐Yes ☒No ☐Unsure

4d Is the intended final product or information expected to support ODOT's equity e;orts (Including but not limited to supporting one of the equity related objectives of the ODOT's Strategic Action Plan or Oregon Transportation Plan) ?

☒Yes ☐No ☐Unsure

4e If you answered yes to any of the equity questions above or can provide alternative details related to equity, please provide additional information:

- 4d: When choosing areas for pilot studies, we plan to focus on transportation structures in rural communities and communities with low accessibility. These communities have been historically most a;ected by reduced mobility and accessibility during past extreme flooding events. Additionally, many of the rural counties east of the Cascade lack accurate hydrologic models for improved design and retrofitting of vulnerable transportation and hydraulic assets. Overall, the research will contribute to climate equity, one of the equity priorities in ODOT's Strategic Action Plan.

Safety

Research outcomes may include interventions and countermeasures to prevent or reduce the frequency of crashes or other causes of transportation-related injury or death; or may include measures to reduce severity of injury (including prevention of death) after a crash or other injurious event. For definitions and details please review the equity vision, goals, and objectives of the ODOT Strategic Action Plan, Oregon Transportation Safety Action Plan and Oregon Transportation Plan.

4m. Will solving the **transportation issue** in question 1 support improving **safety culture** for either transportation workers or the traveling public?

☐Yes ☒No ☐Unsure

4n. Will the solving the **transportation issue** support improving safety through **healthy and livable communities**?

☐Yes ☒No ☐Unsure

4o. Will solving the **transportation issue** support improving safety through using **best available technologies**?

☐Yes ☒No ☐Unsure

4p. Will solving the **transportation issue** support improving safety through **communication and collaboration**?

☐Yes ☒No ☐Unsure

4q. Will the solving the **transportation issue** support improving safety through **investing strategically**?

☐Yes ☒No ☐Unsure

4r. If you answered yes to any of the safety questions above or can provide alternative details related to safety, please provide additional information:

Not applicable

5. Other comments:

The research will be conducted through tasks focused on each of the expected deliverables listed in the answer to Question 2. For the development of hydrologic models, we plan to calibrate model parameters to match the USGS regression equations currently used by ODOT for flood risk assessment west of the Cascade. This approach ensures consistency between the developed model and existing analyses (when climate change e;ects are not fully considered). We will prioritize lumped models such as the Sacramento Soil Moisture Accounting Model (SAC-SMA), but also consider distributed model like the Soil & Water Assessment Tool (SWAT) if needed. The calibrated hydrologic model will enable (a) the use of climate projection data under di;erent future emission scenarios and (b) direct extension to regions west of the Cascade that currently lack accurate projection models.

For the selected pilot regions and structures, downscaled projections using di;erent general circulation models will be analyzed using simulation techniques to provide statistical bounds for the projected variation under distinct future emission scenarios. Both the submitter and the collaborator (Dr. Abbaszadeh) have extensive experience in hydrologic modeling and climate risk assessment, particularly in the context of transportation systems. Relevant past studies by the potential research team are listed as follows for reference:

Yang, D.Y. and Frangopol, D.M., 2019. Physics-based assessment of climate change impact on long-term regional bridge scour risk using hydrologic modeling: Application to Lehigh River watershed. *ASCE Journal of Bridge Engineering*, *24*(11), p.04019099.

Abbaszadeh, P., Gavahi, K., & Moradkhani, H. (2020). Multivariate remotely sensed and in-situ data assimilation for enhancing community WRF-Hydro model forecasting. *Advances in Water Resources*, *145*, 103721. https://doi.org/10.1016/j.advwatres.2020.103721

Abbaszadeh, P., Muñoz, D. F., Moftakhari, H., Jafarzadegan, K., & Moradkhani, H. (2022). Perspective on uncertainty quantification and reduction in compound flood modeling and forecasting. IScience, 25(10), 105201. https://doi.org/10.1016/j.isci.2022.105201

6. Corresponding Submitter's Contact Information:

Name:	David Y. Yang
Title:	Assistant Professor
Affiliation:	Portland State University
Telephone:	503-725-2870
Email:	david.yang@pdx.edu

This form is not a grant application or contract document.