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| Lab Assignment 1  **Assessment modeling for Green Stormwater Infrastructure Planning** |

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| **Section** | **Assigned** | **Due** |
| **AB** | **3/27** | **4/3** |
| **AA** | **3/28** | **4/4** |

Lab policy: <http://courses.washington.edu/geog464/guidelines_win2017.html>

Lab schedule: <http://courses.washington.edu/geog464/labschedule_17.html>

The PowerPoint introduction to this lab is posted on Canvas: [data\_management\_and L1.pptx](https://canvas.uw.edu/courses/1152834/files/folder/lab/presentations)

**1. Background for Assignments within GIS and Decision Support course**

Land use, transportation and water resource use are among the three most pervasive issues facing communities everywhere, in some places more than others depending on perspectives about health and well-being. In states and local communities where the issues intertwine because of significant changes, they have instituted growth management laws and policies to help guide understanding about how the issues connect over space and time and what could be done to ameliorate the problems. Land use development is the biggest driver of population growth, but also goes hand-in-hand if population well-being is to be sustained. Land use and transportation concurrency management is mandated by Growth Management law. Land use change, particularly impervious surface development, is the most significant contributor to wetlands, water, and ecosystem degradation. Transportation infrastructure development, particularly roadway development is a big contributor to contamination of stormwater runoff. Precipitation falls onto impervious surfaces, including highways, and flows as stormwater into lakes, ponds, rivers, streams and creeks. Consequently, there are linkages among land use, transportation and water resources that need our attention if we are to sustain resources for health and well-being.

Regional green infrastructure coordination of planning, improvement programming and project implementation follows in line with the Growth Management approach used in the state of Washington and elsewhere around the country and the world to more efficiently, effectively and equitably sustain health and well-being in communities. Each of the three decision situations can take advantage of assessment and intervention modeling.

The WA Department of Ecology, on behalf of the Puget Sound Recovery effort, has performed a watershed characterization of watersheds in Puget Sound. They identify many purposes of watershed characterization in land use planning.

Read how the WA Department of Ecology’s introduces their program <http://www.ecy.wa.gov/mitigation/landscapeplan.html>

Pay particular attention to the purposes as you continue with this lab:

* Sustain and restore aquatic resources.
* Establish a common approach to coordinate planning efforts.
* Involve the community in developing a green infrastructure plan.
* Promote the integration of the Growth Management Act (GMA) and Shoreline Management Act (SMA).
* Support Shoreline Management Plan (SMP) updates by:
  + Establishing a framework for characterizing landscape processes and developing a restoration plan as required under the SMA.
  + Promoting "no net loss" of shoreline and wetland function.

This is a regional scale example of how the program is applied to the Snohomish River (WRIA 7) Basin:

<https://fortress.wa.gov/ecy/publications/documents/1506009.pdf>

And this is the report on geospatial methods for the data used in the lab: <https://fortress.wa.gov/ecy/publications/parts/1106016part4.pdf>.

**2. Introduction to Assignments 1-4**

The watershed characterization approach contains both assessment and intervention components, but when compared to a geodesign approach to assessment and intervention it is not quite complete. A geodesign approach also contains assessment and intervention. A geodesign approach unpacks the assessment and intervention into three sub-models each, providing a more complete approach. Even if one does not want to follow the geodesign approach, the framework provides insight about what information analyst is missing. That is, it provides explicit insight about the uncertainty of information for problem solving and decision making. This latter issue is important if one wants to know what one does not know. It could save time and money, and perhaps even lives if that matters.

A geodesign assessment model is composed of three sub-models.

1. Representation Model : the database
2. Space-time Process Model: the water flow, water quality and habitat model
3. Evaluation Model: Functional performance levels characterized in system contexts

A geodesign intervention model is composed of three sub-models.

1. Change Model: design options developed by stakeholder groups
2. Impact Model: Scenario-based option impacts in the context of evaluation
3. Decision Model : Scenario-based decision option trade-offs

In lab assignment 1 we perform functional plan assessment, and in lab assignment 2 we perform functional plan intervention.

Lab assignment 1 learning outcomes:

1. Become familiar with comprehensive and functional planning by addressing a bit of both
2. Gain experience with assessing level of functional performance for water flow, water quality, and fresh water habitats developed by WA Ecology
3. Use an assessment approach consisting of three models: representation (what is related to what), process (how are they related over space and time) and evaluation (how much are they related in the context of objectives) model.

WA Ecology’s website for GIS and Decision Support in the Puget Sound region has certain uses and limitations. We can use the watershed characterization as part of a decision support approach to green infrastructure planning.

<https://fortress.wa.gov/ecy/coastalatlas/wc/UsesAndLimitations.html>

Please explore the Watershed characterization GIS data layer gallery. The start page, <https://fortress.wa.gov/ecy/coastalatlas/wc/landingpage.html> features a web map followed by links to explanatory sections. It will be helpful to display the reference outlines for WRIAs and county outlines in the interactive to become familiar with their intersection in the web map and relations to the watershed measures. WA Ecology has modeled water flow, water quality and fish and wildlife habitats using data at the sub-watershed level that aggregates up to watershed level. Explore in particular maps (data) for the following three topics that you will use in this lab assignment. Follow the link to the [‘Layer Gallery’](https://fortress.wa.gov/ecy/coastalatlas/wc/LayerGallery.html) to see some prepared maps with descriptions.

1. Water Flow: Restoration and Protection for Overall Waterflow. Mouse-over this tile and click the ‘learn more’ link to see the map and read a more detailed description. Do the same for 2 and 3 below.

Where are the high priority areas for protection (green) restoration (yellow) of subwatersheds in relation to cities and unincorporated areas of King County? How might you rank the areas from highest priority to least priority when you get access to the data?

1. Water Quality: Restoration and Protection for Sediment (Water Quality)

Where are the high priority areas for protection (teal) and restoration (yellow) of water quality? How would you characterize the data (for areas) from highest priority to least priority when you get access to the data?

As we do not want to process all data in the Puget Sound region for our planning problem, we will restrict the focus to cities in King County. There are three water resource inventory areas (WRIAs) coincident with King County area, WRIAs 7, 8, and 9). Some sub-watersheds are more vulnerable than others; those least vulnerable are the least expensive to protect…so protect them.

**3. Creating the Assessment Model**

An assessment model provides a current status of the condition of an element in relation to some benchmark. The WA Ecology watershed characterization performed an assessment on the basis of pristine conditions, that is, conditions in relation to the absence of any development. The level of performance degradation is thus in comparison to a pristine condition for the same area without any human-induced change. Creating a map of overall watershed conditions could be considered a status quo assessment from a pristine conditions perspective. It constitutes a ‘plan’ for reaching pristine conditions by sub-watershed.

An assessment model can be created by using three sub-models: representation, process, and evaluation.

**3.1 Creating a Representation Model**

A representation model consists of the content and structure of a place, i.e., the features within a study area.

*Study Area Boundary Using a Consortium Perspective*

Use the WA Ecology website and WRIA data to form a regional planning area for green stormwater infrastructure. A WRIA boundary constitutes an effective regional planning area boundary. A regional plan consortium | coalition | forum is composed of a collection of all government and non-for-profit jurisdictional areas, e.g. , cities, unincorporated county, and community groups within the WIRA. Water flows from and into neighboring jurisdictions, moving across jurisdiction boundaries because ‘water runs downhill’. Although the WRIA boundary is a functional boundary, some jurisdictions will inevitably cross WRIA boundaries and therefore be part of multiple consortia. Nonetheless, each jurisdiction derives some functional benefit, and incurs some functional cost, from the water that serves the population within the jurisdiction. As such, water functions are provided by local physical structures of landscapes at the site or reach scale, such as wildlife habitat, salmon spawning habitat, flow attenuation, flood storage, groundwater recharge and sediment retention, etc. When measured, the magnitude of the function is called functional performance level.

*Develop your study area and consortium group using the following data*

King County unincorporated areas and city boundaries are available on the King County GIS Data Portal.

Use this link to access the Cities and Unincorporated King County (city\_kc)

<http://www5.kingcounty.gov/gisdataportal/>

[city\_kc] has a disadvantage where jurisdictions with distinct non-adjacent polygons are separate features. The dissolve operation on city name will put these disparate polygons into multi-part polygons. Get that shapefile here: [city\_kc\_dslv.zip.](https://canvas.uw.edu/courses/1152834/files/folder/lab/data)

Dept of Ecology Water Resource Inventory Boundaries

All WRIA boundaries are available from the Water Resource Inventory Areas (WRIA) dataset.

<http://www.ecy.wa.gov/services/gis/data/data.htm>

What cities are within the WRIA? If you clip the city boundaries to the WRIA boundary, take note that you will perform ‘proportioning’ of population and area as appropriate to the clip you perform.

**3.2 Creating a Process Model.**

Our process model connects water flow to water quality and habitat. We borrow from the work of the Puget Sound Watershed Characterization Project.

*Developing GIS Data about Water Flow, Water Quality, and Habitat*

WA Ecology has created watershed information for water flow, water quality, and habitat within all Water resource inventory areas (WRIAs) of Puget Sound. The datasets are available from the web page at…

<http://www.ecy.wa.gov/services/gis/data/inlandwaters/pugetsound/characterization.htm>

WA Ecology has combined WF and WQ into a single .gdb for each WRIA, so you need the respective WRIAs for those.

These are produced from other more basic datasets. Thus, representation and process models were used to combine the data giving the results to which we have access.

Download the data you need for your WRIA, it will be WRIA 7, 8, and/or 9, depending on your area of interest. Please note the READ ME PLEASE.pptx file included with the data. WRIA’s have been examined at the sub-watershed level in regards to water flow, water quality and habitat restoration. The particular data of interest to us is as follows.

* Water Flow (WF): Restoration and Protection for Overall Waterflow
  + Layer WF\_RP - WF\_RP9.lyr, feature class WF\_RP, field WF\_RP
* Water Quality (WQ): Restoration and Protection for Sediment (Water Quality)
  + Layer PA\_RP - WQ\_RP9.lyr, feature class PA\_RP, field PA\_RP

**3.3 Creating an Evaluation Model**

An evaluation model establishes criteria for describing functional performance. How good is good, how bad is bad. The basis of this evaluation model is the notion of ‘pristine condition’, i.e., a condition before humans arrived to the area. Pristine condition is the idealized goal for restoring water conditions.

Green stormwater infrastructure planning can be addressed best by identifying the areas which provide the most benefit for the least effort in relation to current conditions. In regards to water flow, we want to identify the sub-watersheds with the most pristine (preserved) water flow (least degraded) and will likely require the least amount of restoration effort. In the maps you previewed, these were the green and yellow symbolized sub-watersheds. In regards to Water quality, we want to focus efforts on the sub-watersheds with the least sedimentation, that is, lightest yellow in the maps you previewed. ~~As for fish and wildlife habitats, the green and yellow symbolized sub-watersheds are the most valuable for restoration efforts.~~ However, in the above datasets we must treat all of the data, not just those of greatest value to restoration. ~~Below you find three tables of the information sets with which we are working. Those information in turn provide the data we can use on our evaluation model. Basically we want to know how a sub-watershed is ‘performing’ in regards to ecosystem services using a combination of the three datasets.~~

**4.0 Detailing the evaluation model**

**4.1 Standardizing the data**

The flow and quality categories are the outcomes of the modeling process and are categories based on quantiles. For your work it is important to rename the categories with a numeric value representing the relative position of each category in order from low to high importance.

WFWQ\_order.dbf is a look-up table with ordinal values assigned to the restoration potential values in the WF\_RP and PA\_RP feature classes. The fields in the table are the following:

Name: Description

RP\_code: The restoration potential values used to create the RP categories from tables D\_14 and D-19

RP: Join field that matches the WF\_RP and PA\_RP fields.

WF\_order: The standardized water flow values

WQ\_order: The standardized water quality ~~and~~ values

Use the ‘Join field’ operation to add the fields WF\_order and Name to the WF\_RP feature class and the fields WQ\_order and Name to the PA\_RP feature class.

Standardize the water flow and water quality values to range 1 – 100. Create new short integer fields WFstnd and WQstnd in WF\_RP and PA\_RP respectively. Determine the minimum and maximum values of WF\_order as WFmin and WFmax. These are probably 1 and 16 but it is always important to verify the minimum and maximum values before you use the standardize formula. Do the same for water quality to get WQmin and WQmax. Populate these fields using the following formulas:

WFstnd = 100.0 \* (([WF\_order] – WFmin) / (WFmax – WFmin))

WQstnd = 100.0 \* (([WQ\_order] – Wqmin) / (WQmax – WQmin))

For make two maps of the WRIA by WFstnd and WQstnd using graduated colors.

Objectives for functional performance levels for Water Flow and Water Quality:

How much change in Water Flow and/or Water Quality is an improvement? A vision for threshold levels to interpret improvements is specified here in terms of standardized units of measurement of performance. The following are the threshold performance levels.

Assessment and Intervention Objectives for Functional Performance Levels in water quality and water flow.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Performance threshold level | Name | RP | RP code | Order | Standardized |
| Lowest level | Conservation | D1 | L,H | 1 | 1 |
| Satisfactory level | Restoration/Development | RD2 | M,MH | 6 | 33 |
| Good level | Protection | P2R | MH,M | 11 | 66 |
| Highest level | Highest Protection | P1 | H,L | 16 | 100 |

Total improvements in water flow and water quality are desired. Levels between satisfactory and good are sought, as they are believed feasible in degraded areas.

Make maps of WQstnd and WFstnd categorized by performance threshold level.

**4.2 Evaluation Index – water function**

We are now prepared to create a watershed evaluation (assessment) index, that is, an index of watershed health. Combine the datasets into an index data value for each sub-watershed by adding the components of performance.

Join the WF\_RP feature class to PA\_RP feature class using ~~the fields WF\_RP and PA\_RP~~ AU\_ID as the join field. Export the join result as a new feature class named WFWQ. To calculate the water function index create a new short integer field in WFWQ named WFI and use field calculator to populate it with this equation ([WF\_order] + [WQ\_order]) / 2

Objectives for functional performance levels for water function:

The same question about measures of improvement inWater Flow and/or Water Quality is applied to water function in this table.

Assessment and Intervention Objectives for

Functional Performance Levels in water function index.

|  |  |
| --- | --- |
| Performance threshold level | WFI |
| Lowest level | 1 |
| Satisfactory level | 33 |
| Good level | 66 |
| Highest level | 100 |

Make two maps of the WRIA by water function index using different symbologies: graduated color and categories by WFI performance levels. Compare this map to the maps you made for water quality and water flow. Where do they agree or disagree? Can you explain any disagreement between subwatershed water quality and water function represented in the water function index?

**4.3 Assemble evaluation data as a table**

The guidance file for this section is available on Canvas: [Lab1\_make\_evaluation\_table.pdf](https://canvas.uw.edu/courses/1152834/files/folder/lab/help)

Develop a table with the following Consortium Characteristics.

* Jurisdiction name, including unincorporated King County
* Population within each jurisdiction 2010: https://factfinder.census.gov/faces/nav/jsf/pages/community\_facts.xhtml
* Area (square miles) within each jurisdiction: ArcMap feature table
* Population density (population of jurisdiction / total square mile of jurisdiction)
* **~~M~~**~~edian~~ **I**ncome **P**er **C**apita (IPC) of the population for each jurisdiction: same Census page as above but select income as the table to view. This is different than income per household.
* **T**otal **P**opulation **~~M~~**~~edian~~ **I**ncome per jurisdiction = Total Population of jurisdiction \* IPC
* Water Flow index: ArcMap feature table. For multiple subwatersheds use the average WFI value.

Put a summary record for the last record of the table with these values.

* total population across all jurisdictions within WRIA (sum of above)
* total area of WRIA (sum of above)
* Total population ~~median~~ income (TP~~M~~I) for each jurisdiction:

= pop per sq mile for jurisdiction \* median income for jurisdiction \* square miles for jurisdiction

* total population income of WRIA:

= sum of all total population income across jurisdictions

* Average WFI value

Example table layout

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Jurisdiction | Population | Area | Density | ~~M~~IPC | TP~~M~~I | WFI |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Summary |  |  |  |  |  |  |

**NOTE:** the population for unincorporated King County can be computed as…

Pop\_unicorporated\_KC = KC\_Total\_Population – Sum of all city populations

**If you do not get to this in lab 1, we will do it later.**

**5. Deliverables**

Please prepare answers to these questions as a Word document or PDF file.

1. From section 2:
   1. One paragraph that addresses these questions relative to Water Flow: Restoration and Protection for Overall Waterflow: Where are the high priority areas for protection (green) restoration (yellow) of subwatersheds in relation to cities and unincorporated areas of King County? How might you rank the areas from highest priority to least priority when you get access to the data?
   2. One paragraph that addresses these questions relative to Water Quality: Restoration and Protection for Sediment (Water Quality): Where are the high priority areas for protection (teal) and restoration (yellow) of water quality? How would you characterize the data (for areas) from highest priority to least priority when you get access to the data?
2. Describe your consortium in terms of the collection of jurisdictions included within the WRIA of your choice.
3. Print the Consortium Characteristics Table
4. The maps you made of the WRIA by water quality, water flow and water function index.