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Acknowledgments

We would like to first acknowledge the Environmental Protection Agency (EPA) for providing grant funds to complete this important work for Thurston County and the South Puget Sound.

Watershed Characterization Technical Team

Owen Reynolds, GIS Analyst III, Thurston County GeoData
Barb Wood, Utility Planner, Resource Stewardship
Janie Civille, Aquatic Resource Specialist, Resource Stewardship
Sue Stedman, Administrative Assistant, Resource Stewardship

List of Acronyms and abbreviations

303(d)	List of impaired water bodies specified in the Clean Water Act, Section 303(d)
Basin	1,000 to 10,000 acres
B-IBI	Benthic – Index of Biological Integrity
Catchment	32 to 320 acres
DAU	Drainage Analysis Unit (approximately 0.25 sq mile or 160 acres)
DBH	Diameter breast height
DEM	Digital Elevation Model
Ecology	Washington State Department of Ecology
EIA	Effective Impervious Area
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESB	Engrossed Senate Bill
FEMA	Federal Emergency Management Agency
FRAGSTATS	FRAGSTATS is a computer software program designed to compute a wide variety of landscape metrics
GeoData	Thurston County's GeoData Center
GIS	Geographical Information System

GLO	General Land Office
LiDAR	Light Detecting and Ranging
LWD	Large Woody Debris
NEPA	National Environmental Policy Act
PHS	Priority Habitats and Species
SEPA	State Environmental Policy Act
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment Program
Sub-basin	100 to 1,000 acres
Sub-watershed	320 to 19,200 acres
TIA	Total Impervious Area
TMDL	Total Maximum Daily Load
TRPC	Thurston County Regional Planning
USDA	US Department of Agriculture
USGS	US Geological Survey
WAC	Washington Administrative Code
WADNR	Washington Department of Natural Resources
Watershed	19,200 to 320,000 acres
WDFW	Washington State Department of Fish and Wildlife
WRIA	Water Resource Inventory Area as defined in Chapter 173-500 WAC

Executive Summary

This project was initiated to address a top priority in the Puget Sound Partnership's *Puget Sound Conservation and Recovery Plan* to reduce the environmental damage from stormwater runoff. This includes preventing nutrient and pathogen pollution by assessing the feasibility of a watershed-based National Pollutant Discharge Elimination System (NPDES) permit. This report presents the results of a watershed characterization of landscape conditions in the Totten and Eld Inlets that identified preservation, restoration, and mitigation sites at the watershed scale rather than smaller jurisdictional boundaries used in traditional permit approaches.

There are multiple jurisdictions in Thurston County that have applied for their National Pollutant Discharge Elimination System (NPDES) Phase II and Phase I permits. Thurston County, in addition to the cities of Olympia, Lacey, and Tumwater are designated Phase II permittees. The Washington State Department of Transportation (WSDOT) is a NPDES Phase I permittee in Thurston County.

Each jurisdiction has applied for their respective permit separately. Separate permits could lead to duplicative efforts in planning, assessment, and monitoring as each jurisdiction addresses the six core Clean Water Act (CWA) programs and other requirements under the Safe Drinking Water Act (SDWA). These permits are managed by the Washington State Department of Ecology (WDOE) individually.

Watershed based methods will be most effective when the approach is driven by broader landscape needs and conditions rather than individual site needs. The results of this study provides refined existing data in support of CWA, SDWA, Endangered Species Act (ESA), Shoreline Management Act (SMA), and Critical Area Ordinance updates. This method represents a transition from a site-driven to a more holistic *landscape-driven* approach towards assessing ecosystem function and current ecological processes within a watershed.

This report presents the results of steps One, Two and Three of a six step process detailed in EPA's Watershed-Based NPDES Permitting Implementation Guidance drafted in 2003, and updated in 2007 to assess the feasibility of developing a watershed-based permit based on a watershed scale for the Totten and Eld Inlet basin. These steps are as follows:

- <u>Step One:</u> Select a Watershed and Determine the Boundaries
- <u>Step Two:</u> Identify and facilitate multiple jurisdictions to participate in a watershed-based NPDES permit or permit compliance approach using the EPA's guidance;
- <u>Step Three:</u> Collect and analyze data through a watershed characterization for permit development or permit compliance;
- <u>Step Four:</u> Develop watershed-based permit or permit compliance conditions and documentation.
- <u>Step Five:</u> Issue Watershed-Based NPDES Permit
- <u>Step Six:</u> Measure and Report Progress

Steps four, five and six have not been initiated as proposed, but it is anticipated that work will be completed during the first NPDES Phase I permit period (2007 to 2012).

This document presents the work of the technical team using Gersib et al. (2004) methods. *It is recommended that the reader review the methods prior to reading the report to better understand the results.* In addition, it is a culmination of refinements made by our technical team to meet the needs of Thurston County. The report provides a scientific approach to analyzing the ecological and biological processes that maintain a healthy watershed. The central goal of the watershed characterization work is to identify natural resource areas that could serve as stormwater retrofit sites to mitigate existing urban development in the Totten and Eld Inlets.

At a landscape scale, the Totten and Eld Inlet study subdivided the study area into 308 drainage analysis units (DAU) or catchments and used landscape attributes to characterize the condition of key ecological processes (movement of water, sediment, large wood debris, pollutants, and heat) and biological processes (aquatic integrity and upland habitat connectivity) that have been affected by past urban development. This is accomplished by interpreting existing land cover and natural resource data and by developing databases that identify the location and condition of wetland, riparian, and floodplain resources. The goal is to identify targeted landscape areas having the potential to optimize environmental benefits if restored.

The methods identify possible candidate wetland, riparian, and floodplain restoration sites through photo and Geographical Information System (GIS) interpretation of the study area. In addition to creating these natural resource datasets, a stormwater retrofit database was developed to provide additional options for treating stormwater in urban areas where few viable natural resource options exist.

The stormwater retrofit priority list is a sub-set of data intended specifically for identifying potential wetland, riparian, and floodplain restoration sites that have potential to mitigate stormwater quality and quantity impacts of past urban development. The natural resource restoration priority list is intended to identify sites that maximize overall ecosystem function. Finally, the fish habitat priority list ranks sites that have the potential to maximize habitat benefits to anadromous and resident fish species. Those sites are identified and used as a filter to avoid using natural resource sites for stormwater retrofits.

In the study area, it was determined that the Green Cove Sub-watershed was mostly altered by development with total impervious area (TIA) at 14% of the total watershed. These areas include the City of Olympia, as well as unincorporated Thurston County. The Mud Bay Sub-watershed had the second highest value for TIA at 11%. McLane Creek Sub-watershed is least impacted by urban development with only 2% TIA.

To identify and evaluate potential restoration opportunities, the methods used watershed characterization to identify the ecological and biological processes of each DAU. The methods also identified altered wetland, floodplain, and riparian resources. Each potential restoration site was put in the context of the existing landscape. The sites were then evaluated and prioritized for restoration. In the study area, we evaluated 395 riparian areas, 311 wetland areas, and 12 floodplain areas for a total of 718 potential sites. Those sites were further evaluated for potential stormwater retrofit sites that avoided fish habitat. By default, sites not identified high for restoration are candidates for preservation.

Of these sites, 214 potential wetland, floodplain and riparian restoration sites met our minimum criteria for potential use for restoration. Those sites were prioritized for optimizing overall ecosystem function within the DAU.

Background

This report summarizes a scientific framework for watershed characterization and describes a set of methods developed at the watershed scale to assist in better land use decisions. As a conceptual framework, this document serves as the key deliverable to Thurston County summarizing watershed characterization methods and developing key recommendations that other County departments, local jurisdictions, and other entities can use to help meet current and future environmental assessment and planning needs.

Watershed based methods will be most effective when the approach is driven by landscape need and condition rather than an individual site needs. The results will help to refine and provide new data to meet the needs of the Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Endangered Species Act (ESA), Shoreline Management Act (SMA), and Critical Area Ordinance updates. It represents a transition from a site-driven to landscape-driven approach to assessing current ecological processes of the watershed.

Despite dramatic increases in effort, legal mandates, and expenditures for environmental protection and restoration over the past 20 years, the overall condition of natural ecosystems continues to decline (Karr 1995, Montgomery et al. 1995). A growing body of work indicates that declines in ecosystem integrity are perpetuated by existing policies and traditional techniques that tend to treat local symptoms of resource degradation and fail to address the root biological and physical causes of ecosystem degradation and population decline. These policy and traditional techniques perpetuate a narrow "site" review and analysis that often results in restoration that treat symptoms of localized habitat/resource degradation rather than addressing the systemic causes of ecosystem degradation (Frissell 1996, Angermeier and Schlosser 1995, Montgomery et al. 1995, Reeves et al. 1995, Ebersole et al. 1997).

Thurston County was designated a National Pollutant Discharge Elimination (NPDES) Phase II jurisdiction in the 2000 census. Thurston County submitted a NPDES Phase II permit application to Ecology in March 2003. With the issuance of the NPDES Permit for Phase II communities in February 2007, Thurston County determined that a more holistic approach was needed to incorporate all the required regulations at the watershed level to promote efficiency in monitoring, analyzing, and reporting on the health of our water bodies. Current government efforts are segmented and have not proven to provide protection to Thurston County's streams and the Puget Sound.

This study provides substantial opportunity to blend developing watershed approaches with new modeling and assessment tools to develop outcome-based approaches that Thurston County Resource Stewardship, Strategic Planning, and Public Works, can use to make better land use decisions and management.

General Framework for Watershed Characterization

The following is a very brief summary of how watershed characterizations are conducted in Thurston County. The reader is encouraged to read the methods included in Appendix A to have a better understanding of the landscape indictors, the natural resource attributes, and rules and assumptions used to complete a landscape characterization.

Briefly, the general framework is as follows:

1. Define appropriate spatial scales to be used in watershed characterization;
2. Compile land use/land cover information for pre-development and current conditions and estimate the type and extent of future growth/development;
3. Develop an understanding of the ecological processes within drainages occurring in the area, identify key drivers for those processes, and begin to understand how past and present land use has altered processes and disturbance regimes;
4. Assess landscape sensitivity to process alteration and identify areas most sensitive and most resistant to development;
5. Characterize the general condition of ecological processes within the largest acceptable landscape scale;
6. Identify landscape areas having specific levels of degradation to targeted ecological processes under current conditions;
7. Assess the probability that processes within target landscape areas will be maintained over the long-term using the future build-out scenario; and
8. This framework employs and adapts the five-step strategy outlined by Beechie and Bolton (1999). A complete, detailed scientific framework for watershed characterization is presented in this document.

See Figure A which outlines the process of conducting a watershed characterization

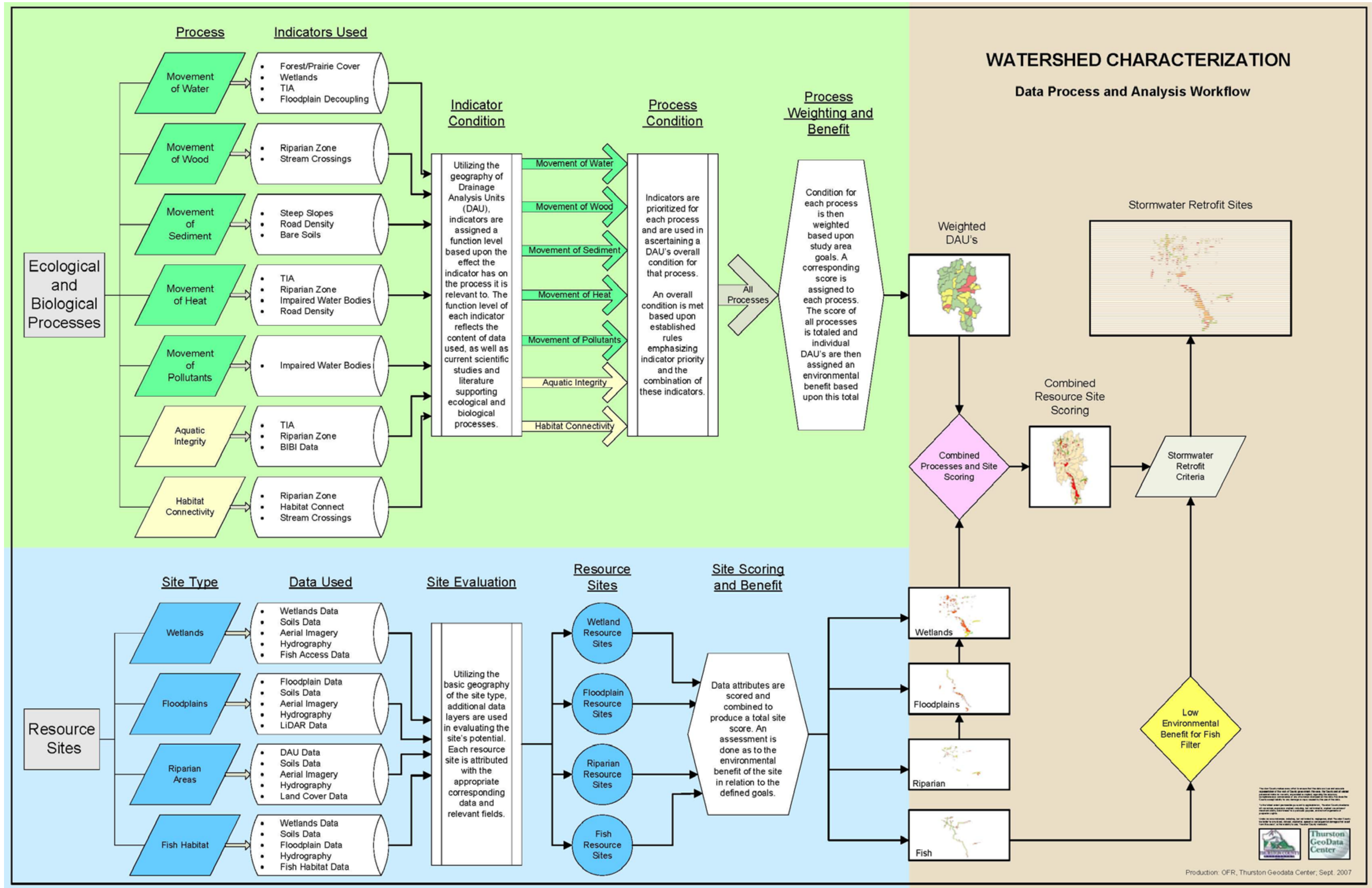


Figure A. Process flowchart

What is in this document?

This document presents the work of the technical team using Gersib et al. (2004) landscape characterization methods and our refinements made by our technical team to meet the needs of Thurston County, a local government. The report provides a scientific approach to analyzing the ecological and biological processes that maintain a healthy watershed. The goal of the watershed characterization work is to identify mitigation projects, restoration sites, and preservation sites to assist in improving watershed function and mitigating impacts from past urban development in the South Puget Sound watersheds, as well as identifying avoidance areas for future development. This work also identifies priority preservation sites that have been identified for potential purchase using Conservation Futures funds.

The methods characterize the condition of key ecological processes (movement of water, sediment, large wood, pollutants, and heat) and biological processes (aquatic integrity and upland habitat connectivity) that have been affected by past urban development. This is accomplished by interpreting existing land cover and natural resource data and by developing databases that identify the location and condition of wetland, riparian, and floodplain resources. Following a description of baseline conditions, areas are then identified that target landscape areas having the potential to optimize environmental benefits if restored.

At the site scale, all possible candidate wetland, riparian, and floodplain restoration sites are identified through photo and Geographical Information System (GIS) interpretation of the study area. In addition to creating these natural resource datasets, a stormwater retrofit database was developed to provide additional options for treating stormwater in urban areas where few viable natural resource options exist.

The stormwater retrofit priority list is intended specifically for identifying potential wetland, riparian, and floodplain restoration sites that have potential to mitigate stormwater quality and quantity impacts of past urban development. The natural resource restoration priority list is intended to identify sites that maximize overall ecosystem function.

What are the general findings of this study?

At the landscape scale, it was determined that the entire study area had a total impervious area (TIA) value of 4%, a coniferous forest value of 20%, a mixed forest value of 29%, and a grasses value of 14%. It should be noted that the TIA values include other landscape attributes (e.g., shadowing) where it couldn't be distinguished from impervious cover. Only the predominant land cover values are listed in the table. It should also be noted that effective impervious area (EIA) is a much stronger indicator for the delivery and routing of water. However, the data required, including stormwater infrastructure is difficult to acquire on a large scale. Thus, by default we use TIA to determine the delivery and routing of water.

Table 1 has the values of major land cover categories of the sub-watersheds

Table 1. Land Cover Values in the Study Areas

Sub-Watershed	Impervious Area (%)	Coniferous Forest (%)	Mixed Forest (%)	Grasses (%)
Kennedy Creek	2	19	36	18
North Schneider	4	21	25	14
South Schneider	2	16	42	15
East Totten	5	24	32	7
Summit Lake	3	17	25	11
McLane Creek	2	20	30	18
West Eld	4	20	29	14
South Eld	4	24	33	11
North Eld	6	24	26	5
Perry Creek	3	24	36	16
Green Cove Creek	12	14	22	9
Mud Bay	9	10	19	9

To identify and evaluate potential restoration opportunities, we used watershed characterization to identify the ecological and biological processes of each drainage analysis unit (DAU). We also identified altered wetland, floodplain, and riparian resources. We then used our understanding of landscape condition to place each potential restoration site in a landscape context. We evaluated and prioritized restoration sites in this context. In the study area, we evaluated 395 riparian areas, over 311 wetland areas, and 12 floodplain areas for a total of 718 potential sites. Those sites were further evaluated for potential stormwater retrofit and fish habitat potential.

Of these sites, 214 potential wetland, floodplain and riparian restoration sites met the minimum criteria of potential use for restoration. Those sites were prioritized for optimizing overall ecosystem function within the DAU.

Introduction to Watershed Characterization

What is watershed characterization?

Watershed characterization is a series of steps that identify, screen, and prioritize hundreds of potential wetland, riparian, and floodplain restoration sites. These steps focus on gathering ecological and biological watershed data needed to identify where landscapes are and are not functioning properly, where degraded natural resources exist, and where to target restoration to maximize environmental benefits. In the end, this analysis will allow Thurston County to choose restoration sites that will provide the greatest function, have a high probability of being successful, and ensure that we get the highest value for our investments.

Through watershed characterization, the technical team seeks to integrate the restoration of wetland, riparian, floodplain, and stormwater impacts by restoring the landscape's capacity to function. We do this by assessing the condition of ecological processes, such as the movement of water, sediment, pollutants, large wood, and heat and aquatic integrity and upland habitat connectivity. We then target restoration to degraded natural wetlands, riparian areas, and floodplains having the greatest potential to mitigate past development impacts and result in measurable environmental benefits.

How is a watershed characterization conducted?

Watershed characterization consists of four key steps.

In Part I, the condition of landscape-scale ecological processes and the extent of human alteration to these systems is analyzed. Key physical processes include the movement of water, sediment, pollutants, large wood, and heat through stream systems within the study area. Key biological processes include aquatic integrity and upland habitat connectivity.

At a landscape scale, the Totten and Eld Inlet study area was subdivided into 308 drainage analysis units (DAU) catchments and multiple landscape attributes were used to characterize how land use change has altered the natural movement of water, sediment, pollutants, and large wood, along with aquatic integrity and upland habitat connectivity. This information was used to target restoration efforts within landscapes that have the greatest potential to restore and maintain environmental benefits over the long-term.

In Part II, natural resource sites (wetlands, riparian, and floodplain) were identified that have the potential to mitigate past development if restored.

Site datasets for wetlands, riparian areas, and floodplains were created which were then used to identify potential restoration sites. Stormwater retrofit projects were identified that could address existing stormwater runoff problems. Existing data and extensive photo interpretation were used to develop wetland, riparian, and floodplain datasets. These datasets differ significantly from existing natural resource data, such as local and state agencies might develop, in that they identify potential restoration sites rather than inventorying existing wetlands, riparian areas, and floodplains.

These potential restoration sites include intact existing wetlands and degraded or destroyed wetlands that have potential, if restored, to meet mitigation needs. The technical team established both site and landscape criteria to evaluate and rank potential floodplain, wetland, and riparian restoration and stormwater retrofit sites.

This process results in two prioritized restoration site lists; one for potential natural resource restoration sites (with potential floodplain, wetland, and riparian restoration sites); and one for potential stormwater retrofit sites using natural resource sites that avoid high quality fish habitat.

In Part III, the ecological benefit of each DAU and the environmental benefit of each resource site is assessed.

In Part IV, potential restoration sites are identified and ranked.

More details on methods used in watershed characterization can be found in the Appendix A of this report.

As the Gersib et al., 2004 methods were applied, it was determined that the methodology needed to be updated and refined. In applying the Gersib et al methods, the following modifications and/ or clarifications were made:

- The indicator "percent change in drainage network" in the matrix was not used in some areas. This was necessary because we did not have sufficient stormwater infrastructure data.
- Further defined "mature forest" to mean "hydrologically mature forest" (Douglas fir 25 years old) (WADNR 1999).
- A "prairie landscape" was added to the matrix. Some studies indicate that the addition of impervious surface over outwash soils has a larger hydrological effect than covering till soils (Brascher, 2006).
- There is the need to develop better indicators for the "movement of sediment". The original use of the matrix was for forestry activities. In an urban environment, with required stormwater best management practices (BMP), cleared earth is typically paved within a limited amount of time, thus no bare soils in the DAU. The exception would be agricultural activities, but they are also temporarily exposed prior to replanting.
- The Totten and Eld Inlets do not include the typical altered floodplain as regulated under the Federal Emergency Management Agency (FEMA).
- There was a lack of data for the condition process "movement of pollutants" thus only areas that had data were analyzed.
- 67 meter buffers were applied throughout the analysis vs. 33 meter, as stated in the matrix for the movement of heat. The 67 meter buffer reflects the standard aquatic buffer that Thurston County currently has in effect, and the 67 meter also accounts for stream layers that are inaccurate.

- The rules and assumptions were updated and developed based on best available science.
- The stormwater retrofit ranking criteria was modified to avoid high quality salmonid habitat.
- Attributes for initial natural resource site identification and condition descriptions were standardized (e.g. a value given for adjacency to public lands).

Further work is required to improve the Gersib et al 2004 methods for future watershed characterizations:

- While estuarine and marine landscape indicators exist in various forms we did not find them complete enough to use in this analysis. The best available science for the nearshore condition includes the Squaxin Island Tribe's nearshore model.
- Thurston County's FEMA maps are outdated and incomplete. Future goals include updating the Federal Insurance Rate Maps (FIRM) using LiDAR.
- Thurston County's stormwater infrastructure maps are incomplete. This data is essential to fully understand the delivery and routing of water. Thurston County has initiated an aggressive program of collecting stormwater infrastructure data to better analyze the movement of water.
- Aquatic integrity and habitat connectivity indicators could be further defined and improved. Based on this work, Thurston County added additional Benthic Indicator Biotic Indicators (BIBI) sites in our proposed study areas to assess aquatic integrity. Additionally, Thurston County is exploring conducting habitat connectivity for specie specific habitat connectivity.

How was local information and expertise acquired and used?

An important part of the watershed characterization effort is coordination with local and regional governmental entities and watershed groups. The reasons for doing this are:

- To ensure that local natural resources managers and interest groups are aware of what studies are being conducted within their area, what a watershed characterization is, and how it works.
- To gain insight into local permitting criteria and policies.
- To ensure that information developed through watershed characterization is compatible with existing planning efforts by local, tribal, or regional governments, whenever possible.
- To acquire locally developed datasets of relevance to watershed characterization.
- To identify and acquire local watershed recovery plans, priorities, and locally identified restoration opportunities.

An integral part of watershed characterization is the identification and use of locally identified themes. These themes are included in Limiting Factors Analyses, watershed plans, salmon recovery plans, etc. The local themes are used, in part, to establish criteria for prioritizing potential restoration sites.

Draft and final reports containing watershed priorities for habitat restoration, salmonid recovery, water quantity and base flow improvements, and water quality improvements were reviewed for incorporation into the ranking of potential restoration sites.

Each of these documents contains locally defined projects or targeted stream reaches for water quality enhancement, runoff control, ecosystem recovery, salmon recovery, sediment control, flood amelioration, or similar benefits. We matched locally identified recovery sites to sites identified through watershed characterization and used this information to help prioritize our candidate restoration sites found in Appendix C.

What are the project deliverables?

Watershed characterization deliverables for the Totten and Eld Inlets Study are:

- Extensive documentation of technical methods, assumptions, and results of watershed characterization in a manner that is comprehensive and understandable.
- Extensive information on the landscape condition of key ecological processes.
- Potential wetland, floodplain, riparian, stormwater retrofit, and fish habitat data layers with all site-specific data.
- A prioritized list of potential natural resource restoration sites for overall ecosystem function in the study area.
- A prioritized list of potential natural resource preservation sites.
- A list of potential Stormwater restoration sites that avoid high quality salmonid habitat sites.

The goal is to make this report clear and understandable to the average person, while still providing all of the technical documentation necessary to support science-based decision-making. To do this, there is a multi-level presentation:

- In the main report body, the format seeks to "tell the story" of the study area and of the results
- Detailed step-by-step results are provided in the appendices
- The technical methods in a separate methods document (Appendix A)
- The GIS data, modeling assumptions, and other technical details are available electronically upon request or on the website

It is hopeful that this format will be more understandable for the non-technical reader and yet ensure that all methods, data, assumptions, and results are readily accessible to technical and regulatory reviewers.

What are the limitations?

The most significant limitation of the results is the data used in the analysis. While the study utilized relatively recent satellite data (SPOT imagery August 2005 and LiDAR 2001), other coverages used include 2005/2006 aerials and other state data. Thus, the landscape has probably significantly changed, and thus all sites should be verified as still available (e.g., not developed).

Another caveat is the Department of Natural Resources (DNR) stream hydro layer used in the analysis. When the DNR hydro layer was compared to LiDAR data, it was obvious that the stream layer is not accurate in some reaches. To compensate for the errors we applied a 67 meter buffer vs. a 33 meter buffer as detailed in the original methods.

The Study Area

What is the study area and how was it defined and subdivided for analysis?

The Totten and Eld Inlets Study Area is shown in *Figure 1. Totten and Eld Inlet Study Area*. The study area was delineated using LiDAR data. Multiple scales were established including approximately 0.25 sq mile DAUs, 12 sub-watersheds, and the entire Totten and Eld study area. These scales were based on the Center for Watershed Protection definitions and the goal of the study to develop stormwater retrofit sites (Zielinski, 2002). The analysis used the 0.25 sq mile DAUs, sub-watersheds, and the watershed (Figure 2. Study Area Drainage Analysis Units). The delineation excluded all direct discharges to Budd Inlet

Potential Restoration Opportunities

Potential natural resource restoration sites were determined by assessing several ecological and biological landscape indicators that were then used to assess the ecological and biological processes at the DAU scale.

Step One: Follow the Matrix and Pathways of Landscape Indicators (Matrix) to assess biological and ecological processes at the DAU scale.

Step Two: Identify potential natural resource sites using aerial photos and other GIS data in the study area.

Step Three: Determine current state of all ecological and biological processes at the DAU scale to determine their ecological benefit to maintain sites if restored.

Step Four: Rank natural resource sites for their environmental benefit if restored.

How were preservation and restoration sites identified?

The goal of this study was to determine natural resource sites that can be restored to provide greater function in the DAU to mitigate past disturbances, specifically the movement of water. By default, all natural resource sites not ranked medium or high for restoration can be assumed to be of high ecological value for avoidance and preservation.

There are two essential steps to identify and assess natural resource sites; determine the ecological and biological processes at the DAU scale using the Matrix; and identify all degraded natural resource sites in the study area. These two data sets are the foundation of the watershed characterization.

The matrix was used to identify DAUs that are “properly functioning” (PF), “at risk” (AR) or “not properly functioning” (NPF) for the five ecological processes (movement of water, wood, sediment, pollutants, and heat), and the two biological processes (aquatic integrity and habitat connectivity).

The natural resource site (potential wetland, riparian, and floodplain restoration sites) datasets were determined primarily through aerial photo and LiDAR interpretation of the study area and supplemented by existing natural resource inventories, and locally identified natural resource recovery areas. See the revised watershed characterization methods document (Appendix A) for detailed descriptions of the methods specific to the development of each natural resource database.

How were preservation and restoration sites prioritized?

The focus of this work is to identify natural resource sites that can be restored with a high probability of success given their location in the landscape. All natural resource sites having a low restoration value are assumed to have a high avoidance and preservation value.

Based on the needs within the study area, three priority restoration site lists were developed. The first, a natural resource restoration priority list, identifies and prioritizes potential wetland, riparian, and floodplain restoration sites having potential to maximize environmental benefit within the study area. The second is a list of restoration sites that are prioritized for anadromous fish habitat restoration. The third, a stormwater quality and quantity restoration priority list, identifies and prioritizes potential wetland, riparian, and floodplain restoration sites having potential to provide stormwater water quality improvement within the study area.

Data on the following key environmental attributes were compiled on each candidate restoration site:

- All ecological and biological process condition rankings
- Anticipated environmental benefits gained if the resource is restored
- Type of natural resource
- Site targeted for restoration in a local or regional recovery plan
- Site on or adjacent to publicly owned land
- The size of the candidate restoration site

Detailed methods for prioritizing natural resource restoration sites are described in Appendix A and detailed data and results are presented in Appendices B and C.

When developing the priority list for natural resource restoration, all potential riparian, wetland, and floodplain restoration sites were initially considered candidates for natural resource restoration. Attributes of each candidate site were then compared to criteria established for all landscape attributes. These sites were further evaluated based on the DAU ecological rank of PF, AR, or NPF. This process eliminated sites from further consideration and, at the same time, ranked remaining sites. The resulting potential natural resource sites environmental benefit lists are presented in Table 2.

The potential natural resource restoration site database consists of 718 polygons that were created in ArcMap as a data layer, including:

- 395 unique wetland sites
- 311 unique riparian sites
- 12 unique floodplains sites

Table 2. Potential Natural Resource Restoration Sites

All Potential Resource Sites				
	Wetland	Riparian	Floodplain	Total
Totten Drainages				
Kennedy Creek	28	22		50
North Schneider	37	46		83
South Schneider	9	13		21
East Totten	30	18		48
Summit Lake	7	20		27
Eld Drainages				
McLane Creek	38	51	6	95
West Eld	80	60		140
South Eld	11	11		22
North Eld	11	6		17
Perry Creek	24	35		59
Green Cove	22	17	6	45
Mud Bay	13	20		33

We initially considered all potential riparian, wetland, and floodplain restoration sites when developing the priority list. Attributes of each candidate site were then evaluated using established criteria. This process eliminated sites from further consideration and ranked remaining sites.

After criteria were applied to the initial site database, a total of 214 sites were further evaluated to determine if they could be viable as stormwater retrofit sites (see Table 3).

Table 3. Actual Natural Resource Restoration Opportunities

Resource Sites			
	Wetland	Riparian	Floodplain
Totten Drainages			
Kennedy Creek	11	23	
North Schneider	12	22	
South Schneider	2	4	
East Totten	4	1	
Summit Lake	1	4	
Eld Drainages			
McLane Creek	11	26	0
West Eld	21	21	
South Eld	1	4	
North Eld	2	1	
Perry Creek	8	13	
Green Cove	4	6	2
Mud Bay	3	7	
TOTAL	80	132	2

What are the preservation and restoration opportunities within the study area?

Based on the site's environmental ranking and the ecological process rank of the DAU that it resides in, a total of 214 potential wetland, riparian, and floodplain restoration sites met minimum ranking criteria and were prioritized. These sites were further evaluated for stormwater retrofit sites and fish habitat sites. These prioritized lists and data used in the prioritization process are presented in Appendix C.

Were any of the sites given closer examination?

Upon availability of the 2009 aerial photography, the sites will be verified as still existing. If sites are still available (haven't been developed), then an economical analysis will be completed to determine which sites are viable and practicable to pursue further for restoration and/or preservation opportunities.

How should this information be used?

The information in this report should be used as the first screening tool to evaluate restoration opportunities in the sub-watersheds in the study area. The prioritized sites list can be used to select projects that provide the greatest ecological benefit if restored. The information should also be used to rank preservation sites for Conversation Futures purchases.

Conditions of Natural Resources in the Study Area

All the candidate floodplain, wetland, and riparian restoration sites using aerial photo interpretation have been analyzed, but only a limited number have had preliminary field verification. The potential restoration site priority lists developed through watershed characterization should be considered as the starting point for a more extensive site assessment effort by project environmental staff or their consultant support. This is, in reality, recognition that the selection of the best potential restoration sites requires both a landscape-scale assessment and a detailed site-specific analysis.

Watershed characterization products are limited by the number, location, and extent of potential wetland, floodplain, and riparian restoration sites within the study area to mitigate past development. The goal of a watershed characterization is to eliminate or reduce the need for hard stormwater infrastructures, such as a conveyance system to engineered ponds, and use the natural function of the resources as a benefit to flow control.

What are the conditions in the Totten and Eld Inlet study area?

The Totten and Eld Inlet study area drains 73.5 sq miles. Draining to Totten Inlet includes Kennedy Creek, Schneider Creek, Summit Lake, and various unnamed tributaries. Draining to Eld, includes McLane, Perry, and Green Cove creeks, as well as various unnamed tributaries (see Figure 3. Study Area Sub-Watersheds).

Totten and Eld Inlets, located in Thurston County, are two of five inlets that form the southern terminus of Puget Sound. It is located between Budd Inlet on the east and Totten on the west.

Pre-development land cover

Eld Inlet has long played an important role in Thurston .County's history and economy. The rich shellfish beds in Eld Inlet provided a steady source of foods for the Indian tribes who lived in the region. In 1841 a Navy sloop, the U.S. Vincennes, commanded by Lt, Charles Wilkes, explored and charted the inlets and channels around the Cooper Point Peninsula while on a surveying expedition.

Many of the well-known geographic features throughout the Puget Sound region were named by Wilkes for the seamen on that expedition. Among these men, was Thomas Budd, acting master of the Vincennes; midshipman Henry Eld; and John Cooper, an armorer. In 1845 Michael T. Simmons led a group of settlers across the Columbia River and north to the Olympia area. After founding the town of Tumwater, the Simmons family later settled in the southwest corner of the Cooper Point peninsula on Mud Bay.

In 1853, natural beds of Olympia oysters were found in Budd Inlet, and soon a new industry began. The Brenner brothers were among the first settlers to industrialize the oyster. The Callow Act and the Bush Act enabled all occupants of the oyster lands to own their property, and deeds were awarded to both the Indians and the white settlers. As other industry started to appear on the Sound, a pulp mill began operation in Shelton in 1927, adversely affecting the shellfish industry in the south Sound. Members of the Olympia Oyster Growers Association took on the long battle to keep the delicate Olympia Oyster alive. Experimentation with Pacific oysters showed that it was a hardier species and soon brought improvement to the industry. Today, there are multiple commercial growers of clams, oysters, and mussels operate in Eld Inlet. The shellfish industry in Eld Inlet is expanding, as well, as efforts are made to seed geoduck clams in the sub-tidal waters of Eld Inlet.

Early settlers to the region were able to take the clean waters of Eld Inlet and its tributaries for granted. There were so many shellfish, so many salmon, so much clean water, and so few people. The decimation of the Olympia oyster beds in the late 1920's by the Shelton pulp mill was one of the early indications that our natural resources are fragile.

In the late 1970s and early 1980's people in south Puget Sound became aware of a threat to the good water quality previously enjoyed by the region. That threat was from Nonpoint Pollution. Previous studies had pointed to sewage treatment outfall pipes and industrial plant effluent as the source of pollution. New research was pointing to a more diffuse source--one that we all shared a part in. That source of pollution, called Nonpoint because it doesn't come out of the end of a pipe, comes from such sources as failing septic systems, livestock wastes, untreated stormwater, wastes from boats, sediments washed off cleared lands. Early in the 1980's six areas of Puget Sound were closed either totally or intermittently to commercial shellfish harvesting because of bacterial contamination mostly from nonpoint sources of pollution. During the previous ten years, no closures had occurred. The southern portion of Eld Inlet was one of the areas that was closed intermittently to commercial shellfish harvest. During heavy rainfalls, bacterial pollution is washed into the Inlet from the watershed, causing water to exceed commercial water quality public health standards (Eld Inlet Watershed Action Plan, October 1989).

Current conditions

The topography of the Eld watershed is best described by dividing the .watershed into three parts: the Cooper Point peninsula, the Griffin peninsula (also called the Steamboat Island peninsula), and the Delphi Valley. The Inlet itself has about 30 miles of shoreline with its widest section stretching 7,000 feet between Frye Cove on the west and Countryside Beach on the east. The Cooper Paint peninsula extends 7-1/2 miles into ·the southernmost reaches of .Puget Sound.

While its narrow northern end is less than a mile across, it widens to over four miles toward its southern end. The land rises steeply from the coastal beaches, with banks often reaching a height of 100 feet within 500 feet of the beach. The steep slopes are indented many places by draws, ravines and gullies holding small, seasonal stream courses. The one significant exception to this coastal topography is the estuarine area at the southwest comer of the peninsula where the land adjacent to Mud Bay is very low and flat, only a few feet above high tide level.

In the interior of the peninsula the land is a rolling terrace punctuated by small depressions and a few low hills. At the northern end of the peninsula the land rises gradually and smoothly to a center spine that is rarely more than 50 feet higher than the top of the coastal bluffs. This center spine defines the easternmost boundary of the watershed. To the south a low hill rises in the west. It reaches a height of 243 feet just west of The Evergreen State College core area.

Surrounding this hill is land of low relief with several shallow, closed depressions holding wetlands. A broad low, valley, containing the principal stream on the peninsula, runs north along the eastern boundary of the watershed. This stream, Green Cove Creek, flows through a sizable ravine that leads to Green Cove on Eld Inlet.

The topography of the Griffin peninsula is similar to that of the Cooper Point peninsula. The Griffin peninsula extends six- miles into Puget Sound. Sections of the shoreline rise sharply from the beach. The steep banks, varying from 5 to 80 feet in height, are indented occasionally by gullies, draws and ravines carrying seasonal runoff into Eld Inlet. Small creeks and seasonal drainage flow into Sanderson Harbor, Frye Cove, and Young Cove.

The interior of the northern section of the peninsula is a forested plateau of rolling hills and small depressions. The terrain of the southern areas has fewer variations. The Delphi Valley and surrounding Black Hills exhibit a wide variety of topography. The highest point is 807 feet in the Black Hills north of Black Lake, while the lowest is Mud Bay at sea level.

The Black Hills are steep and sharply dissected by fast-flowing streams. Perry Creek, McLane Creek, and Swift Creek are the major streams that have their headwaters in the Black Hills and flow through this area. The Delphi Valley sits at the base of the Black Hills and provides a broad valley through which McLane and Swift Creeks flow. Because of the varied topography of the Eld watershed, wetland areas dot the watershed. Wetlands are defined as areas that are "inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." (excerpted from the Thurston County Zoning Ordinance) The Griffin Peninsula contains small scattered wetlands, particularly in the vicinity of Young Road. On the Cooper Point Peninsula, the largest wetland is the one along Green Cove Creek as it flows along Kaiser Road. This one originates in the Grass Lakes area. There are numerous other wetland areas scattered throughout the Peninsula. At the southern end of Eld Inlet there are extensive wetlands in the Mud Bay area. Some of these areas have drainage channels and are grazed' by cattle. In the Delphi Valley there are wetlands associated with McLane Creek Along Perry Creek, there are extensive wetlands, particularly at the headwaters of the creek. (Eld Inlet Watershed Action Plan, October 1989).

Kennedy Creek basin has a drainage area of 17.76 square miles. Approximately 9.6 miles long, this is by far the largest tributary to Totten Inlet. The creek originates in the Black Hills and descends gradually to lowlands. With the exception of a series of falls, cascades, and log jams at river mile 2.5, the rest of the creek is rather gentle in slope. Almost half of the watershed is used for forestry. Much of the rest is undeveloped.

The Green Diamond timberland on Kennedy Creek extends from the public fish viewing area (about a mile upstream of the mouth of Kennedy Creek) to just below the mouth of the tributary that drains Summit Lake into Kennedy Creek. Water quality issues related to forest practices on Green Diamond timberland are covered by a habitat conservation plan.

There is scattered residential development and small commercial areas in the upper watershed, above Green Diamond timberland. There is sparse development below the Green Diamond timberland, near the mouth of the creek. Summit Lake discharges to Kennedy Creek, although the discharge usually stops in late summer. There is recreational use throughout the watershed. Kennedy Creek is one of the highest chum producing streams in Washington State (Washington Department of Fish and Wildlife 2000). The creek discharges to the head of Totten Inlet.

Four percent of the entire Totten and Eld study area is covered by urban land uses (see Figure 4 and 4a, Classification Percent Totals for the Totten and Eld Study Area).

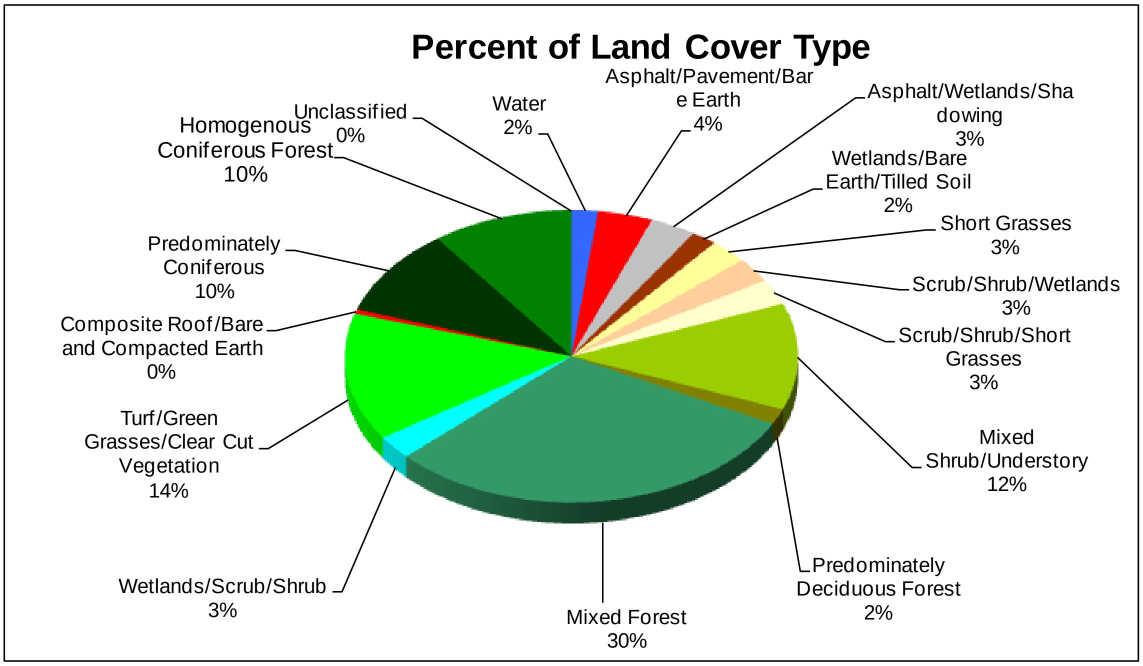


Figure 4a. Classification Percent Totals for Totten and Eld Study Area

Land cover data derived from 2005 SPOT imagery.

In addition to classifying land cover in the study area, 14 landscape indicators were evaluated (see Figure 5, Landscape Indicators). We analyzed the condition of each of the following indicators within each DAU:

1. Forest Land Cover
2. Prairie Resources
3. Wetlands-Assimilative capacity and hydro alteration
4. Total Impervious Surface (TIA)
5. Riparian Zones
6. Steep Slopes
7. Habitat Connectivity
8. Impaired Water Bodies
9. Benthic Indices of Biotic Indicators (BIBI)
10. Road Density
11. Stream Crossings
12. Stream Channel Straightening
13. Floodplain Decoupling
14. Bare Soils
15. Heat
16. Pollutants

The current condition of each DAU was determined to be “properly functioning”, “at risk” or “not properly functioning” based on methods detailed in the Matrix (see Appendix A for complete methods).

Hydrogeology and groundwater recharge

With the exception of the Black Hills area, which was formed during the earlier Tertiary Period, the Griffin and Cooper Point peninsulas were formed during the Ice Age. Beginning 2.5 million years ago at the beginning of the' Ice Ages, at least four times the Puget Sound Lowlands were invaded' by glacial ice from the north, retreating most recently only 10,000 years ago. Two main glacial advances are most important to the watershed: the Salmon Springs glaciation and the later Vashon glaciation. Each time the massive glacier advanced, it dammed up the Puget lowlands so that a huge lake was formed. The outlet for its waters was through the Black and Chehalis River valleys, since the Straits of Juan de' Fuca were blocked by the ice. On the bottom of the lakes, "rockflour", the finely ground remains of rocks pulverized by glacial action settled out. These deposits became the familiar "blue clays" of the Puget lowland. Each time the ice age glacier advanced, it also compacted underlying sediments with its great weight and deposited a concrete like material called "till" (or hardpan) beneath it. Each time it retreated, water from the melting ice deposited thick layers of sand and gravel known as “outwash.”

Each of these glacial sediments, clay, till, and outwash, is present from place to place in the watershed and in varied combinations. They provide both the formations that hold the ground water for the area's wells, and the parent material for most of the different soils.

The following descriptions discuss the composition of the different geological formations present in the watershed:

1. **Volcanic bedrock** underlies the Black Hills and most of the area's glacial deposits. It is unreliable as an aquifer.
2. **Pre-Salmon Springs deposits,** generally of clay and silt, include some highly productive confined aquifers. These deposits should supply much of the groundwater for future wells on the peninsulas.
3. **Salmon Springs Drift** underlies most of the watershed at a maximum altitude of about 30 feet above mean sea level. It is the source of water for almost all of the deep wells on the upland areas. These wells generally penetrate the regional water table at or within a few tens of feet above sea level. The Drift, which has relatively low permeability, but is important as an aquifer, is missing in places and is rarely more than 30 feet thick (although it can be up to 90 feet thick in places).
4. **Kitsap Formation** is unimportant as an aquifer in Thurston County. Its fine-grained sediments are relatively impermeable. It does, however, play a significant part in the occurrence of ground water underlying the peninsulas in that it confines water in the underlying Salmon Springs Drift at some places. In other places the Kitsap Formation effectively retards the downward percolation of water thereby causing storage of large volumes of water in the overlaying deposits of Vashon Advance Outwash or Colvos Sand.
5. **Vashon Advance Outwash and Colvos Sand** are sands and gravels deposited by the advancing Vashon glacier. They are generally of moderate permeability and are the source of

many domestic supplies throughout the peninsulas where the deposits are under water table conditions.

6. **Vashon Till** in gravelly clay, has a very low permeability and is not a source of water. It plays an important role in the availability of groundwater, however. Till acts as an effective barrier that retards the downward percolation of water, and perched zones of water often occur on and within its upper parts.
7. **Vashon Recessional Outwash** are gravels and sands deposited with the retreat of the Vashon-glacier. Below the water table it is an excellent aquifer. Wells that tap the Vashon recessional outwash and till are located chiefly on the higher parts of the watershed, about 100 to 160 feet above sea level. The water is either perched above the till, in the outwash, or is within the till. Permeabilities are generally low and these wells normally yield only enough water for small scale domestic use. Late summer water levels are so low in many of these wells that the supplies are not dependable.
8. **Recent Alluvium** deposits are silts and sands deposited after the complete recession of the Vashon ice sheet. Generally, the alluvium is a shallow valley fill covering the underlying deposits. Large ground water supplies can be developed from alluvium deposits. The valley bottom of McLane Creek is a principal example of recent alluvium deposits in the watershed (Eld Inlet Watershed Action Plan, October 1989).

Water quality

Totten and Eld Inlet and several of its tributaries are on the 303(d) list of water bodies not meeting water quality standards for at least one water quality parameter. Some waterbodies are not currently on the 303(d) list, but they do not meet water quality standards. The parameters of concern include fecal coliform bacteria, dissolved oxygen, pH, and temperature (Ecology TMDL 2006).

Table 4. Tributaries to Totten, Eld, and Little Skookum inlets on the 2004 303(d) list for fecal coliform bacteria and temperature.

Inlets	Tributaries	Listing[a] Parameter	Location on the Creek	Township	Range	Section	Listing ID
Totten	Pierre Creek	FC	Near mouth	19N	3W	27	40958[b]
	Burns Creek	FC	Near mouth	19N	3W	27	40605[c]
	Kennedy Creek	Temp	125m above Old Olympic Hwy bridge	19N	3W	32	23545
		FC					41736
	Schneider Creek	FC	Near mouth, RM 0.3	19N	3W	33	12583
Eld	McLane Creek	FC	RM 0.2	18N	3W	24	12581
				18N	2W	19	41707
	Perry Creek	FC	RM 1	18N	3W	13	12582
		FC	RM 2.2 @ Hwy 108				7601

[a] FC = fecal coliform; Temp = temperature
[b] the 2004 303(d) list contains other FC listing IDs which will be consolidated to a single listing ID of 40958
[c] the 2004 303(d) list contains other FC listing IDs which will be consolidated to a single listing ID of 40605

Fish Resources

Totten Inlet Stock

Wild spawning in Kennedy Creek accounts for the majority of fall chum production from Totten Inlet. Spawning begins in November with the peak in mid-November, early for fall chum. This timing separates the fish from Skookum Creek stocks. Kennedy Creek fall chum are genetically unique when compared to other Puget Sound chum. The stock was considered "healthy" in 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Escapement from 1968 to 1992 ranged from 1,100 to 35,000, averaging 10,700 fish. Escapement declined in the late 1970s when a hatchery rack was installed to collect broodstock for a South Sound chum enhancement program. The program was discontinued and the run recovered, averaging about 16,000 fish from 1984 to 1992 (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 19,200 to 85,300 between 1993 and 2000. Mean escapement for that period was 38,700 (Baranski 2002, personal communication (Salmonid Habitat Limiting Factors Water Resource Inventory Area (WRIA) 14 (Kuttle, 2002)

WRIA 14's streams support two species of salmonids, chum and coho, as well as winter steelhead and coastal cutthroat. These species also use nearshore areas, along with chinook salmon, which were listed under the Endangered Species Act (ESA) in 1999. Steelhead were listed under the ESA in 2007. The limiting factors analysis conducted for the WRIA 14 salmon recovery plan indicates that salmonid habitat has been degraded by land use practices associated with forest management, removal of large woody debris (LWD), development, and agriculture. Other issues include culvert problems, nearshore habitat and riparian degradation, loss of channel complexity, and high sedimentation levels.

Eld Inlet Stock

The primary fall chum spawning streams in Eld Inlet are McLane, Swift (both in WRIA 13), and Perry Creeks. Spawning occurs from late-November to early January, relatively broad compared to other fall chum stocks. The stock is unique genetically from other Puget Sound chum stocks (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Chum were not planted in either Swift or Perry Creeks. Hood Canal chum were planted in McLane Creek from 1976 to 1983. The stock was characterized as "healthy" in 1992. Escapement from 1968 to 1992 ranged from 4,300 to 37,600 fish and averaged 14,800 for that period. Stock abundance was stable and showed signs of increasing (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). More recent escapements have been good, ranging from 26,600 to 89,900 between 1993 and 2000, with a mean escapement of 50,400 for that period (Baranski 2002, personal communication).

Table 5. Salmon and Winter Steelhead Distribution for Totten and Eld Inlet Streams.

Inlet	*Stream Name*	*Species*	*Uppermost Distribution River Mile (RM)*
Totten			
	Kennedy Creek	Chinook	2.5
		Coho	2.5
		Chum	2.5
		Steelhead	2.5
		Cutthroat	2.5
	Schneider Creek	Coho	5
		Chum	5
		Steelhead	5
		Cutthroat	5
Eld			
	McLane Creek	Chinook	0.9
		Coho	1
		Chum	2
		Cutthroat	3.5
	Swift Creek	Chinook	1
		Coho	1
		Chum	1
		Pink	1
		Cutthroat	1
	Beatty Creek	Coho	1
		Cutthroat	1
	Perry Creek		
	Green Cove Creek	Coho	3.4
		Chum	1.8
		Winter steelhead	3.4

The Washington State Conservation Commission report on Habitat Limiting Factors for WRIA 13 (Haring and Konovsky, 1999) and Washington State Conservation Commission report on Habitat Limiting Factors for WRIA 14 (Kuttle, 2002)

Shellfish Resources

The cool, clean waters of South Puget Sound provide some of the finest shellfish habitat in the world and present an array of recreational, commercial and tribal harvest opportunities. Commercial production of oysters, clams and mussels from these waters and tidelands contribute significantly to Washington’s position as the nation’s leading producer of farmed bivalve shellfish, generating nearly $97 million in 2005. The commercial shellfish industry is thriving, demand is expanding in markets worldwide, and clean water is the essential catalyst for continued success.

Shellfish Classifications

The Washington Department of Health (DOH) monitors levels of fecal coliform bacteria in the marine waters to determine suitability for shellfish harvesting. The department also periodically surveys shorelines and drainages to look for pollution problems that might affect the growing areas.

Four of the five South Sound inlets are classified for commercial shellfish harvesting, and the classification of these areas tends to correlate with population and development levels in the adjacent watersheds (Table 1). Budd Inlet, with the most developed of the five watersheds, has been closed to shellfish harvesting for decades. In contrast, Totten Inlet, with the least developed watershed, has never been closed due to fecal pollution. DOH closed a portion of Eld Inlet in the early 1980s because of fecal pollution, then reopened much of the area in 1998 following successful control of the pollution sources and improvements in water quality. The work in Henderson Inlet has been more challenging due largely to the scale and complexity of the pollution problems and continued population growth and urbanization in the watershed. In Nisqually Reach, the story has been more mixed, with both downgrades and upgrades over the past 15 years, but with some notable successes in recent years due to targeted cleanup efforts. DOH also oversees an early warning system to help identify and respond to declining conditions in shellfish growing areas. Since the system was first instituted in 1997, Totten Inlet has not yet appeared on the annual list of "threatened shellfish growing areas," while at least a portion of Eld Inlet has been listed four times, Nisqually Reach four times, and Henderson Inlet nine times through 2005 (Thurston Regional Planning Council. 2006. South Puget Sound Forum Indicators Report).

Area	Year	Acreage	Classification Change
Totten Inlet	*no classification changes – approved for commercial harvest*		
Eld Inlet	1983	690 acres	↓ downgraded from Approved to Conditional
	1998	450 acres	↑ upgraded from Conditional to Approved
Budd Inlet	*no classification changes -- prohibited for commercial harvest*		
Henderson Inlet	1984	180 acres	↓ downgraded from Approved to Conditional
	1985	120 acres	↓ downgraded from Conditional to Prohibited
	2000	8 acres	↓ downgraded from Conditional to Restricted
	2001	300 acres	↓ downgraded from Approved to Conditional
	2005	49 acres	↓ downgraded from Conditional to Prohibited
Nisqually Reach	1992	1000 acres	↓ downgraded from Approved to Conditional
	2000	74 acres	↓ downgraded from Conditional to Restricted
	2000	20 acres	↑ upgraded from Conditional to Approved
	2002	900 acres	↑ upgraded from Conditional to Approved
	2002	60 acres	↑ upgraded from Restricted to Approved

Table 1. Commercial shellfish classifications for Totten Inlet, Eld Inlet, Budd Inlet, Henderson Inlet and Nisqually Reach (DOH 2005).

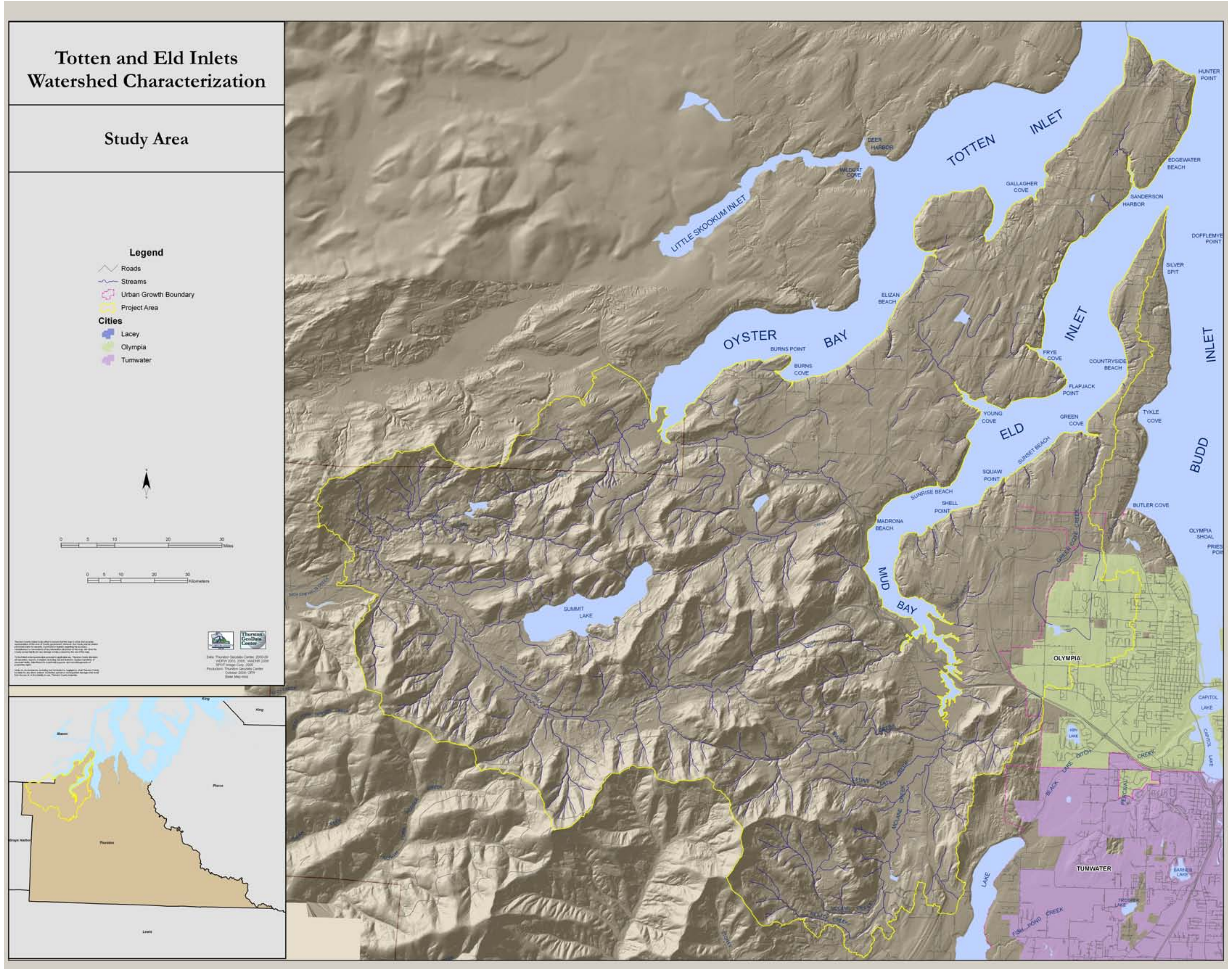


Figure 1 Totten and Eld Inlets Study Area

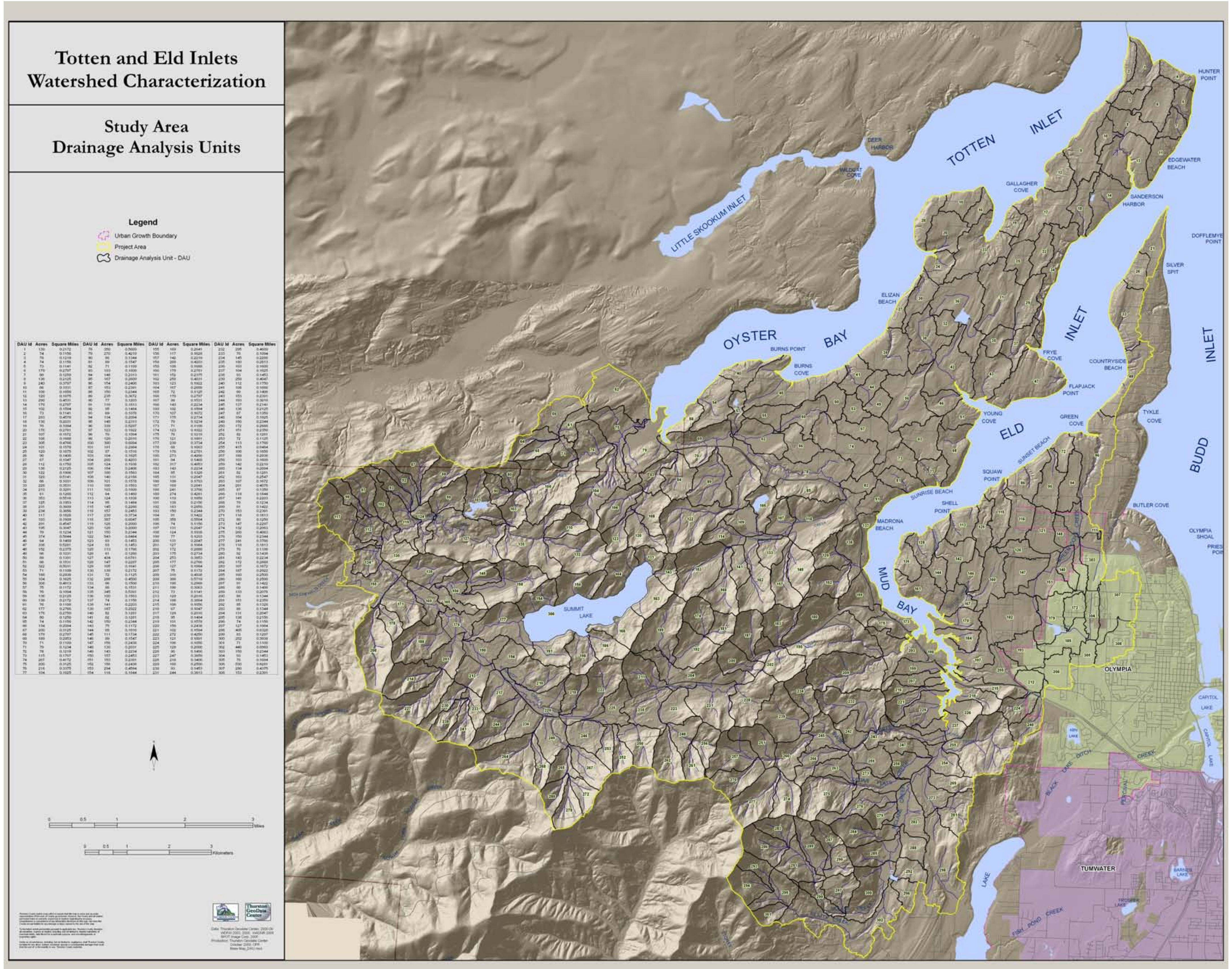
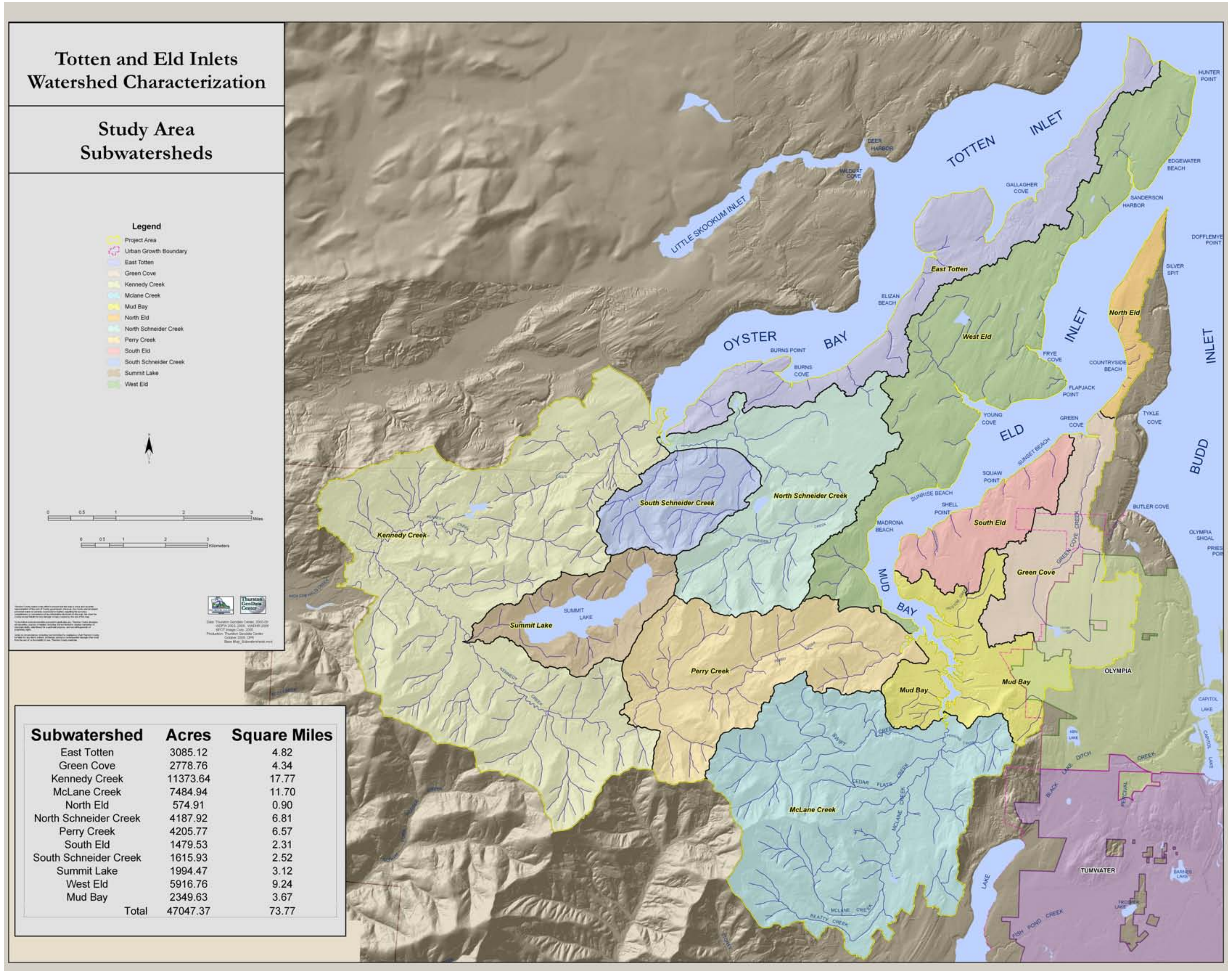


Figure 2 Totten and Eld Inlets Study Area Drainage Analysis Units



Subwatershed	Acres	Square Miles
East Totten	3085.12	4.82
Green Cove	2778.76	4.34
Kennedy Creek	11373.64	17.77
McLane Creek	7484.94	11.70
North Eld	574.91	0.90
North Schneider Creek	4187.92	6.81
Perry Creek	4205.77	6.57
South Eld	1479.53	2.31
South Schneider Creek	1615.93	2.52
Summit Lake	1994.47	3.12
West Eld	5916.76	9.24
Mud Bay	2349.63	3.67
Total	47047.37	73.77

Figure 3 Totten and Eld Inlets Study Area Sub-watersheds

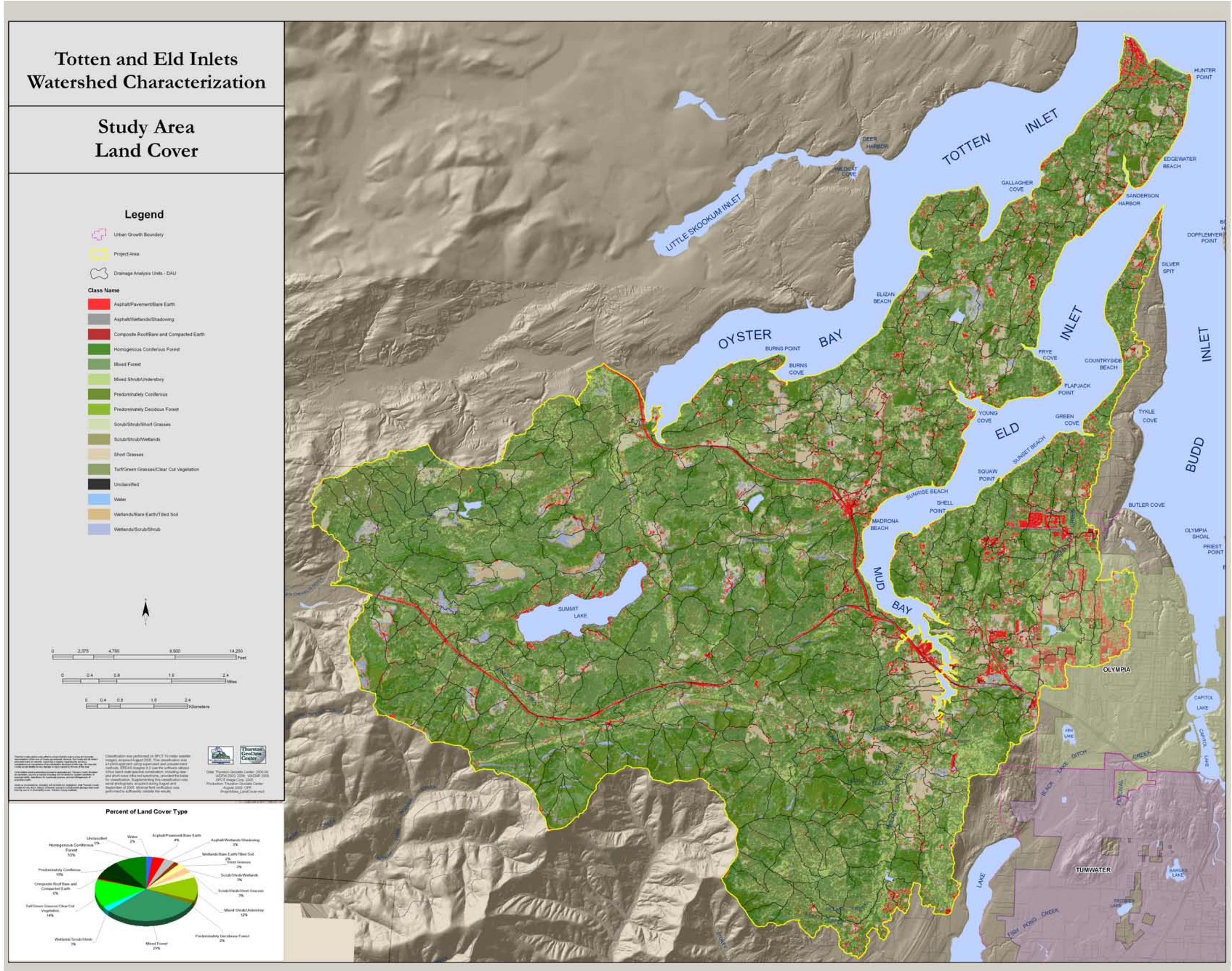
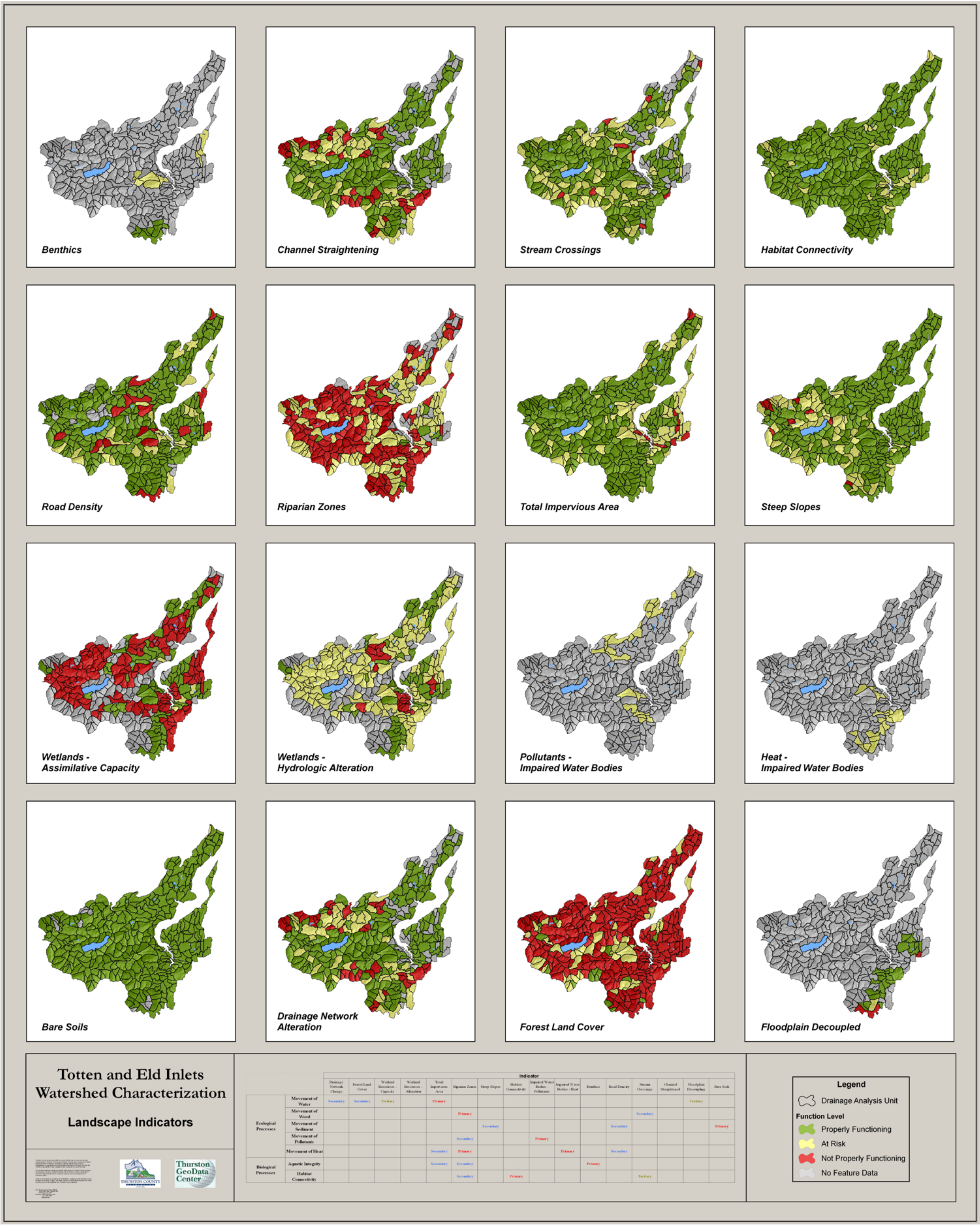


Figure 4 Totten and Eld Inlets Study Area Land Cover



		Indicator															
		Drainage Network Change	Forest Land Cover	Wetland Resources - Capacity	Wetland Resources - Alteration	Total Impervious Area	Riparian Zones	Steep Slopes	Habitat Connectivity	Impaired Water Bodies - Pollutants	Impaired Water Bodies - Heat	Benthics	Road Density	Stream Crossings	Channel Straightened	Floodplain Decoupling	Bare Soils
Ecological Processes	Movement of Water	Secondary	Secondary	Tertiary		Primary										Tertiary	
	Movement of Wood						Primary							Secondary			
	Movement of Sediment							Secondary					Secondary				Primary
	Movement of Pollutants						Secondary			Primary							
	Movement of Heat					Secondary	Primary				Primary		Secondary				
Biological Processes	Aquatic Integrity					Secondary	Secondary					Primary					
	Habitat Connectivity						Secondary		Primary					Tertiary			

Figure 5 Totten and Eld Inlets Study Area Landscape Indicators

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