Washington State Department of Ecology Watershed Characterization Tool

The Watershed Characterization Tool ranks user-defined hydrological units relative to others in terms of their importance and degradation for specific watershed processes. It then uses both rankings to determine the extent to which management actions within the unit should focus on restoration or protection. The Watershed Characterization Tool uses a watershed approach, prioritizing management opportunities based on hydrological considerations. Models used in the Watershed Characterization Tool could be used in other areas of the country, provided they are adapted by regional experts for each unique region in which they are applied.

OVERVIEW

Lead developer(s): Washington State Department of Ecology (WSDOE).[1]

Year developed: In 1995, development of the tool was initiated when stakeholders identified the need for tools that local governments and others could use to prioritize wetland management. WSDOE published its first results using the tool in 2010.[1]

Geographic area: To date, the tool has only been developed for application in western Washington. It has been applied to the Upper and Lower Chehalis Basins and Puget Sound watersheds (Fig. 1).[1]

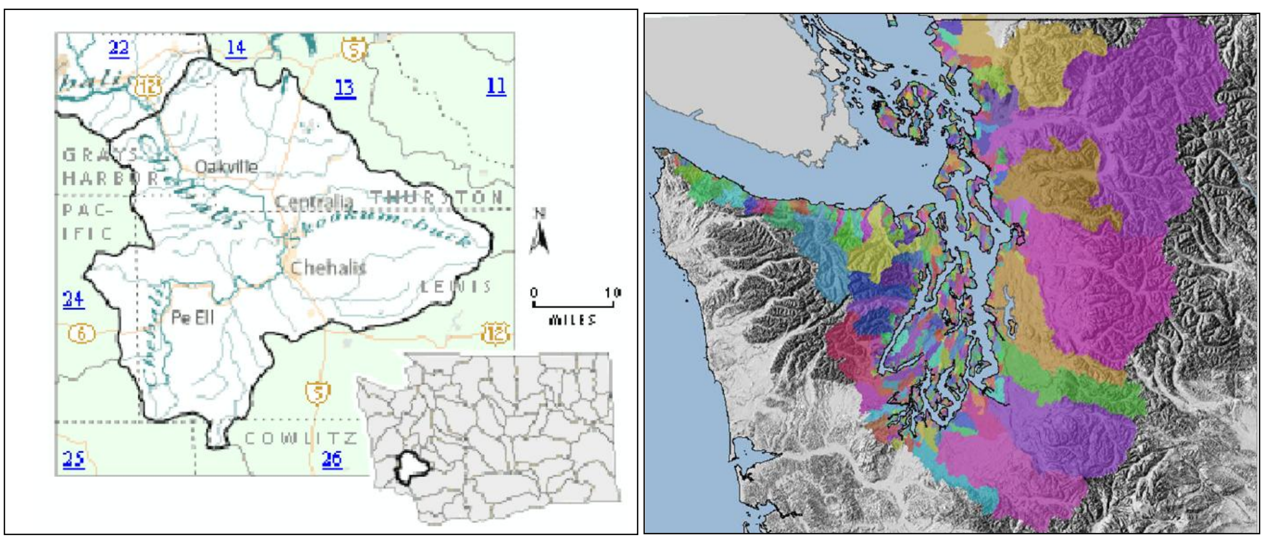


Figure 1. Geographic regions to which the WSDOE Watershed Characterization Tool has been applied to date include the Upper and Lower Chehalis Basins (left) and Puget Sound watersheds (right). Used with permission from Washington State Department of Ecology.

Resource types: Watersheds.

Restoration/conservation: Restoration (reestablishment and rehabilitation), creation, enhancement, preservation/protection, acquisition without preservation/protection.[1]

Stakeholders: Local governments required by state law to use science-based tools to inform their wetland programs.[1]

Current status: State law and guidelines requiring local governments to use watershed characterization in the development of Shoreline Master Programs supported the development of the tool. Further, local comprehensive plans are required to employ the best available science. The majority of local governments in the Puget Sound region of the state of Washington are currently using the tool to help develop watershed-based land use plans. Some local governments are also using the characterization to guide the selection of wetland mitigation sites through in-lieu fee programs. The Watershed Characterization tool includes a water flow model and water quality models for sediment, phosphorous, nitrogen, metals, and pathogens (Volume 1). Habitat models and guidance for integrating and applying the water flow, water quality, and habitat models are also under development.[2]

PRIORITIZATION ANALYSIS

Landscape prioritization tool(s): The approach begins with the selection of an appropriate "analysis unit," a drainage-based area that will be analyzed as part of the prioritization analysis. For example, in a recent project completed by Ecology for the Chehalis Basin, a technical committee selected analysis units as the reach-scale catchments used by the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP). The technical team was composed of scientists from the University of Washington, EPA personnel, and staff from local governments (particularly local GIS staff). The selected analysis units are grouped into larger "landscape groups," such that all analysis units within a landscape group share similar environmental conditions. Analysis units that share similar landform, geologic, and water flow characteristics may then be aggregated into a new set of analysis units within each landscape group.[3]

Within each landscape group, the Watershed Characterization Tool ranks all analysis units relative to each other in terms of their status as "important areas," reflecting their ability to help maintain watershed processes relative to other analysis units. WSDOE's best-developed and most-applied watershed process model to date is its water flow process model. In the process model, four "importance" ranks are possible: low, medium, medium-high, and high. The tool first ranks each analysis unit in terms of individual component watershed processes (e.g., groundwater recharge) before summing the individual component rankings to obtain an overall ranking for that watershed process (e.g., overall water flow ranking). For example, in the Chehalis study, WSDOE used a water flow process model to determine important areas for the delivery, storage, discharge, and recharge of surface and groundwater. The rankings obtained for each of these component importance analyses were then added to produce rankings in terms of overall importance. A technical team may decide to weight each component process differently before summing, but usually keeps weightings equal unless data suggest otherwise.[3]

In addition, WSDOE also ranks analysis units in each landscape group by their "impairment level," a relative ranking of the level at which human activities are likely damaging watershed processes. In the Chehalis study, in addition to ranking by importance, WSDOE ranked analysis units relative to each other in terms of impairment for the water flow processes of delivery, storage, discharge, and recharge. WSDOE assigns single component rankings values of low, medium, medium-high, and high and weights and sums them to obtain an overall impairment ranking.[3]

The result of this process for each watershed process that is analyzed (e.g., the water flow model for Chehalis) is two sets of maps, one for the importance analysis and one for the impairment analysis. Each set of maps is composed of an overall ranking map as well as component maps for each watershed process (e.g., water delivery, storage, recharge, and discharge for Chehalis). The result is that each analysis unit is assigned two rankings of low, medium, medium-high, or high, one from the importance map and the other from the impairment map. Together, the pair of rankings indicates whether the analysis unit is most suitable for restoration (high importance, high impairment), conservation (low importance, low impairment), or protection (high importance, low impairment). The rankings may also indicate areas that are less sensitive to future disturbance and do not warrant conservation actions (low importance, high impairment).[3]

These four management categories, along with color-codes used to represent them in GIS mapping, are illustrated by the management matrix in Figure 2.

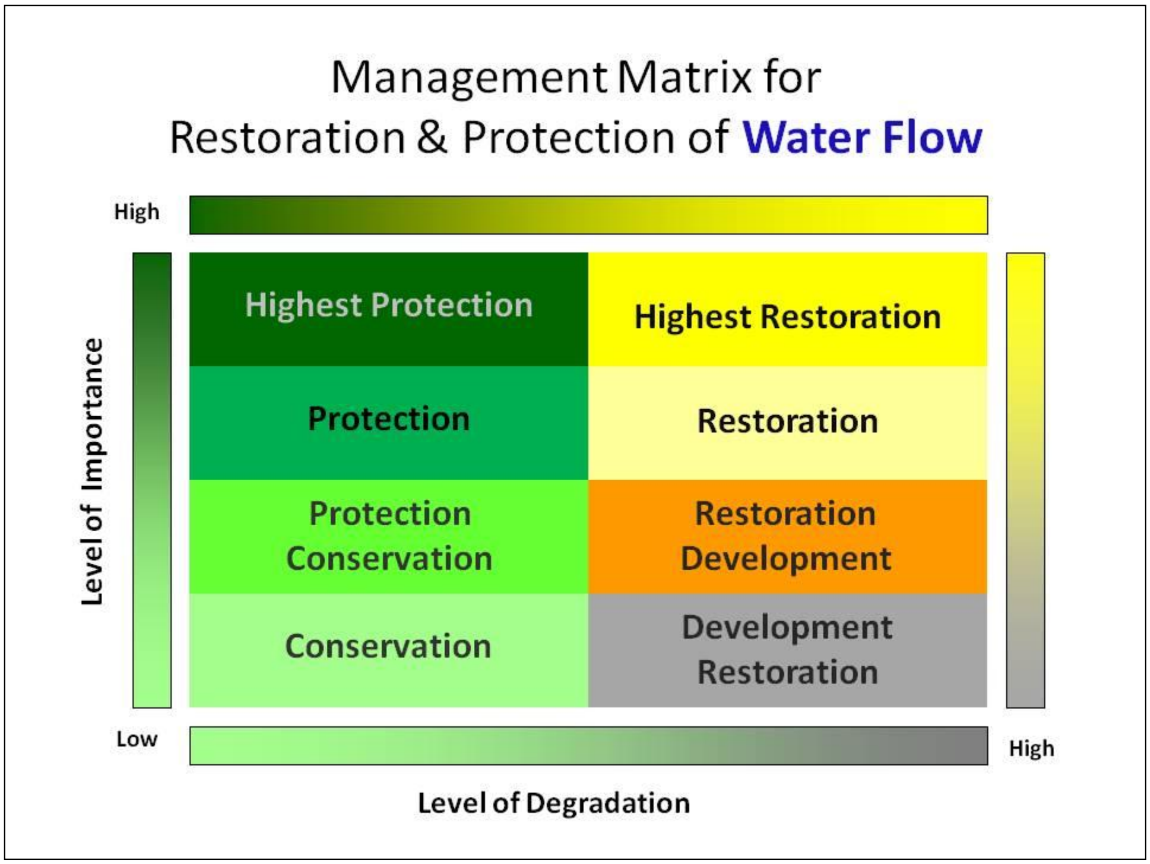


Figure 2. Importance and impairment rankings are used to obtain a management recommendation for each component.[4] Used with permission from Washington State Department of Ecology.

In the Chehalis, WSDOE used this typology to produce color-coded maps for each process component, as well as the summed processes, that show where the best opportunities exist for protection, restoration, and conservation among analysis units (Fig. 3). If planners in the

Chehalis were interested in improving general water flow processes they may use the composite map (Fig. 3) to prioritize analysis units for restoration (dark yellow) and protection (dark green). If planners in the Chehalis were interested in targeting recharge specifically, the management map for recharge (Fig. 3E) shows that protection is a priority in the watershed indicating that under current conditions the recharge process is not significantly degraded. Conversely, there is a greater area requiring restoration for storage in the watershed, indicating that this process is relatively more degraded (Fig. 3C).[2,3]

<u>Water delivery tool:</u> The model determines areas to be more important for water delivery that have higher annual precipitation and contain higher coverage of rain-on-snow and snow-dominated zones. Areas are more degraded for water delivery if they have poor timing of water delivery caused by large percent coverage by either non-forest vegetation or impervious surfaces.[3]

Prioritization objectives assessed:

- Surface water supply

Table 1. The water delivery tool evaluates surface water supply based on the factors and data listed below.[3]

Factor used in analysis	**Data source(s)**
Average annual precipitation weighted by area of extent	Precipitation isohyetal map
Timing of water delivery (rain-on-snow and snow-dominated zones)	Data layers from WDNR[5]
Percent non-forest vegetation	WDFW land use/land cover data[6]
Percent impervious surface	

WDNR = Washington State Department of Natural Resources; WDFW = Washington Department of Fish and Wildlife

<u>Water storage tool:</u> The model considers the percent of depressional wetlands and percent unconfined and moderately confined floodplains to indicate areas that are important for surface water storage. For degradation, it considers the historic area of storage wetlands and unconfined and moderately unconfined floodplains impacted by urban and agricultural development.[2,3]

Prioritization objectives assessed:

- Surface water supply

Table 2. The storage tool evaluates surface water supply based on the factors and data listed below.[3]

Factor used in analysis	**Data source(s)**
Percent depressional wetlands	WDNR topography;[7] SSURGO hydric soils[8]
Percent unconfined and moderately confined floodplains	SSHIAP data for floodplain confinement[9]
Urban land use (i.e., moderate/high density residential, commercial and industrial)	WDFW land use/land cover data[6]
Rural/agricultural land use	WDFW land use/land cover data[6]
Miles of streams and rivers	Pacific Northwest Hydrography Network[10]
Area of unconfined and moderately confined	SSHIAP floodplain confinement data[9]

floodplains	

WDNR = Washington State Department of Natural Resources; SSURGO = Soil Survey Geographic (database); SSHIAP = Salmon and Steelhead Stock Inventory Assessment Program; WDFW = Washington Department of Fish and Wildlife

<u>Groundwater recharge tool:</u> The importance of an area for recharge is determined using a simple equation that calculates recharge based on permeability of the soil and annual average precipitation. Impairment is calculated by multiplying the total recharge value by a recharge coefficient, which is derived from the land use type (e.g., high intensity land use = higher coefficient value).[3]

Prioritization objectives assessed:

- Groundwater supply

Table 3. The groundwater recharge tool evaluates surface water supply based on the factors and data below.[2,3]

Factor used in analysis	Data source(s)
Average annual precipitation	Precipitation isohyetal map
Area of high permeability soils (coarse gained soils, such as recessional and advance outwash and alluvium in lowland areas)	SSURGO soils data[8]
Area of low permeability soils (bedrock such as till, basalt, and granite)	
Land cover types	CCAP[11]
Reduction coefficients	High Intensity = 0.9 (80 to 100% impervious) Medium Intensity = 0.7 (51 to 79% impervious) Low Intensity = 0.35 (20 to 50% impervious)

SSURGO = Soil Survey Geographic (database); CCAP = Coastal Change Analysis Program

<u>Groundwater discharge tool:</u> Importance for groundwater discharge was modeled as a function of miles of streams and rivers that cross areas located in unconfined floodplains and that contain permeable deposits. Impairment to discharge is modeled based on the density of wells (which decrease discharge through groundwater pumping), miles of unconfined streams in high permeability deposits of urban and rural floodplains, and area of potential slope wetlands in areas of urban or rural land use.[3]

Prioritization objectives assessed:

- Groundwater supply

Table 4. The groundwater discharge tool evaluates surface water supply based on factors and data below.[2,3]

Factor used in analysis	Data source(s)
Unconfined floodplains	SSHIAP data for floodplain confinement[9]
Miles of streams and rivers	Pacific Northwest Hydrography Network[10]
Area of slope wetlands	WDNR topography[7]; SSURGO hydric soils[8]
Urban and rural land use	WDFW land use/land cover data[6]

Density of Class A and B wells	Department of Health Well Data

WDNR = Washington State Department of Natural Resources; SSURGO = Soil Survey Geographic (database); SSHIAP = Salmon and Steelhead Stock Inventory Assessment Program; WDFW = Washington Department of Fish and Wildlife

Overall watershed characterization tool: The rankings obtained for each of these component importance analyses were then added to produce rankings in terms of overall importance.

Prioritization objectives assessed:

- Surface water supply
- Groundwater supply

Factor used in analysis	**Data source(s)**
Water delivery	Precipitation isohyetal map; Data layers from WDNR;[12] WDFW land use/land cover data[13]
Storage	WDNR topography;[14] SSURGO hydric soils;[15] SSHIAP data for floodplain confinement;[16] WDFW land use/land cover data;[6] Pacific Northwest Hydrography Network[17]
Groundwater recharge	Precipitation isohyetal map; SSURGO soils data;[8] C-CAP[18]
Groundwater discharge	SSHIAP data for floodplain confinement;[9] Pacific Northwest Hydrography Network;[10] DNR topography;[7] SSURGO hydric soils;[8] WDFW land use/land cover data[6]

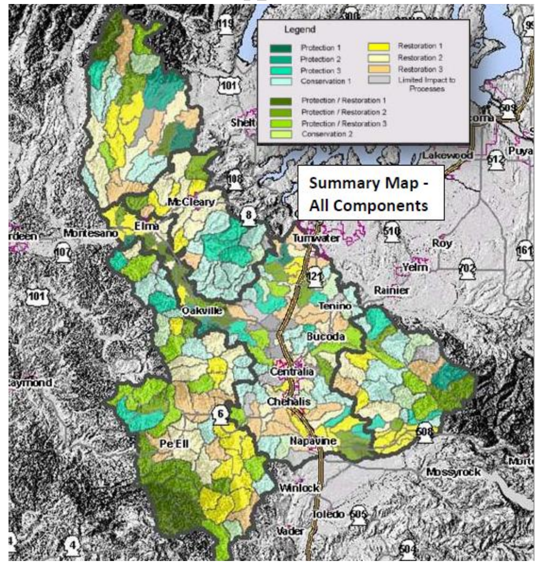
WDNR = Washington State Department of Natural Resources; SSURGO = Soil Survey Geographic (database); SSHIAP = Salmon and Steelhead Stock Inventory Assessment Program; WDFW = Washington Department of Fish and Wildlife; CCAP = Coastal Change Analysis Program

Prioritization products: Five prioritization outputs for the Chehalis Basin that rank hydrologic units in terms of suitability for wetland restoration, protection, and conservation for water delivery, surface water storage, and groundwater recharge and discharge are provided in Fig. 3. The characterization models and data for Puget Sound can be downloaded at: http://www.ecy.wa.gov/services/gis/data/pugetsound/characterization.htm.

Refinement of landscape prioritization priorities: In addition to the Watershed Characterization Tool, WSDOE has also developed rapid assessment methods for completing on-the-ground site-specific prioritization. Prioritization using rapid assessment methods is a separate step that follows application of the landscape prioritization tool.[1]

Figure 3. Output maps from the WSDOE Watershed Characterization Tool for the Upper and Lower Chehalis Basins showing priorities for restoration (yellow), protection (green), and conservation (light yellow/light green), in addition to areas in which future disturbances are likely to have less impact (orange). An output map is generated that summarizes overall priorities for the particular watershed process analyzed – in this case, an overall hydrologic priorities map (Figure 3A). Additional output maps show priorities for individual component processes, which are here represented by water delivery (Figure 3B), surface water storage (Figure 3C), groundwater discharge (Figure 3D), and recharge (Figure 3E).

A



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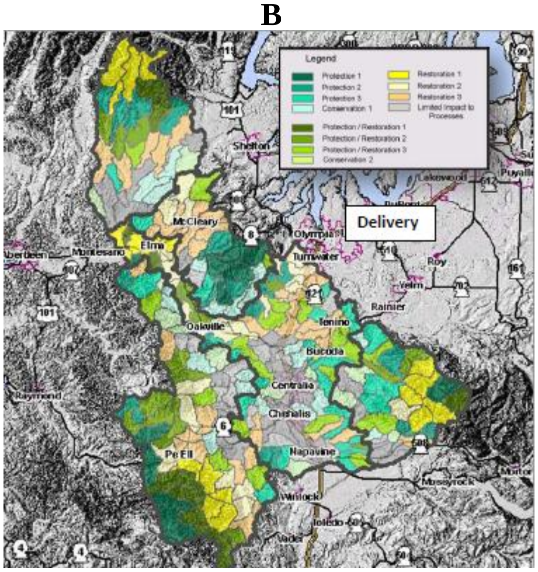

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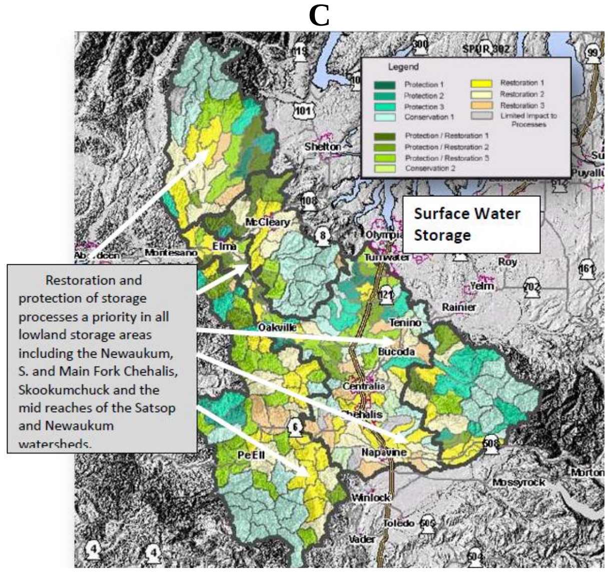

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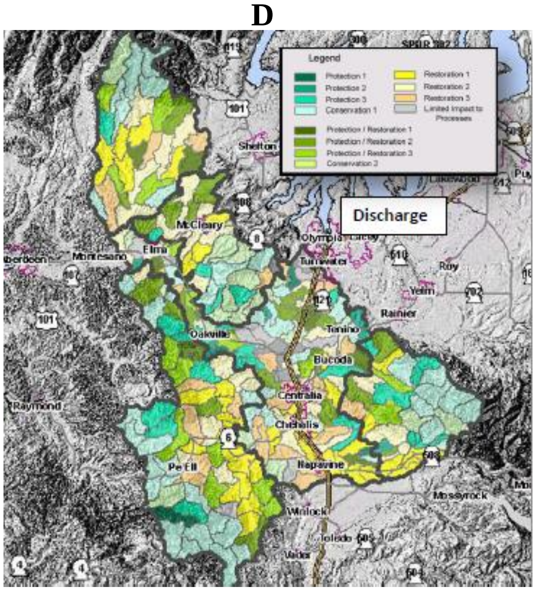

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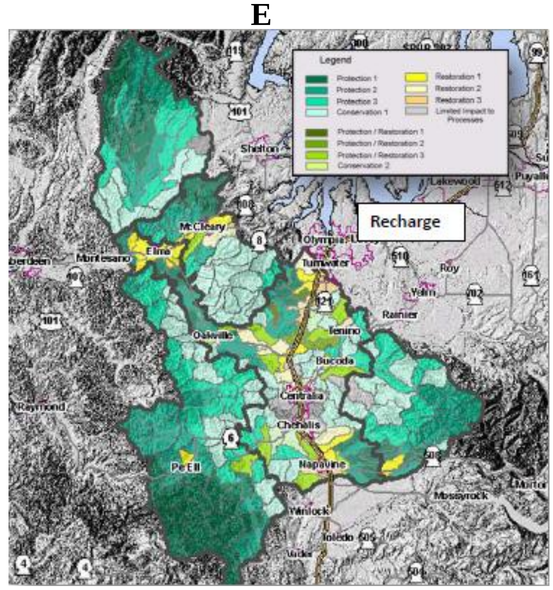

IMPLEMENTATION

Regulatory/non-regulatory programs:

- Section 404 wetland compensatory mitigation.
  - Non-profit in-lieu fee programs use the tool to inform restoration planning and site selection.[1]
  - Mitigation bankers use the tool to guide site selection.[1]
  - Watershed approach to mitigation: The tool allows users to prioritize the relative importance and impairment of different analysis units for wetland restoration on a watershed basis, thus facilitating a watershed approach.[3]
- Local wetland regulatory programs: Local governments are required to characterize watersheds under the Shoreline Guidelines from the Shoreline Management Act. The requirement has driven development of the Wetland Characterization Tool.[2]
- Total Maximum Daily Load (TMDL) programs.[1]
- Non-profit wetland restoration efforts.[1]
- Washington Fish and Game uses the tool to identify priority sites for species protection under state habitat protection laws.[1]
- Treaty rights of Indian tribes stating that local governments must support the provision of salmon also provide an incentive for local governments to use the tool. Because the tool facilitates restoration of important waterways for salmon, it helps local governments avoid possible conflict with tribes.[1]
- In eastern Washington, non-regulatory incentives for using the tool, such as higher priority under the Wetland Reserve Program, are currently under consideration.[1]

Transferability:

- The Watershed Characterization Tool should have appeal nationally considering current interest in the watershed approach.[1]
- Models used in the Watershed Characterization Tool could be used in other areas of the country, provided that regional experts adapt them for each unique region in which they are applied.[2]

Data gaps:

- Soil data: WSDOE cited a lack of soil data for federal lands as a major data gap. NRCS soils data do not cover Forest Service lands which comprise about half the land in the state. Because WSDOE believes that the Forest Service is unlikely to obtain soil data, and obtaining soil data is resource-intensive, they are not actively seeking to fill this data gap.[1]
- Wetland data: WSDOE is in the process of developing more up-to-date wetland maps for the model by obtaining Landsat data under an EPA grant. They are also in the process of patching in NOAA wetlands data, such as those for seasonally ponded and dry wetlands.[1]
- Data resolution: Currently, WSDOE's models analyze raster datasets that are 30m resolution, but they would like to improve the resolution to 1m resolution.[1]
- WSDOE is currently seeking to obtain 1m-resolution wetland Landsat data as part of its effort to improve the overall resolution of its model.[1]
- Hydrology data necessary for modeling the complex hydrological functions of eastern Washington are limited. In general, WSDOE is uncertain how effectively the Watershed

Characterization Tool can be applied on the eastern side of the state due to a lack of scientific information in that region.[1]

Barriers:

- WSDOE reports that although there is a large demand for them to complete development of the Watershed Characterization Tool, their capacity to do so quickly is limited by the fact that they only have 2-3 staff members available to work on the tool. The basic concepts have been established, WSDOE's progress completing the individual watershed process models is limited only by the number of personnel available to work on it.[1]
- Stakeholder involvement is necessary to produce an effective prioritization result but takes time to accomplish. It took about two years for WSDOE to develop the Watershed Characterization Model and about two more to receive feedback on it from stakeholders.[1]
- Funding: Some data exist that WSDOE would like to have but that are too costly to obtain. For example, C-CAP has 1m resolution data that WSDOE could use to improve their model but cannot obtain because they are too expensive.[1]

Future goals:

- Obtain a larger amount of data for the eastern side of the state so that output maps can be created for that region.[1]
- Develop a uniform set of models with Watershed Characterization Tool to produce output maps for the entire state of Washington.[1]
- Sufficient staff and funding limit WSDOE's ability to achieve these goals.[1]

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[1] Interview on 8/3/2011 with Tom Hruby, Senior Ecologist, Washington State Department of Ecology.
[2] Feedback received on 5/18/2012 from Stephen Stanley, Wetland Specialist, Washington State Department of Ecology.
[3] Stanley S, Grigsby S, Hruby T, and Olson P. 2010. Chehalis Basin Watershed Assessment: Description of Methods, Models and Analysis for Water Flow Processes. Washington State Department of Ecology. Publication #10-06-006. Olympia, WA.
[4] Stanley, S., S. Grigsby, D. B. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, George Wilhere. 2011. Puget Sound Characterization. Volume 1: The Water Resources Assessments (Water Flow and Water Quality). Washington State Department of Ecology. Publication #11-06-016. Olympia, WA.
Stanley S, Grigsby S, Hruby T, and Olson P. 2009. Puget Sound Watershed Characterization Project: Description of Methods, Models, and Analysis. Washington State Department of Ecology. Publication #10-06-005. Olympia, WA.
[5] http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html
[6] http://www.wdfw.wa.gov/wlm/gap/dataprod.htm
[7] http://www3.wadnr.gov/dnrapp6/dataweb/dmmatrix.html
[8] http://soils.usda.gov/survey/geography/ssurgo/
[9] http://wdfw.wa.gov/hab/sshiap/
[10] http://hydro.reo.gov/
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[17] http://hydro.reo.gov/

[18] http://www.csc.noaa.gov/crs/lca/pacificcoast.html