Modeling Quality Assurance Project Plan

For:

Improving Water Quality and Habitat through Riparian Restoration in the Middle-Green Sub-basin

WDOE Grant G1200473

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Prepared for:

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G1200473

Estimation of Mature Revegetation Effective Shade and Associated Stream Temperature Improvements

January 2014

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2.0 Abstract

We propose to model the potential increase in Effective Shade resulting from riparian vegetation plantings along Newaukum Creek and the Green River conducted as part of this grant. We will use the Ecology shade models developed for temperature Total Maximum Daily Load (TMDL) studies of those systems. The potential improvement in shade will also be input to the Qual2kw temperature TMDL models of these systems to estimate the potential downstream temperature benefits associated with these plantings.

3.0 Introduction

Using funds provided by a National Estuary Program (NEP) Watershed Protection and Restoration Grant administered by the Washington Department of Ecology (Ecology), King County is carrying out riparian revegetation along reaches of Soos Creek, Newaukum Creek, and along the Middle Green River near Kanaskat. The revegetation efforts in 2012-2013 will be followed by maintenance and monitoring of planted areas through 2014.

This project is important because both Newaukum Creek and the Middle Green River have extensive sections with little riparian vegetation and, as a result, little to no shade for moderating water temperatures along the watercourses. Temperature Total Maximum Daily Load (TMDL) allocations for the Newaukum Creek and Green River mainstems in the form of target reductions in heat load to the water surface have been developed (Coffin et al. 2011, Lee et al. 2011). These TMDLs specified that reductions in heat load would be achieved through the development and restoration of riparian shade.

A shade and temperature modeling effort is currently underway for Soos Creek, with the expectation that a TMDL will be developed in the form of targeted heat load reductions along the creek that would be achieved through riparian revegetation (Tetra Tech 2012).

Revegetation of the riparian zones of these river and stream reaches can eventually help control excessive summer water temperature. In addition, the targeted sections of all three watercourses contain Endangered Species Act-listed Chinook and steelhead, which will benefit from the accompanying increase in food availability and habitat improvement. This project responds to priorities listed in the WRIA 9 Habitat Plan and the Action Agenda of the South Central Action Area Caucus Group.

Riparian vegetation is an important link between fluvial and terrestrial ecosystems for a number of important processes. The condition of riparian vegetation plays an important role in the control of stream temperature. Riparian vegetation can reduce the amount of incoming solar radiation depending on factors such as time of day, stream aspect, stream width, and height and density of streamside vegetation. Local topography also influences the timing and amount of incoming solar radiation. Solar radiation is the primary source of heat to the stream and plays a central role in the control of stream temperature.

This Modeling Quality Assurance Project Plan (QAPP) describes the proposed application of the shade and Qual2kw models developed as part of the Newaukum and Green River mainstem TMDLs to estimate the potential reduction in heat load and temperature improvements resulting from the revegetation efforts conducted as part of this grant. This Modeling QAPP also describes how estimates of average mature revegetation canopy height and density will be developed for input to the shade model. Estimates are necessary because the revegetation plantings will not have reached a mature state before the end of this study.

3.1 Overall Project Goals and Modeling Objectives

The overall goal of the project is to establish native riparian vegetation that provides shade (i.e., reduces the solar heat load) to the adjacent stream reaches. The specific objective of the modeling work described in this Quality Assurance Project Plan is to quantify the success of the plantings in reducing heat flux to the stream channels through shading when the plantings reach maturity.

Another objective of this project is to quantify (using instream hemispherical photographic analysis) the reduction in heat load that occurs at selected sites during the duration of this grant. The sampling QAPP to address that particular objective is provided in a separate document (King County 2012). The hemi photo series do not feed directly into the modeling effort, but instead are intended to provide additional evidence of the direct effect that shading has on heat flux to the water and informing the timeframe for expecting to see temperature improvements.

4.0 Project Organization and Schedule

The team members directly involved in this project includes Ecology staff who provide grant administration, oversight and technical support to the project and King County staff who manage the project and conduct the technical work. Specific team members and their responsibilities for the modeling component of the study are listed in Table 1. The proposed schedule for performing the planned modeling effort and associated deliverables is outlined in Table 2.

Table 1. Organization of project staff and responsibilities

Staff	Title	Responsibilities
Kim Harper Ecology SEA Program Phone: (425) 649-4451	Project Manager	Review and approval of QAPP
Tom Gries Ecology EAP Phone: (360) 407-6327	NEP Quality Coordinator	Review of QAPP
William Kammin Ecology Phone: (360) 407-6964	QA Officer	Review and approval of QAPP
Sally Abella King County Phone: (206) 296-8382	Project Manager	Help prepare QAPP, co-author draft and final report
Curtis DeGasperi King County Phone: (206) 684-1268	Lead Modeler	Prepare QAPP, model set up and application, co-author draft and final report
Chris Knutson King County Phone: (206) 263-097	Modeling Assistance	Help prepare QAPP, Assist with model set up and application, co-author draft and final report

Table 2. Proposed schedule for completing modeling work and reports.

Activity	Time period	Staff	Description
Draft Modeling QAPP	Oct 2013	Curtis DeGasperi, Sally Abella, Chris Knutson	Preparation and distribution of draft Modeling QAPP for review.
Final Modeling QAPP	Nov 2013	Curtis DeGasperi, Sally Abella, Chris Knutson	Preparation and distribution of final Modeling QAPP
Draft Study Report	October 2014	Curtis DeGasperi, Sally Abella, Chris Knutson	Preparation of draft report documenting project field study data and model application
Final Study Report	December 2014	Curtis DeGasperi, Sally Abella, Chris Knutson	Final report

5.0 Study Area and Model Domain

The study area includes portions of Soos Creek, Newaukum Creek and the Middle Green River and their associated riparian corridors (Figure 1). The reaches defined by red lines in the figure represent those areas in which some revegetation and monitoring will be carried out.

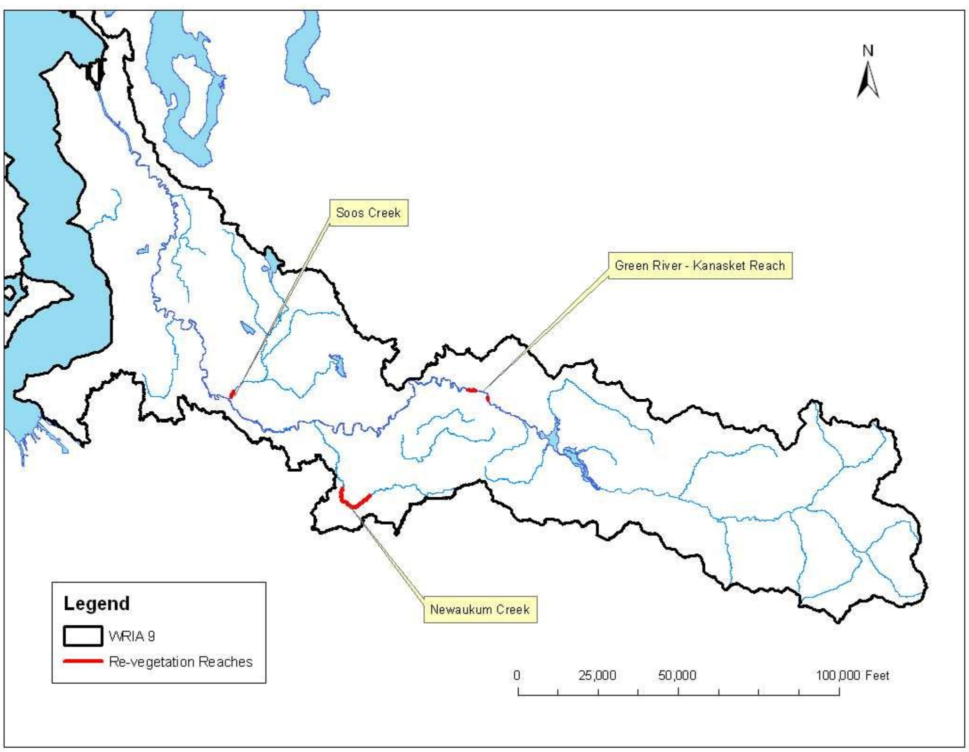

Figure 1. Study area map showing the locations of the proposed revegetation reaches along Soos Creek, Newaukum Creek and the Green River.

The model domain of the Green River extends from Tukwila to the Tacoma Public Utilities intake just below Howard Hanson Dam (Figure 2). The domain of the Newaukum Creek temperature TMDL model extends from the confluence with the Green River to a point on the Newaukum Creek mainstem approximately 18 km upstream of the mouth (Figure 3).

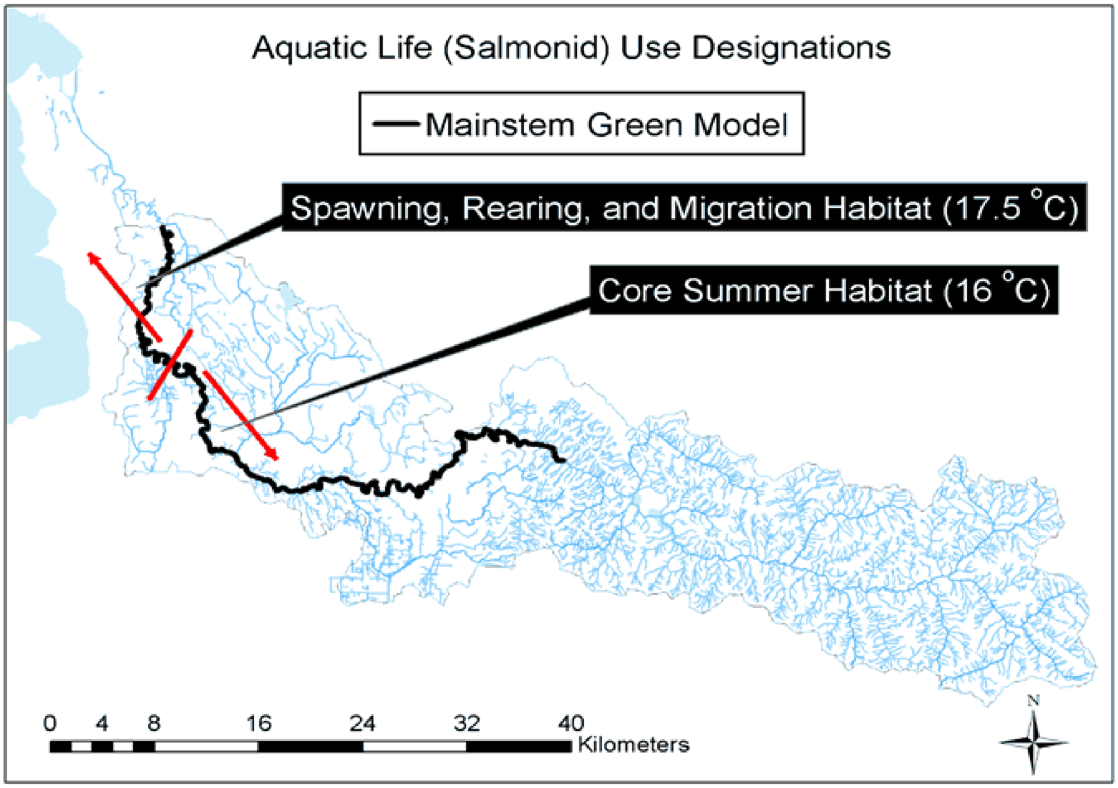

Figure 2. Study area map showing the extent of the Green River mainstem shade and Qual2kw models. *Source: Coffin et al. 2011*

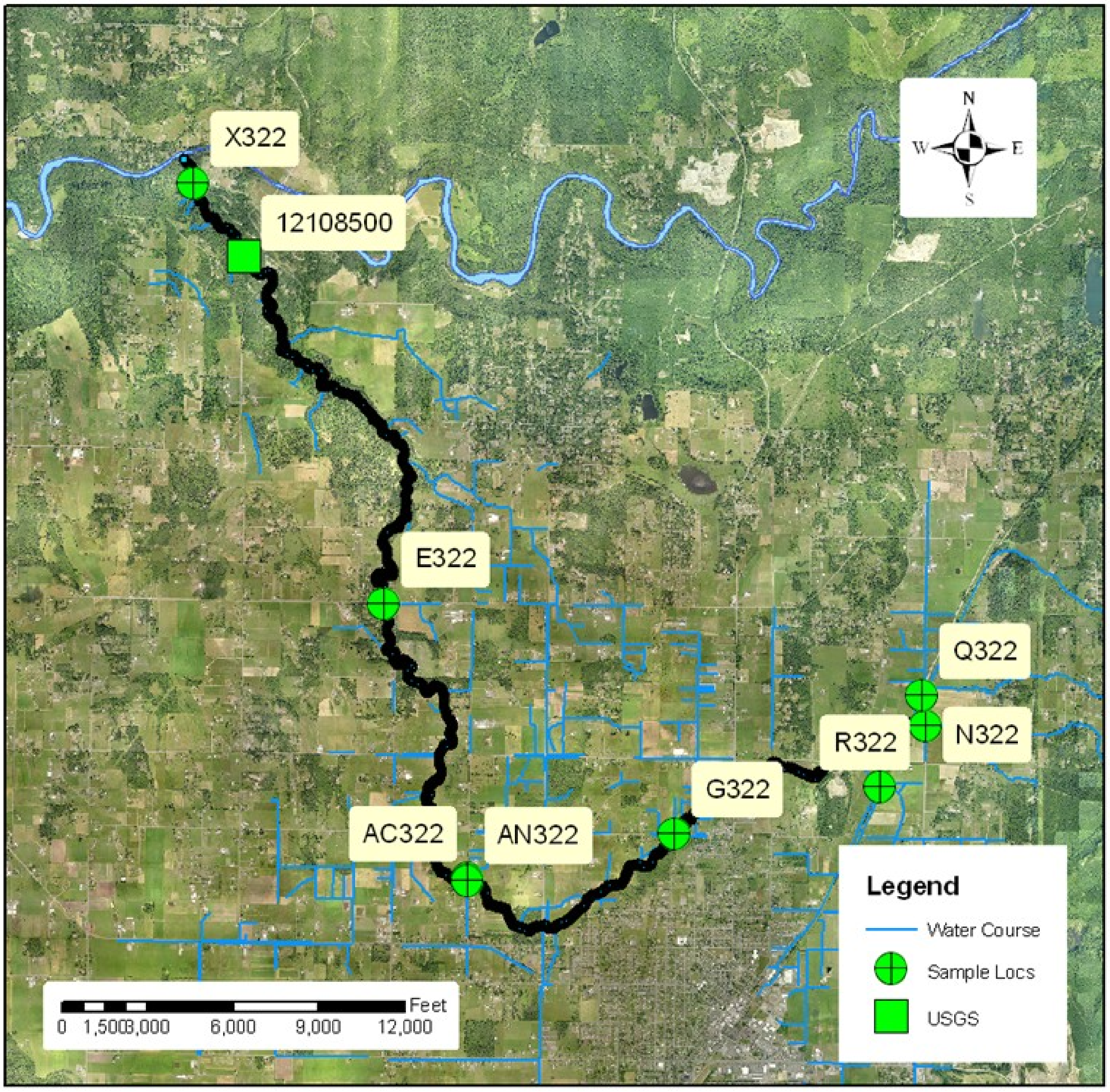

Figure 3. Study area map showing the extent of the Newaukum Creek shade and Qual2kw models. *Source: Lee et al. 2011*

6.0 Model Development

Although the models proposed for use in this study have already been developed, additional data must be developed to use as the input revegetation tree height and canopy density of the grant-funded plantings at maturity. The rationale for using the existing TMDL models and the proposed approach for developing estimates of average mature revegetation canopy height and density are described below.

6.1 Model Selection and Application

Existing TMDL models are the most appropriate models to use in this study because they form the basis of the heat load allocation established for each river or stream and they provide the appropriate benchmark condition for progress in meeting the TMDL heat load allocations. Three sequenced models were used to evaluate the Green River and Newaukum temperature loading capacity and to determine the allocation necessary to meet temperature standards.

The three TMDL models work in sequence. TTools is an ArcGIS model that processes geographically referenced inputs such as river centerline, left and right bank vegetation and topographic elevation data into inputs to the shade model (version 3.1b02). The shade model takes the output from TTools and calculates the effective shade along the river/creek for a user-specified day and year at a relatively fine longitudinal resolution.[1] The shade model output averaged over the temperature model reach or segment length is then input to Qual2kw (in this case the steady-state version 5.1b52).[2] Qual2kw is then calibrated to continuous river/creek temperature data collected during critical summer conditions based on observed weather conditions and measured and estimated flow and temperature inputs. The shade and Qual2kw models are then used to evaluate system potential shade and temperature improvement based on the assumption of complete riparian cover by mature trees.

The current condition shade model for the Green River and Newaukum Creek will be modified to represent the projected mature vegetation height and canopy density of the revegetation plantings. The reduction in heat load between the projected and current condition shade model will be quantified for each planting area and also summed over the entire model domain and compared to the load allocations specified in the relevant temperature TMDL report based on system potential shade.

The current condition TMDL Qual2kw model will then be modified with the projected increase in effective shade from the shade model and the 7-day moving average of the daily maximum temperature profile for the river/creek under current and projected revegetation project shade will be presented graphically and the projected temperature improvements will be summarized in the draft and final study report.

6.2 Data Requirements

In order to conduct this analysis, estimates are needed of the final successful planting extent and the potential average canopy height of the plantings at each revegetation location when the stand becomes mature. Estimates of mature vegetation canopy density will be developed using the average mature planting buffer width and the relationship between buffer width and canopy density shown in Figure 4.

[1] At points along the river/creek centerline every 30 and 50 m for the Newaukum Creek and the Green River TMDL models, respectively.
[2] Qual2kw model reach lengths in the Newaukum Creek and Green River models are 300 and 500 m, respectively.

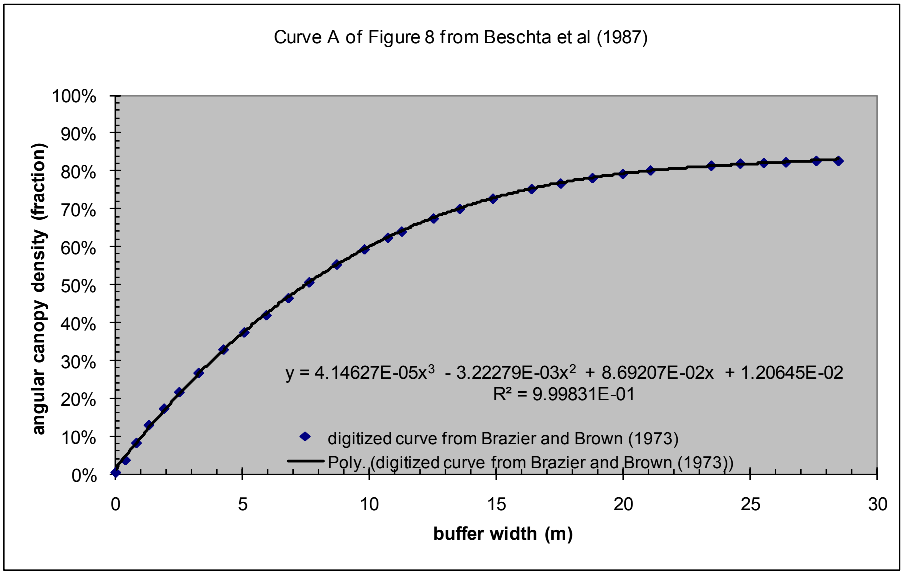

Figure 4. Relationship between buffer width and canopy density. *Source:Beschta et al. 1987*

Mature stand height will be based on average values derived for a revegetated area taking into account a range of heights for each tree species at maturity, weighted by the relative abundance of each species planted in the revegetated areas. Resources for determining tree heights will include the National Resource Conservation Service (NRCS) web tool for indexing tree growth based on soils and height ranges reported in Pojar and McKinnon (1994). Two sets of values may be derived for each planted area in order to bracket the potential height range: a minimum and a maximum average mature stand height, based on the range of values determined from sources consulted.

6.3 Data Acceptance Criteria and Rules

As noted above, estimates of mature vegetation height will be based on information extracted from the NRCS geographic soils database that provides estimates of potential tree height based on local soil characteristics. A second source of information on potential revegetation height will be a book on plants of the Pacific Northwest (Pojar and McKinnon 1994) that includes typical height of indigenous shrubs and trees that were used in the plantings in this study. These heights will be the best estimates available, as data for typical mature planting heights in the area based on local experience are not currently available.

Model evaluation, assessment and acceptance criteria are not proposed for this study, because the models proposed have already been assessed and were accepted for use in the respective TMDL studies.

7.0 Model Assessment Actions

The elements in this section identify activities that will be performed during the project to ensure that the selected models and the data selected for use in the models conform to the stated project objectives.

7.1 Assessment and Response/Corrective Actions

Final assessment of model performance will be conducted to determine whether the model, including its uncertainty, can be appropriately used to inform decision making. This determination will be based on assessment of the quality of the data used, evaluation of how well the model predictions correspond to the natural system, and analyses of sensitivity and uncertainty. The project team will make an overall recommendation for the appropriate use and application of the model and will summarize any important limitations in the final report.

7.2 Data Management

Once mature planting tree heights have been estimated, the current condition shade models will be renamed and the tree heights for the appropriate reach and bank will be increased as appropriate. The updated shade model will be run and the effective shade averaged over the same length as used to produce the heat load allocation table in each TMDL study (Coffin et al 2011, Table 13; Lee et al 2011, Table 8). The updated shade model will also be used to provide shade input to the current condition Qual2kw model, which will also be renamed and saved. The temperature model run will be compared graphically to the current condition and system potential shade model output. All files will be stored in a network folder that is regularly backed up and secure. Summary model output (i.e., shade and temperature profiles) will be stored and maintained in Excel spreadsheets in the same network directory. All files will be provided to Ecology as part of the review of the draft study report.

7.3 Model Sensitivity and Uncertainty Analysis

To evaluate the sensitivity and uncertainty of the model results, the model will be run with a lower and upper value for mature stand height. This will provide an upper and lower bound of likely reduction in heat load resulting when revegetation areas mature.

8.0 Project Deliverables

The following deliverables will be completed for this project according to the schedule presented in Table 2.

- Draft and final report documenting the development of input data and the setup and application of the shade and temperature models used for this study. The report will include, at a minimum, the following:
    - Summary of data compiled for model development (data sources and summary statistics)
    - Details of model setup, such as the locations and extent of revegetation planting areas represented in the models.
    - Details of model simulations/analyses performed
    - Quantitative and qualitative discussion of model results and sensitivity and uncertainty analyses
    - Recommendations for additional data collection and further model developments

9.0 Index to QAPP Elements

Table 3 provides an index to the sections (or sub-sections) above that correspond to U.S. Environmental Protection Agency (USEPA) QAPP elements for the development, modification and use of models (USEPA 2012).

Table 3. Index to EPA Quality Assurance Project Plan Guidance CIO 2106-G-05 QAPP (USEPA 2012)

EPA QAPP Element from Section 4.0 QAPP Elements for Development, Modification and Use of Models	Section(s)	Start page
4.2 Project Management		
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4.2.4 Project Organization and Schedule	4.0	5
4.2.5 Problem Background, Overview, and Intended Use of Model	3.0	4
4.2.6 Data/Project Quality Objectives and Measurement Performance Criteria	6.3	10
4.2.7 Special Training Requirements and Certification	na	na
4.2.8 Documentation and Records Requirements	8.0	11
4.3 Data Acquisition: Model Development, Modification, and Use (Do)		
4.3.1 Problem Specification and Identification of Model Purpose and Scope	3.0	4
4.3.2 Model Development or Selection Process	6.0	8
4.3.3 Data Requirements for Model Input	6.2	9
4.3.4 Evaluation of the Model	6.3	10
4.4 Assessments: Model Assessment Actions (Check)		
4.4.1 Assessments to Acceptance Criteria and Responses/Corrective Actions	7.0	10
4.4.2 Data Management Tasks	7.2	11
4.4.3 Model Output Sensitivity and Uncertainty Analysis	7.3	11
4.5 Review, Evaluation of Usability: Model Usability and Reporting Requirements (Act)		
4.5.1 Model Evaluation Methods and Activities	6.3	10
4.5.2 Description of Model Documentation	8.0	11
4.5.3 Specifications for Model Maintenance and User Support	na	na
4.5.4 Reports to Management	na	na

na = Not applicable to this project

10.0 References

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