Date: October 2, 2017

To: Hilary Foote, Tillamook County

From: John Runyon, Cascade Environmental Group and Barbara Wyse, Highland Economics, Steve Faust, Cogan Owens Greene

Re: Tillamook SB 1517 Pilot Project: Wetland and Agricultural Use Inventory

Introduction

This memo describes the inventory of wetland features and agricultural uses on Exclusive Farm Use (EFU or F-1 zone) lands in Tillamook County (hereafter referenced as "Agricultural Lands" or "EFU"). The purpose of the wetland feature inventory step is to use existing data, reports, and aerial imagery to characterize current and historical wetlands and other features that shape wetland and associated stream and river habitat restoration potential within EFU lands. The purpose of the agricultural use inventory is to compile information on agricultural uses on EFU lands and classify and describe key aspects of agricultural land uses.

Information from the wetland and agricultural use inventories will provide the foundation for the subsequent assessment of agricultural land use patterns, wetland values, habitat restoration benefits, and agricultural economic values. The purpose of the inventory is to present the data, but not to analyze it. In other words, each inventory provides little to no analysis of the relationships between different characteristics or land use patterns. Such analysis will be provided in the next step, assessment of EFU Agricultural Lands and assessment of wetlands.

The memo starts with methods and data (page 1), and then presents an overview of the County's watersheds and EFU agricultural lands (page 11). After these introductory sections, the wetland inventory (page 16) agricultural inventory (page 30) are presented. Some of the datasets are important to both the wetland inventory and the agricultural inventory. As such, these data, including information on drainage and drainage districts, are provided in both the wetland and the agricultural inventory. This is done in order to ensure that the sections of the memo focusing on each inventory are complete and can stand alone for readers potentially interested in focusing on one inventory or the other.

Methods Overview

The inventory evaluated a wide range of spatial datasets for the purpose of summarizing wetland and agricultural use characteristics. The datasets chosen for GIS analysis and mapping were selected based on the following criteria: 1) The dataset was created relatively recently (i.e., after 2000); 2) the dataset is spatially extensive (i.e., covers at least a large portion of the County); and 3) the dataset is technically sound (i.e., based on accepted and documented scientific and technical methods).

This document includes example maps showing wetland and agricultural land use characteristics for one area of the County. The wetland and agricultural land use inventory GIS data and a mapping application is provided on the Tillamook County Website: http://tillamookcountymaps.co.tillamook.or.us/geomoose2/geomoose.html

County and Watershed Inventory Reporting Framework

The wetland and agricultural inventory results are summarized at two spatial scales: County-wide and for each of the watersheds that drain areas within the County. Hydrologic Unit Codes (HUC) is the national standard for delineating watersheds. For this study, the County is covered by eighteen 5th-field HUCs (Figure 1). The system is hierarchical such that smaller watersheds nest into river basins (i.e., 1st- or 2nd-field HUCs, such as the Columbia or Willamette river basins) or watersheds (3rd- or 4th-field HUCs). For example, the Wilson-Trask-Nestucca 4th-field HUC encompasses nine 5th-field watersheds[1].

In general, the 5th-field hydrologic units (hereafter referenced as "watersheds") within Tillamook County are delineated such that all surface drainage within each watershed converges at a single outlet point. It was not always possible, however, to delineate watersheds in this way while adhering to the size and subdivision standards of the system, so there are some watersheds that do not follow the single outlet point. There are "remnant areas" along the coast where individual streams are too small for the given watershed. Such remnants are combined into a single watershed if they are adjacent to one another and could be combined. (e.g., Necanicum River watershed is mostly in Clatsop County but has one stream within Tillamook County that flows into the Pacific Ocean). A number of watersheds similarly encompass drainages in both Tillamook County and adjoining counties.

In addition to typical watershed drainage systems, some Tillamook County watersheds encompass estuaries and other areas that are subject to saltwater and freshwater tidal inundation. Some of the tidal areas are where multiple river systems come together. For example, the Tillamook Bay watershed covers the tidally-influenced portions of the Miami, Kilchis, Wilson, Trask, and Tillamook rivers.

For the purposes of the inventory, watersheds, or portions of watersheds, are identified as "tidal" or "freshwater" based, respectively, on whether the areas are below or above the highest measured tide (HMT), also referenced as "head tide". This method is in accordance with the Oregon Department of State Lands (DSL) definition of tidal and freshwater wetlands (DSL 2016). Other County wetland studies have also used this method for defining tidal wetland extent (e.g., Ewald and Brophy 2012). The HMT was determined to be 11.62 feet, NAVD88[2].

All the wetland and agricultural inventory results are summarized by the eighteen HUCs within the County[3]. While the focus of the analysis is on EFU lands, for context at the County level, the inventory also includes a summary of much of the data for Non-EFU lands.

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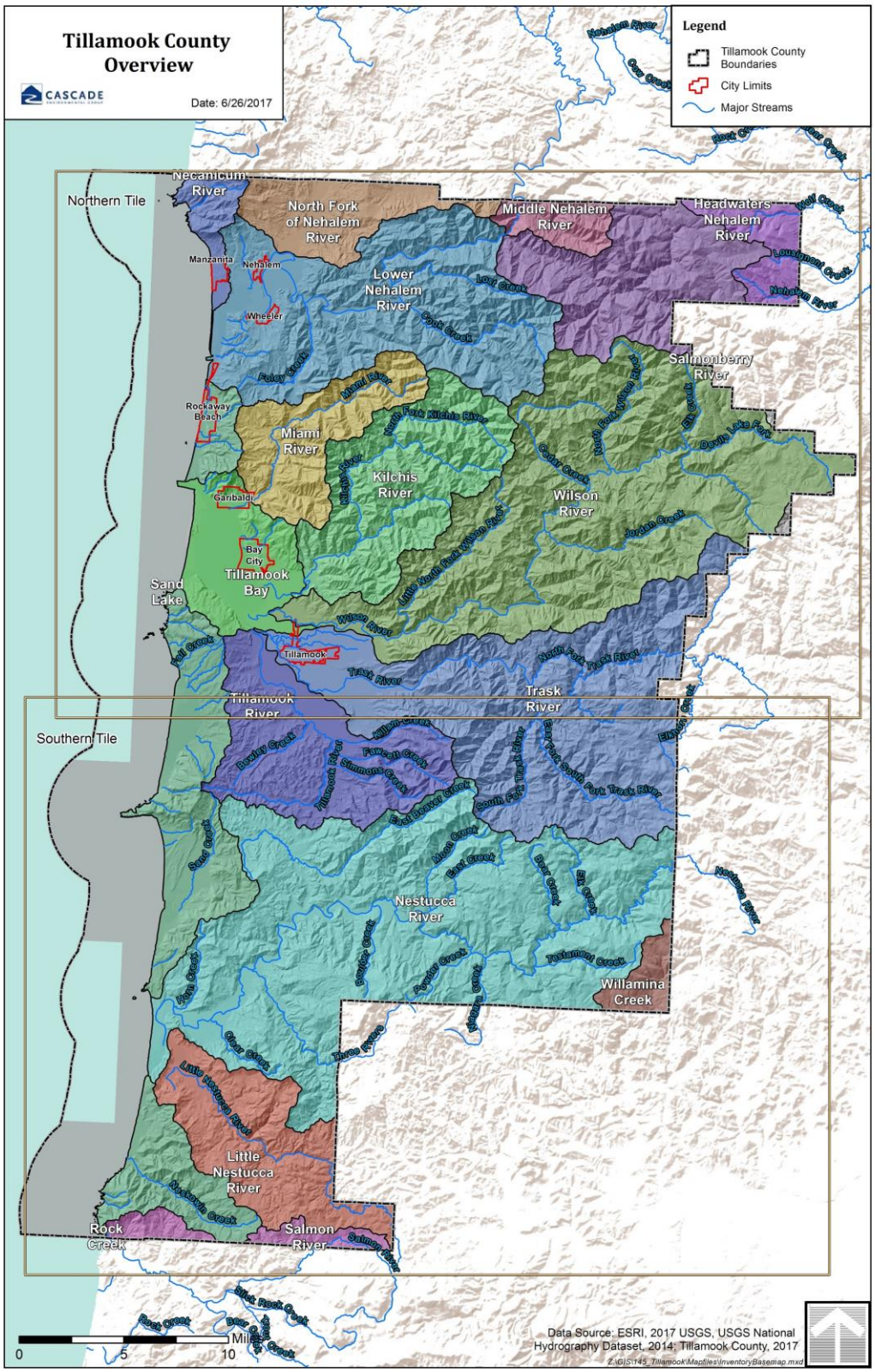
[1] Little Nestucca River, Sand Lake, Nestucca River, Tillamook River, Wilson River, Kilchis River, Miami River, Tillamook Bay, and Trask River watersheds

[2] HMT was determined according to methods described by DSL (2010) using the National Oceanic and Atmospheric Administration (NOAA) tidal station located at Garibaldi. The tidal station at Garibaldi was chosen to represent the entire County, as it is the sole station with a published "Highest Observed Water Level" value. The value of 15.91 feet, standard datum, was converted first into feet, mean lower low water (MLLW), then into feet, North American Vertical Datum of 1988 (NAVD88) with NOAA's online horizontal and vertical transformation utility, VDatum (https://vdatum.noaa.gov/vdatumweb/), to yield a value of 11.62 feet, NAVD88. The value of 11.62 feet was then applied to a 10-meter resolution raster-based digital elevation model (DEM) sourced from the National Elevation Dataset (USGS 2013; available at: https://viewer.nationalmap.gov/basic/#productSearch) in ESRI ArcGIS 10.1 software to identify areas above and below HMT.

[3] Two watersheds that are primarily within Washington County were not included in this study because they cover a very small area in Tillamook County and do not include any Agricultural Lands: Gales Creek (222 acres) and Scoggins Creek-Tualatin River (476 acres).

Figure 1. An overview of Tillamook County Streams and Watersheds. The Northern and Southern Tiles Delineate the Focus Areas for the Following Two Figures



Inventory Data Sources and Methods

Table 1 summarizes the inventory data sources and mapped characteristics.

Table 1. Wetland Inventory Datasets, and Mapped Characteristics

Dataset	Source	Mapped Characteristics and Derivative(s)	Summary
HUC5 (5th field watersheds)	National Hydrography Dataset, (USGS, 2016)	Watershed boundaries	HUC is the national standard for delineating watersheds. The County includes eighteen 5th field HUCs. A number of other HUCs encompass both the County and adjoining counties. The total HUC area (acres) includes just the portion within the County.
Streams	StreamNet Mixed Scale Hydrography V3.1, 2012	Major streams – named streams greater than 0.5 mile in length	The approximate location of stream channels.
F-1 Zoning	Tillamook County, 2017	Areas within F-1 zoning designation	Areas within F-1 zoning that are designated EFU.
Topographic Elevations	LiDAR (USGS, 2013)	Areas below/above highest measured tide (HMT), 11.62 ft. NAVD88	11.62 feet, which is the HMT, is used as an approximation of the head of tide. Elevations below this point are assumed to represent areas that historically could have been subject to tidal influence. Many of these areas have been leveed, drained, or filled so that they are no longer subject to tidal inundation.
Soils	USDA, NRCS gridded Soil Survey Geographic (gSSURGO) for Tillamook County, 2016	Geomorphic floodplain; soils drainage class; potential historical wetland areas	Geomorphic floodplain is a landform classification based on historical processes and does not reflect the current status of the floodplain (e.g., areas that have been leveed or drained). The geomorphic floodplain is determined based on soil types that correspond with historical floodplain deposition from rivers or streams inundating the floodplain during flood events. Soil hydric classification provides information on the potential for the soil to support wetlands. Soil drainage class (5 categories) is useful for understanding where the water table is in relation to the surface: e.g., for poorly drained soils the water table is close to the surface (or at the surface, at least for part of the year); well drained soils are characterized by a deeper water table. Historical wetlands depict areas that are not currently classified as NWI wetlands and have a large proportion of hydric soils. These areas have a high probability of containing historical wetlands.

Dataset	Source	Mapped Characteristics and Derivative(s)	Summary
National Wetland Inventory (NWI)	USFWS, 2016	NWI mapped freshwater and tidal wetlands; modified freshwater and tidal wetlands within the NWI wetland classification	The existing wetland inventory was based on the USFWS' NWI spatial dataset updated in 2016. This dataset was determined to provide the greatest accuracy and coverage of all available datasets. The NWI dataset was classified into "tidal" or "freshwater" categories based each wetland's location either below or above highest measured tide (HMT), respectively, in accordance with the DSL definition of tidal wetlands (DSL 2016). Modified NWI areas are within the NWI wetland classification and characterized as wetlands but with modified hydrology as a result of levees, fill or other activities.
Levees / Fill Areas	Russell Scranton, 2004	Constructed levees; railroad embankments; other areas where fill has been placed to raise surface elevations	Levees, railroad embankments, or fill in areas that are designed to prevent flooding and protect lands that are adjacent to rivers and streams that historically would flood with some frequency.
Tide Gates	Russel Scranton, 2004	Tide Gate locations	Tide gates drain tidelands (areas that incoming tides regularly cover) for agricultural or other uses. On tidewater side of the pipe there is a hinged door which opens outwards towards the bay or estuary. When water levels are higher on the side of the pipe towards the drained area, the weight of the water holds the door open, allowing water to flow out into the bay or estuary. When the tide rises, the level of water on the tidewater side becomes higher than on the drained area side, holding the door closed so water does not flow back into the drained area. With traditional tide gates, passage of fish between the tidewater and the drained area is limited.

Dataset	Source	Mapped Characteristics and Derivative(s)	Summary
Stream Intrinsic Potential (IP)	Coastal Landscape Analysis and Modeling Study (CLAMS), 2008	Coho Intrinsic Potential (IP) >= 0.8; high IP	Coho salmon intrinsic potential (IP) is a measure of historical habitat quality in terms of supporting Coho adult spawning and juvenile rearing. IP is an attribute modeled from GIS data based on key geomorphic and other characteristics: channel and valley constraint, channel gradient, and mean annual water discharge. High IP Coho habitats are characterized by river and stream channels that are low-gradient (less than 4%); have unconstrained channels (e.g., absence of features that constrain channel movement so that the channel is free to meander across a wide valley floodplain); and have sufficient flow, as determined by upstream watershed area, to support both spawning and rearing. IP is based on historical potential and does not account for current features (e.g., levees) that can constrain channel movement, reduce floodplain access by fish during high-flow periods (e.g., tide gates), or other activities that modify historical habitat quality.
Drainage Districts	Tillamook County, 2017	Active drainage districts	Drainage districts are local bodies formed for the purpose of creating and maintaining levees, and draining, ditching, and other activities intended to improve water movement and drainage for agricultural and other land uses.
Tiger 2010 Streets	U.S Census Bureau, 2010	Road locations	Street locations and names.
Sea-Level Rise	National Oceanic and Atmospheric Administration (NOAA), Coastal Services Center, 2012	3-foot (~1m) sea-level rise	There is very high confidence (greater than 90% chance) that global mean sea level will rise at least 8 inches (0.2 meters) and no more than 6.6 feet (2 meters) by 2100. The actual amount of sea level change at any one region and location greatly varies in response to regional and local conditions. Forecasting sea level rise at the scale of the County is helpful for evaluating the impact of restoration projects on attenuating flooding related to sea level rise.
Restoration Projects	Oregon Watershed Restoration Inventory (OWRI), OWEB 2014.	Restoration project location and boundaries	The location and boundaries for habitat restoration projects within Agricultural Lands that significantly changed drainage through levee removal and other drainage modifications to allow tidal and river inundation.

Dataset	Source	Mapped Characteristics and Derivative(s)	Summary
USDA Cropscale Cropland	United States Department of Agriculture(USDA), 2016	Crop and other land uses	The spatial area of 41 crop types and other land uses in Tillamook county agricultural areas, including 30 crop types, 4 different types of development and 7 types of natural areas. We grouped these into 8 categories, 6 for crops and one each for developed areas and natural areas.
NRCS Soil Survey gSSURGO			
CAFO points	Oregon Department of Agriculture, 2017	Location of CAFO operations	Point data of base of operations for confined animal feeding operations (CAFO) in Tillamook County.
CAFO digitized lands	Oregon Department of Agriculture, 2017	Land area used for manure management by CAFO operations	Polygon data showing spatial extent of lands used for manure management by CAFOs in in Tillamook County. These data were digitized by Oregon Department of Agriculture for only some watersheds in Tillamook County.
Irrigation water rights	Oregon Water Resources Department, 2017	Point of use of irrigation water rights.	Polygon data showing the place of use of irrigation water rights in Tillamook County, as recognized by the Oregon Water Resources Department.

Wetland Inventory: Methods for Existing Tidal and Freshwater Wetlands

The existing wetland inventory is based on the U.S. Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) spatial data. These data were updated in 2016. We evaluated various wetland data for Tillamook County and determined that the NWI provides the greatest accuracy in terms of delineating existing wetlands and the most extensive coverage of all available data. Other information considered for the wetland inventory includes the tidal wetlands spatial data developed by Russell Scranton (2004), *The Application of Geographic Information Systems for Delineation and Classification of Tidal Wetlands for Resource Management of Oregon's Coastal Watersheds*, and the tidal wetlands spatial data developed as part of a restoration prioritization study for the Tillamook Bay Estuary (Ewald and Brophy 2012).

The Scranton (2004) data does not provide a framework for determining the scope and extent of existing wetlands in the County because it does not thoroughly capture the range of freshwater wetlands. The study's mapping resolution and margin of error are too great to support the desired wetland details and level of certainty. Ewald and Brophy's (2012) data also does not provide a framework for the inventory because it does not capture freshwater wetlands and is limited to the Tillamook and Nehalem Systems.

For the purpose of the inventory, the NWI data is classified into "tidal" (below HMT) or "freshwater" (above HMT) categories based on each wetland's location either below or above HMT, in accordance with the DSL definition of tidal wetlands (DSL 2016). Ewald and Brophy (2012) also used this method for defining tidal wetland extent.

Acreage of NWI wetlands is determined based on tidal and freshwater status and watershed location. Wetlands mapped within the NWI are classified according to the USFWS Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). The Cowardin classification system is a hierarchical habitat-based classification that incudes categories for vegetation cover, hydrological regime, and water regime modifiers. Modified NWI wetlands are identified by querying the following NWI water regime modifiers: diked/impounded; partially drained/ditched; excavated; and farmed. The modified wetlands are then identified based on modified status and watershed location.

Wetland Inventory: Methods for Historical Tidal and Freshwater Wetlands

Historical wetlands were defined for the purposes of this inventory as 1) areas that are not currently identified in the NWI as supporting wetland vegetation or hydrological characteristics; and 2) areas that include hydric soils as defined and mapped by the USDA Natural Resource Conservation Service (NRCS). Hydric soils meet one or more of the NRCS-defined hydric soil indicators (NRCS 2017). Mapped hydric soils are selected as an indicator for potential historical wetland presence because hydric soils typically develop under long-sustained wet conditions. Once hydric soils develop, they maintain relic hydric characteristics indefinitely even if the area is drained, diked, or grazed.

Hydric soils are delineated in a manner that indicates the proportion of the map unit components, or soils types, that meet hydric soil criteria. For example, a map unit component that is dominantly hydric

soils may have small areas of non-hydric soils within the mapped landform. The hydric soils within a mapped unit are rated based on the following criteria:

- Hydric: All components in the map unit are hydric
- Predominantly hydric: 66%-99% of the components in the map unit rated hydric
- Partially hydric: 33%-66% of the components in the map unit rated hydric
- Predominantly non-hydric: 1%-33% of components in the map unit rated hydric
- Non-hydric: no components rated hydric

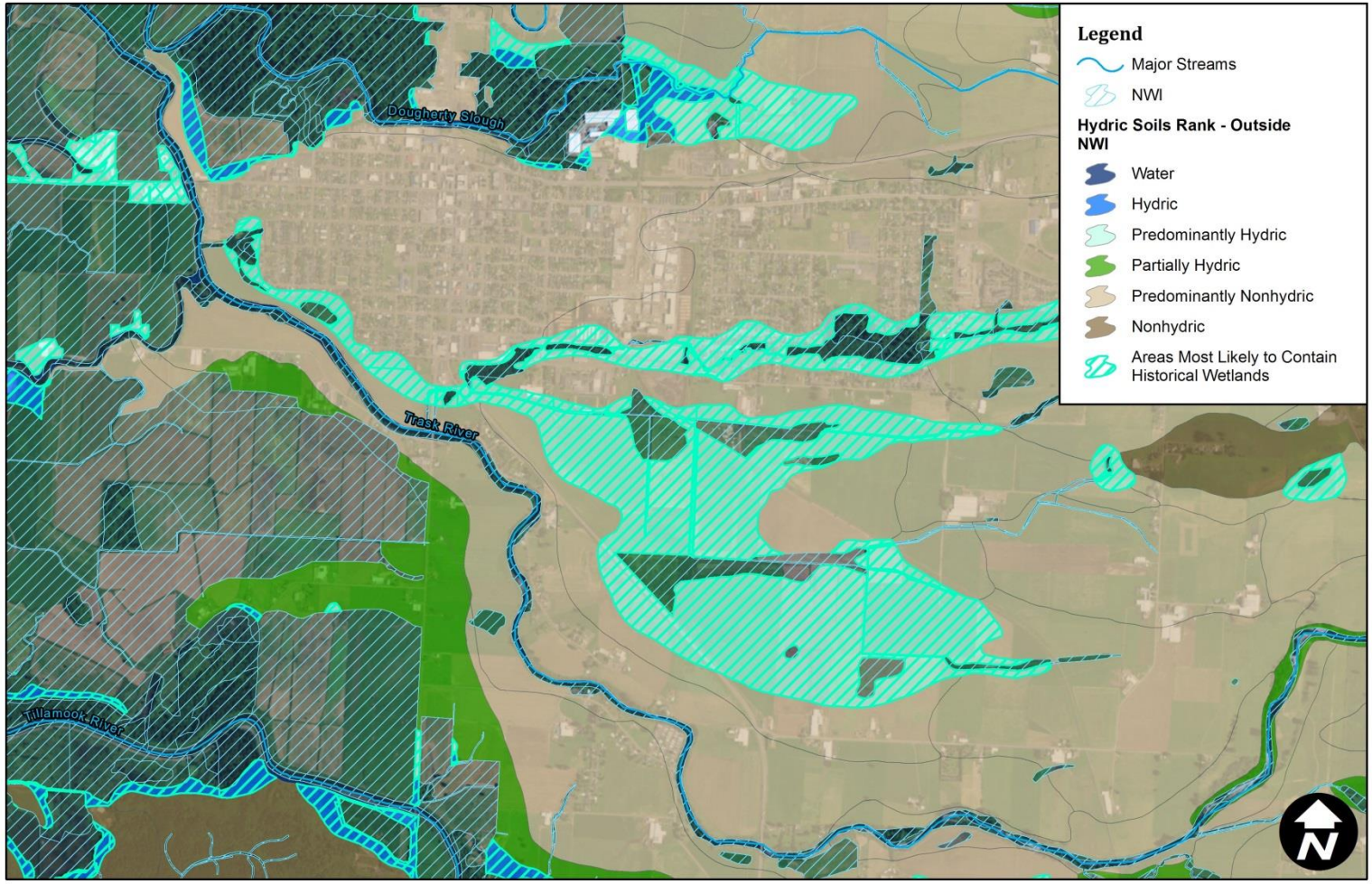
To represent areas likely to have supported historical wetlands, all **hydric** and **predominantly hydric** ranked soils that do not occur within NWI wetlands (i.e., existing identified wetlands) are mapped. To quantify potential historical wetland areas, the median of the range of hydric rating values within each hydric rank is calculated and multiplied by the total acreage of the rank. For example, if there are 1,200 acres of predominantly hydric soils (containing 66%-99% hydric components) mapped outside of NWI wetlands within the County, the total acreage for that rank was multiplied by the median value of the hydric class (calculated from the actual values; in this case 85%), to yield a total of 1200*0.85 = 1,020 acres.

The method of applying the median of each hydric class results in a conservative estimate of potential historical wetland acreage. A more refined estimate of historical wetlands requires corroborating data or detailed field observations. In addition, based on the nature of the NRCS gSSURGO soil database, which only includes hydric classes as an attribute of each soil map unit, it was not possible to map the actual locations of hydric components within each soil map unit. Thus, mapped polygons representing predominantly and partially hydric soils are presented as a probability of historical wetland presence. Mapped units with hydric and predominantly hydric soils have a very high probability of containing historical wetlands, but the exact location cannot be determined with this method.

To augment the inventory of historical wetland presence, filled areas as mapped by Scranton (2004) are included in the inventory. The filled lands data were developed using the DSL 1972 Ownership and Filled Lands Inventory and a selection of historical photographs available from the U.S. Army Corps of Engineers and other sources. The filled lands data include features such as dikes, dirt and paved roads, railroads, highways, gravel driveways, golf courses, dredging spoils, marina jetties, and buildings. It is assumed that areas of fill placement located in low-lying, floodplain areas have a high probability of supporting wetland characteristics, even if they no longer support wetland characteristics. However, because it was not possible to conclusively identify hydric soils within the mapped filled areas, the fill areas are presented as a separate dataset and are not included in the mapping or quantification of historical wetlands.

Figure 2 illustrates an example of the historical wetland classification for a portion of central Tillamook County.

Figure 2. An Example of the Historical Wetland Classification for Agricultural Lands in Central Tillamook County



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Scale: 1 inch = 2,000 feet
Data Source: ESRI, 2017; USGS, NHD, 2014; Soil Survey Staff, 2017

Historical Wetlands and Hydric Soils in Central Tillamook County

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Overview of Tillamook County's Watersheds and EFU Agricultural Lands

Table 2 summarizes the County's eighteen watershed areas and the proportion of each watershed designated as EFU. The County covers approximately 718,719 acres, of which 37,589 acres (5.23%) are EFU (Figures 3 and 4).

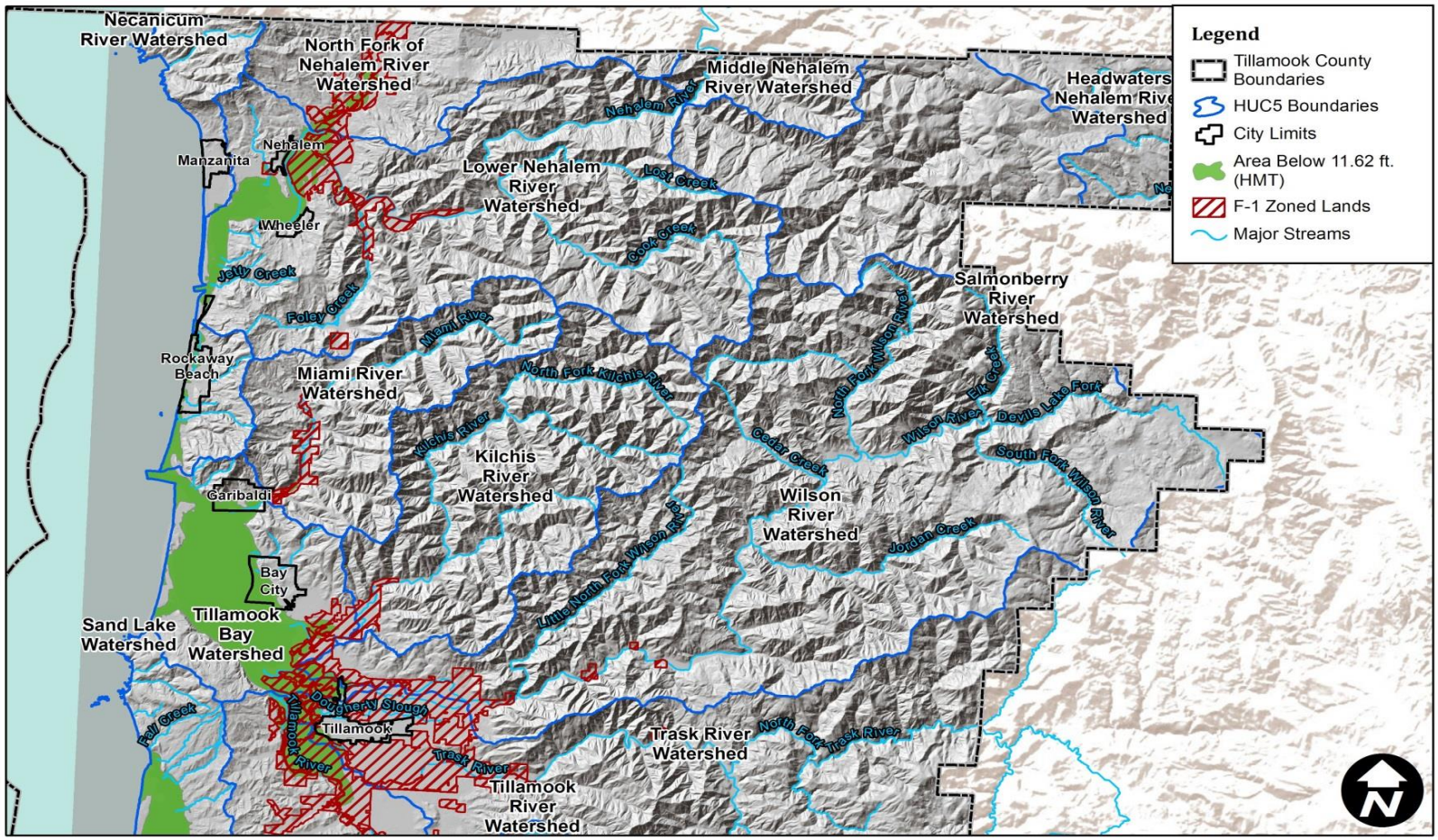
The proportion of each watershed in EFU varies dramatically (Figure 5). Eleven watersheds have some portion of area within Agricultural Lands. There are six watersheds with at least 7% of their area in EFU, with the largest proportion in the Tillamook River Watershed (15.23%). There are no EFU in the following seven watersheds: Headwaters Nehalem River, Middle Nehalem River, Necanicum River, Rock Creek, Salmon River, Salmonberry River, and Willamina Creek.

For the most part, EFU are concentrated in the valley bottoms, often within floodplains adjacent to rivers and streams. In addition to the river valleys, a large proportion (15.55%) of the County's EFU lands are below HMT (11.62 feet, NAVD88). The areas below HMT include lands that were historically tidally influenced; in many instances land drainage has been altered (e.g., levees or other modifications) to limit tidal inundation and accommodate agricultural land uses (Figures 3 and 4). Ten watersheds have some portion of EFU below HMT (Figure 6).

Table 2. Summary of Tillamook County Watershed Areas, Agricultural Lands (EFU), and Areas Below HMT (below Head of Tide)

Watershed (5th-Field HUC)	Watershed Area (Acres)	Agricultural Lands (Acres)	Percent Watershed within Agricultural Lands	Watershed Area Below HMT (Acres)	Agricultural Lands Below HMT (Acres)	Percent Agricultural Lands Below HMT
Headwaters Nehalem River	9,928	-	0.00%	-	-	-
Kilchis River	41,280	557	1.35%	-	-	-
Little Nestucca River	32,413	3,021	9.32%	987	459	15.21%
Lower Nehalem River	70,078	2,714	3.87%	4,053	1,000	36.85%
Miami River	23,052	831	3.61%	79	54	6.47%
Middle Nehalem River	6,943	-	0.00%	-	-	-
Necanicum River	6,389	-	0.00%	120	-	-
Nestucca River	139,693	9,736	6.97%	1,115	279	2.86%
North Fork Nehalem River	17,574	1,994	11.35%	733	570	28.60%
Rock Creek	125	-	0.00%	6	-	-
Salmon River	7,108	-	0.00%	19	-	-
Salmonberry River	34,896	-	0.00%	-	-	-
Sand Lake	53,885	1,718	3.19%	4,909	1	0.06%
Tillamook Bay	21,255	1,948	9.17%	10,954	1,057	54.27%
Tillamook River	39,361	5,968	15.16%	1,995	1,669	27.97%
Trask River	90,666	7,008	7.73%	861	561	8.01%
Willamina Creek	5,439	-	0.00%	-	-	-
Wilson River	118,634	2,094	1.77%	312	196	9.36%
SUM TOTAL	**718,719**	**37,589**	**5.23%**	**26,142**	**5,847**	**15.55%**

Figure 3. The Northern Section of Tillamook County Showing Streams, EFU Agricultural Lands, and Areas below HMT (below Head of Tide)



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Data Source: ESRI, 2017; USGS, NHD, 2014

F-1 Zoning and Streams in Northern Tillamook County

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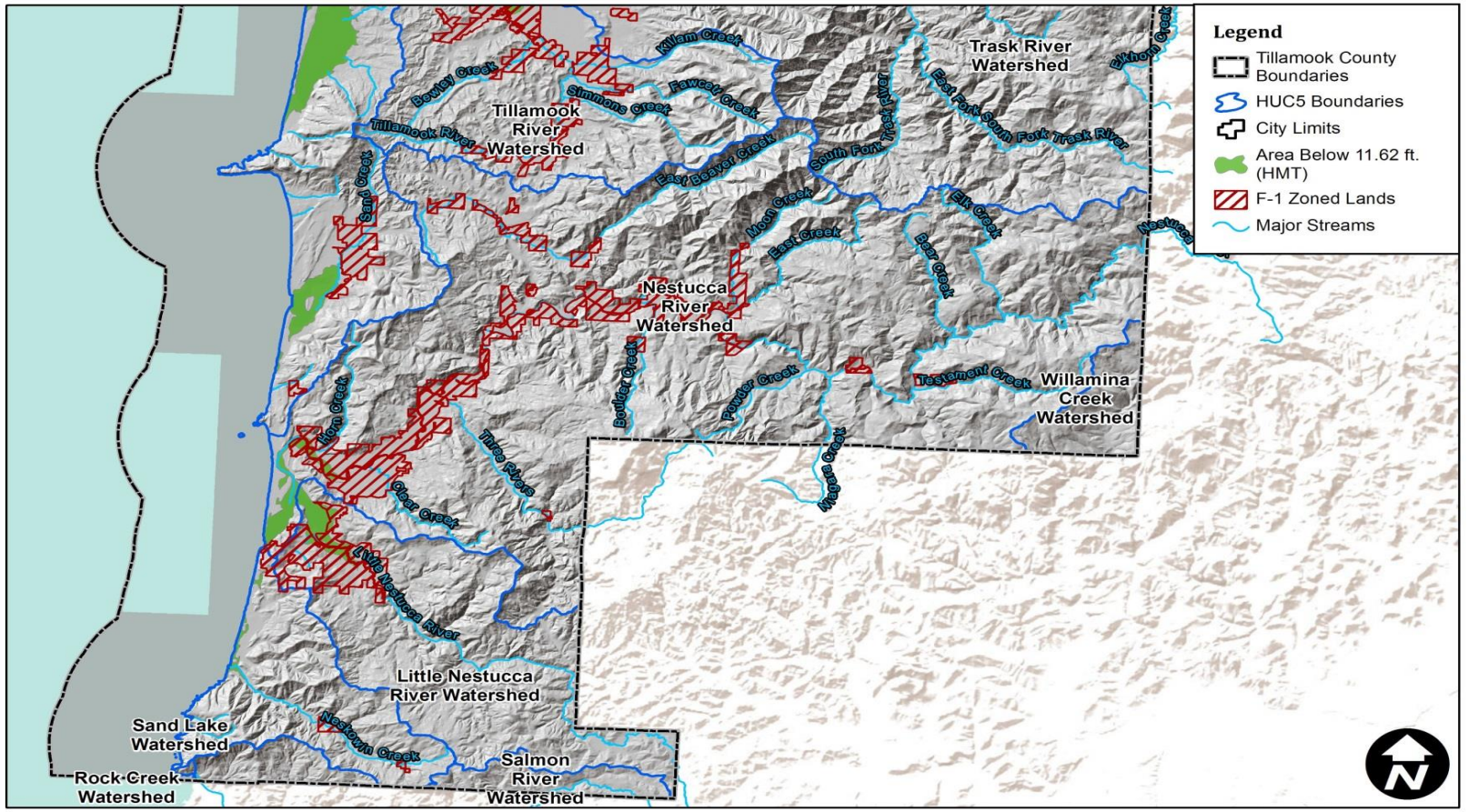
Figure 4. The Southern Section of Tillamook County Showing Streams, EFU Agricultural Lands, and Areas below HMT (below Head of Tide)



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Data Source: ESRI, 2017; USGS, NHD, 2014

F-1 Zoning and Streams in Southern Tillamook County

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Figure 5. EFU Agricultural Lands as a Percent of Watershed Area

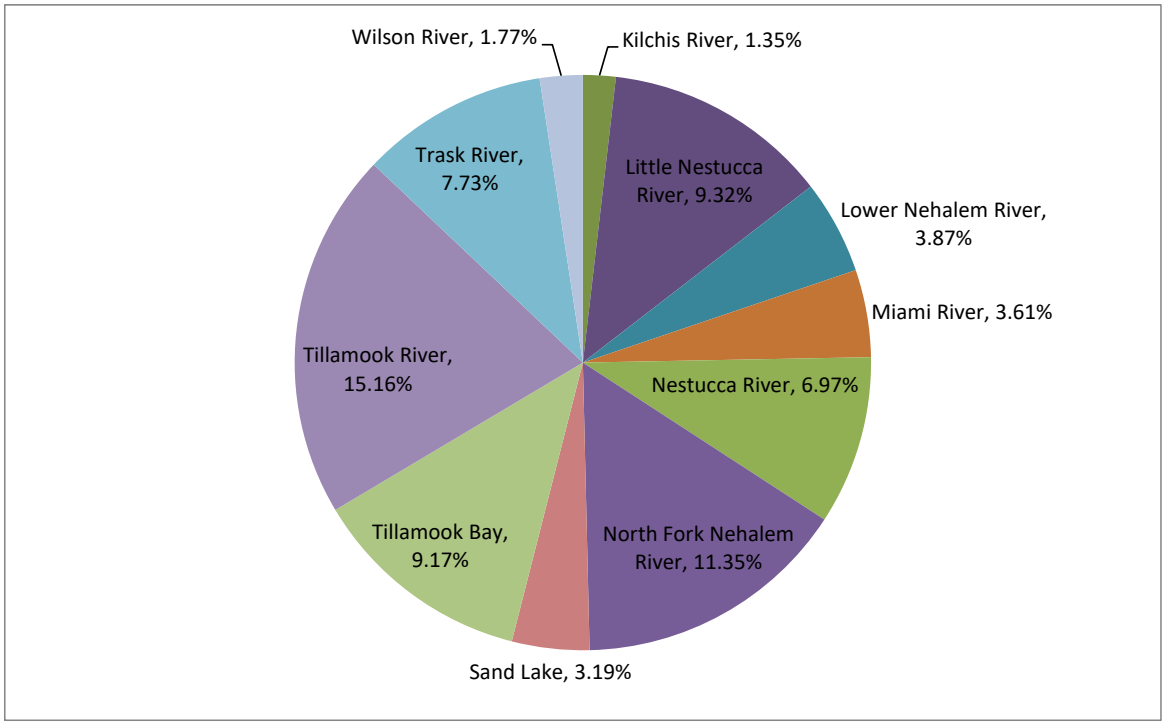
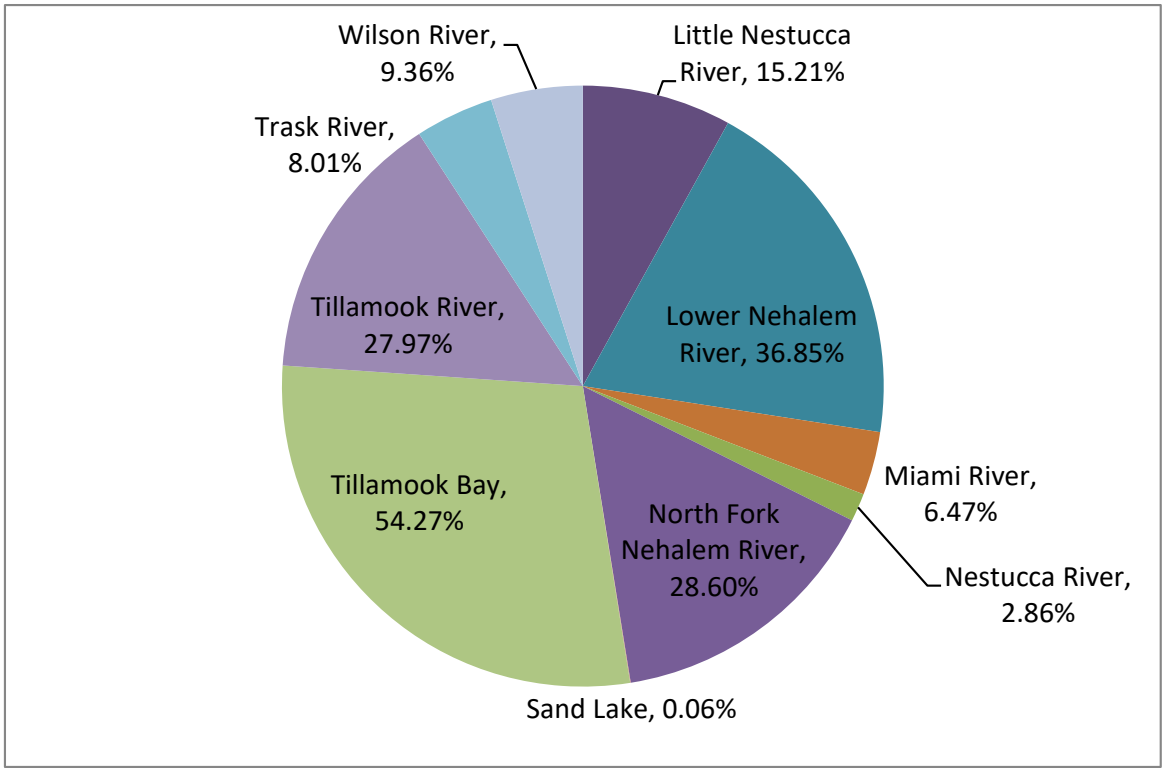


Figure 6. Percent EFU Agricultural Lands in Each Watershed below HMT



Wetlands Inventory

For each characteristic or attribute of wetlands, the wetland inventory presents information first for the EFU lands. For context, the inventory then includes wetland information on other, non-EFU lands.

EFU Lands: Wetland and Floodplain Characteristics

Table 3 summarizes wetland and floodplain characteristics for EFU lands. NWI wetlands are summarized for areas below HMT and above HMT. It is important to note that for wetlands below HMT, there is a high probability that they are, or were historically, tidal. We do not, however, define them as exclusively tidal because the data do not have the resolution to make the determination of whether or not specific areas are subject to tidal inundation. Areas above HMT are characterized as freshwater wetlands because there is a high degree of confidence that these areas are not tidally inundated.

There are 4,087 acres of NWI wetlands below HMT within the County's Agricultural Lands. The area of NWI wetlands below HMT ranges from no acreage in the Kilchis River, North Fork Nehalem River, and Sand Lake Watersheds to 1,444 acres in the Tillamook River Watershed. Of the 4,087 acres of wetlands below HMT identified in the NWI, 3,478 acres (85%) have been modified. Most of the modified wetlands identified in the NWI are tidal wetlands that have been converted to freshwater wetlands as a result of levees or other modifications. The largest concentration of NWI modified wetlands under HMT are in the Tillamook Bay Watershed (738 acres) and Tillamook River Watershed (1,265).

There are 5,009 acres of NWI freshwater wetlands in the County's Agricultural Lands. The area of NWI freshwater wetlands ranges from 99 acres in the Kilchis River Watershed to 1,694 acres in the Nestucca River Watershed. There are no NWI freshwater wetlands in the North Fork Nehalem River Watershed.

In comparison to NWI wetlands below HMT, there is less modification of freshwater wetlands. Of the 5,009 acres of freshwater wetlands identified in the NWI, 2,435 acres (48%) are modified. Most of the modified Agricultural Land freshwater wetlands identified in the NWI are wetlands that have been altered as the result of drainage modifications. Figure 7 illustrates areas under HMT and NWI freshwater wetland locations for an Agricultural Land area along the Wilson River.

Geomorphic floodplains cover 12,400 acres of the County's Agricultural Lands. The area within geomorphic floodplains ranges from 24 acres in the Sand Lake Watershed to 3,074 acres in the Trask River Watershed.

Filled areas encompass 624 acres of the County's Agricultural Lands. The fill areas range from no acres of fill in the Sand Lake Watershed to 129 acres in the Tillamook Bay Watershed.

Non-Agricultural Lands: Wetland and Floodplain Characteristics

Table 4 summarizes wetland and floodplain characteristics for the County's Non-Agricultural Lands. There are 18,614 acres of NWI wetlands below HMT within Non-Agricultural Lands. The area of NWI wetlands below HMT ranges from 5 acres in the Rock Creek Watershed to 9,356 acres in the Tillamook River Watershed. In comparison to Agricultural Lands, there has been dramatically less modification of wetlands below HMT within Non-Agricultural Lands. Of the 18,614 acres of wetlands below HMT identified in the NWI, only 349 acres (2%) are modified. Most of the modified wetlands identified in the

NWI are tidal wetlands that have been converted to freshwater wetlands as a result of drainage modifications. The Tillamook Bay Watershed has the largest area with modified NWI tidal wetlands (145 acres).

There are 15,597 acres of NWI freshwater wetlands within Tillamook County's Non-Agricultural Lands, which is more than triple the acreage of freshwater wetlands identified within Agricultural Lands (5,009 acres). The area of NWI freshwater wetlands ranges from 1 acre in the Rock Creek Watershed to 3,079 acres in the Sand Creek Watershed.

In comparison to NWI wetlands below HMT, there has been less modification of freshwater wetlands. Of the 15,597 acres of freshwater wetlands identified in the NWI, only 486 acres (3%) are modified. Most of the modified Non-Agricultural Land freshwater wetlands identified in the NWI are wetlands that are altered as the result of drainage modifications.

Geomorphic floodplains cover 6,738 acres of the County's Non-Agricultural Lands, which is about half of the acreage of geomorphic floodplain identified within Agricultural Lands (12,400). The area within geomorphic floodplains ranges from 1 acre in the Rock Creek Watershed to 3,079 acres in the Sand Lake Watershed.

Filled areas encompass 611 acres of the County's Non-Agricultural Lands. The fill areas range from no acres in several watersheds to 241 acres in the Tillamook Bay Watershed.

Table 3. Wetland and Geomorphic Floodplain and Filled Area Characteristics for Agricultural Lands. (n/a = No EFU Agricultural Lands Present in Watershed)

Watershed (5th-Field HUC)	NWI Wetlands Below HMT (Acres)	NWI Wetlands Below HMT Modified (Acres)	NWI Freshwater Wetlands (Acres)	NWI Freshwater Wetlands Modified (Acres)	Geomorphic Floodplain (Acres)	Filled Areas (Acres)
Headwaters Nehalem River	n/a	n/a	n/a	n/a	n/a	n/a
Kilchis River	-	-	99	9	374	8
Little Nestucca River	431	361	549	405	249	30
Lower Nehalem River	597	405	361	115	1,117	126
Miami River	23	14	153	46	342	2
Middle Nehalem River	n/a	n/a	n/a	n/a	n/a	n/a
Necanicum River	n/a	n/a	n/a	n/a	n/a	n/a
Nestucca River	258	255	1,694	1,064	2,690	18
North Fork Nehalem River	-	-	-	-	655	16
Rock Creek	n/a	n/a	n/a	n/a	n/a	n/a
Salmon River	n/a	n/a	n/a	n/a	n/a	n/a
Salmonberry River	n/a	n/a	n/a	n/a	n/a	n/a
Sand Lake	-	-	444	35	24	-
Tillamook Bay	831	738	280	215	877	129
Tillamook River	1,444	1,265	692	387	1,855	91
Trask River	394	343	487	133	3,074	124
Willamina Creek	n/a	n/a	n/a	n/a	n/a	n/a
Wilson River	109	95	251	27	1,143	79
SUM TOTAL	**4,087**	**3,478**	**5,009**	**2,435**	**12,400**	**624**

Figure 7. An Example of Areas under HMT (below Head of Tide) and NWI Freshwater Wetland Locations for Agricultural Lands Adjacent to the Lower Wilson River

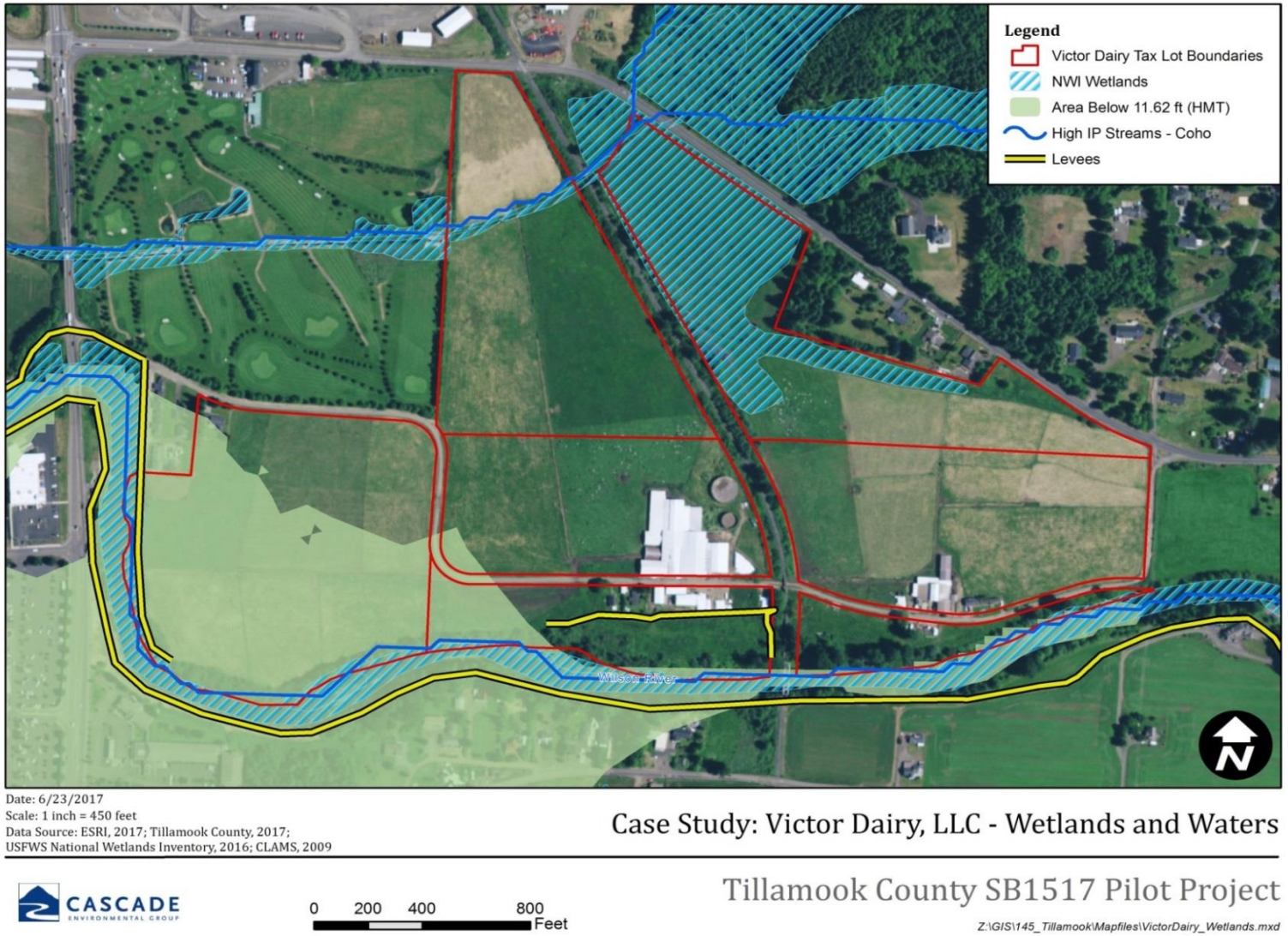


Table 4. Wetland and Floodplain Characteristics on Non-Agricultural Lands

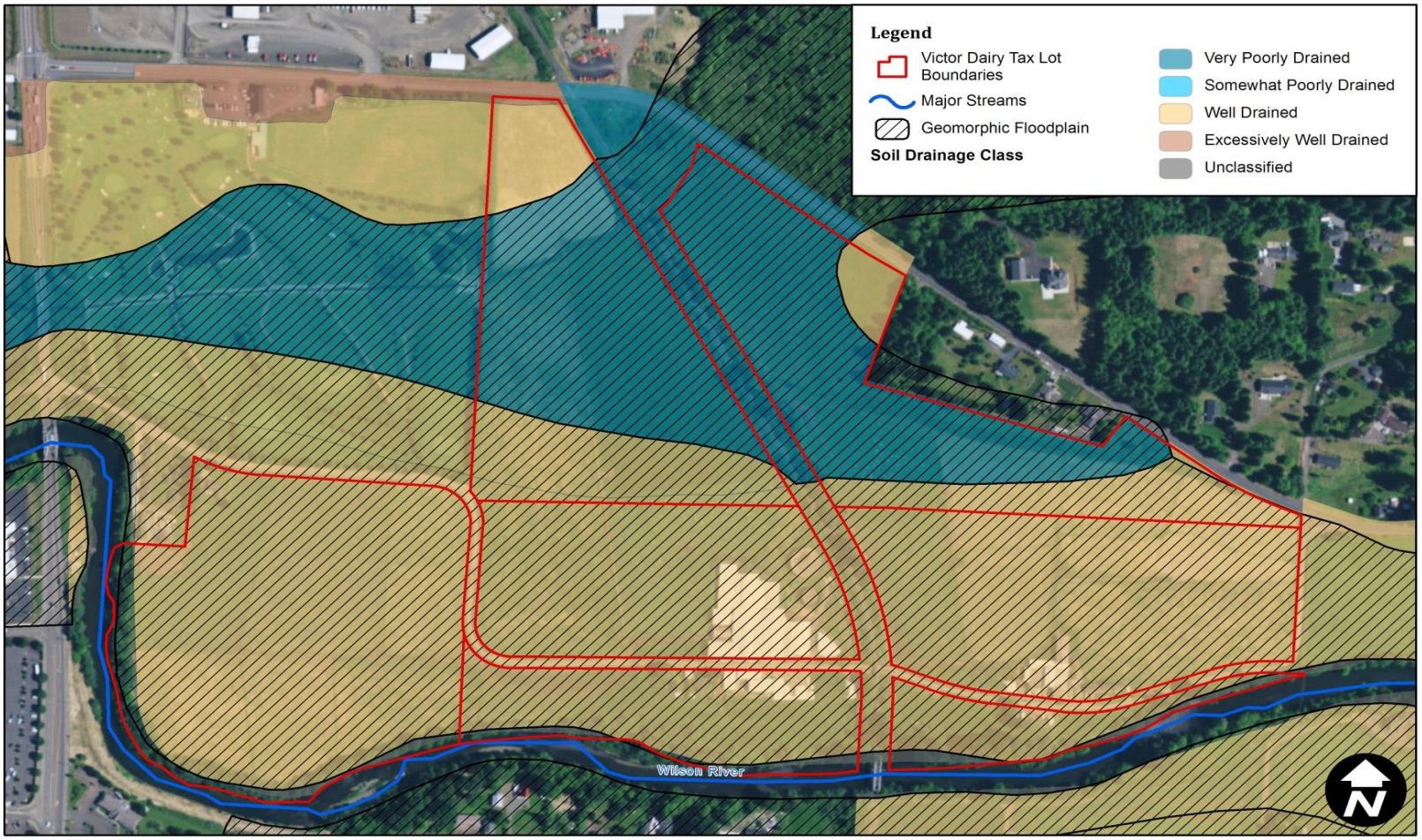
Watershed (5th-Field HUC)	NWI Wetlands Below HMT (Acres)	NWI Wetlands Modified Below HMT (Acres)	NWI Freshwater Wetlands (Acres)	NWI Freshwater Wetlands Modified (Acres)	Geomorphic Floodplain (Acres)	Filled Areas (Acres)
Headwaters Nehalem River	-	-	88	1	24	-
Kilchis River	-	-	539	1	143	4
Little Nestucca River	515	3	602	9	447	5
Lower Nehalem River	2,777	22	1,839	120	761	91
Miami River	13	5	413	7	94	2
Middle Nehalem River	-	-	133	1	-	-
Necanicum River	71	-	235	11	-	1
Nestucca River	725	10	2,272	38	1,193	-
North Fork Nehalem River	374	48	728	126	970	7
Rock Creek	5	-	1	-	-	-
Salmon River	16	-	96	-	170	38
Salmonberry River	-	-	385	-	-	-
Sand Lake	4,201	9	3,079	58	531	9
Tillamook Bay	9,356	145	805	38	246	241
Tillamook River	296	47	1,379	52	1,265	43
Trask River	222	58	1,116	24	449	91
Willamina Creek	-	-	47	-	-	-
Wilson River	42	2	1,841	2	444	80
SUM TOTAL	**18,614**	**349**	**15,597**	**486**	**6,738**	**611**

Agricultural Lands: Soil Drainage Characteristics

Table 5 summarizes soil drainage classes for the County's Agricultural Lands. Soil drainage classification is an indicator of the soil's distance to the water table. Poorly drained soils are closer to the water table than well drained soils.

Soils classified as very poorly drained cover 10,832 acres of Agricultural Lands, ranging from 37 acres in the Kilchis River Watershed to 2,903 acres in the Tillamook River Watershed. There are 2,380 acres with somewhat poorly drained soils. In contrast, there are 23,394 acres with well drained soils and 854 acres with excessively well drained soils. Figure 8 shows an example of soil drainage classes and geomorphic floodplain locations for agricultural lands along the Wilson River.

Figure 8. An Example of Soil Drainage Classes and Geomorphic Floodplain for Agricultural Lands Area along the Wilson River



Date: 6/26/2017
Scale: 1 inch = 450 feet
Data Source: ESRI, 2017; Tillamook County, 2017; USGS, NHD, 2016; Suil Survey Staff, gSSURGO Database for Oregon, 2016

Case Study: Victor Dairy, LLC - Soil Attributes

CASCADE ENVIRONMENTAL GROUP

0 200 400 800 Feet

Tillamook County SB1517 Pilot Project

Z:\GIS\145_Tillamook\Mapfiles\VictorDairy_Soils.mxd

Table 5. Soil Drainage Classes on Agricultural Lands

Watershed (5th-Field HUC)	Very Poorly Drained (Acres)	Somewhat Poorly Drained (Acres)	Well Drained (Acres)	Excessively Well Drained (Acres)	Not Classified (Acres)
Headwaters Nehalem River	n/a	n/a	n/a	n/a	n/a
Kilchis River	37	20	463	36	
Little Nestucca River	895	118	2,006	-	3
Lower Nehalem River	1,214	46	1,348	57	48
Miami River	97	1	592	142	
Middle Nehalem River	n/a	n/a	n/a	n/a	n/a
Necanicum River	n/a	n/a	n/a	n/a	n/a
Nestucca River	1,744	90	7,669	233	2
North Fork Nehalem River	946	192	846	-	9
Rock Creek	n/a	n/a	n/a	n/a	n/a
Salmon River	n/a	n/a	n/a	n/a	n/a
Salmonberry River	n/a	n/a	n/a	n/a	n/a
Sand Lake	265	104	1,310	19	20
Tillamook Bay	1,049	153	740	3	3
Tillamook River	2,903	502	2,542	-	20
Trask River	1,453	1,068	4,289	188	10
Willamina Creek	n/a	n/a	n/a	n/a	n/a
Wilson River	228	86	1,590	175	16
SUM TOTAL	**10,832**	**2,380**	**23,394**	**854**	**131**

Agricultural and Non-Agricultural Lands: Management and Infrastructure

Table 6 summarizes the area within drainage districts, number of tide gates, and length of levees for Agricultural and Non-Agricultural Lands.

There are 8,779 acres managed by drainage districts in the County. The area managed by drainage districts is mostly concentrated on Agricultural Lands (7,947 acres), with much less area (832 acres) managed by districts within Non-Agricultural Lands. The Agricultural Lands under drainage district management are concentrated in the Little Nestucca River Watershed (731 acres); Lower Nehalem River Watershed (1,273 acres); Nestucca River Watershed (1,646 acres); Tillamook Bay Watershed (787 acres); Tillamook River Watershed (1,804 acres); and the Trask River Watershed (1,341 acres). The Non-Agricultural Lands under drainage district management are, for the most part, extensions of the same districts, and thus concentrated in the same watersheds: Lower Nehalem River Watershed (125 acres); Nestucca River Watershed (19 acres); Tillamook Bay Watershed (437 acres); Tillamook River Watershed (30 acres); and the Trask River Watershed (176 acres).

Tide gates, by definition, are located in areas subject to tidal inundation. There are 41 tide gates within Agricultural Lands, with the largest numbers concentrated in the Little Nestucca River Watershed (6 tide gates); North Fork Nehalem River Watershed (9 tide gates); Tillamook Bay Watershed (6 tide gates); and the Tillamook River Watershed (11 tide gates). The total number of tide gates within Non-Agricultural Lands is similar (40 tide gates), with the largest numbers concentrated in the North Fork Nehalem River Watershed (9 tide gates); Tillamook Bay Watershed (10 tide gates); and the Tillamook River Watershed (9 tide gates).

There are 25 miles of levees within the County's Agricultural Lands, primarily concentrated in the Tillamook Bay Watershed (7 miles) and the Tillamook River Watershed (11 miles). There are 38 miles of levees on Non-Agricultural Lands. These levees, which are primarily connected to the levees on Agricultural Lands, are concentrated within the Tillamook Bay Watershed (14 miles) and the Tillamook River Watershed (7 miles).

Table 6. Drainage Districts, Tide Gates, and Levees on Agricultural and Non-Agricultural Lands (n/a = No Agricultural Lands Present in Watershed)

Watershed (5th-Field HUC)	Agricultural Areas in Drainage Districts (Acres)	Non-Agricultural Areas in Drainage Districts (Acres)	Agricultural Areas # Tide Gates	Non-Agricultural Areas # Tide Gates	Agricultural Areas Levees (Miles)	Non-Agricultural Areas Levees (Miles)
Headwaters Nehalem River	n/a	-	n/a	-	n/a	-
Kilchis River	61	0.2	-			
Little Nestucca River	731	8	6	3	-	1
Lower Nehalem River	1,273	125	4	1		4
Miami River	-	-	-	-	-	-
Middle Nehalem River	n/a	-	n/a	-	n/a	-
Necanicum River	n/a	-	n/a	-	n/a	-
Nestucca River	1,646	19	2	2		1
North Fork Nehalem River	-	-	9	9	-	2
Rock Creek	n/a	-	n/a	-	n/a	-
Salmon River	n/a	-	n/a	-	n/a	-
Salmonberry River	n/a	-	n/a	-	n/a	-
Sand Lake	2	-	-	1	0	3
Tillamook Bay	787	437	6	10	7	14
Tillamook River	1,804	30	11	9	11	7
Trask River	1,341	176	3	4	3	4
Willamina Creek	n/a	-	n/a	-	n/a	-
Wilson River	300	37	-	-	4	2
SUM TOTAL	**7,947**	**832**	**41**	**40**	**25**	**38**

Agricultural and Non-Agricultural Lands: Restoration Projects, Fish Habitat, and Sea Level Rise

Table 7 summarizes restoration projects, fish habitat, and expected Sea Level Rise for Agricultural and Non-Agricultural Lands.

The restoration projects included in the inventory focus on levee removal and other actions designed to restore historical drainage patterns. Restoration projects that meet these criteria cover a total of 872 acres within the County[4]. All the restoration projects are within tidal areas (below HMT) and are designed to restore tidal processes and wetland functions. The inventory includes one project in the Little Nestucca River Watershed (96 acres); one project in the Miami River Watershed (34 acres); two projects in the Tillamook Bay Watershed (Southern Flow Corridor, 366 acres, and the lower Kilchis River, 67 acres); and one project in the Trask River Watershed (Southern Flow Corridor, 309 acres). Figure 9 shows the restoration project locations.

High Intrinsic Potential (IP) is a measure of the historical potential of the river or stream to support high quality Coho salmon spawning and juvenile rearing habitat. High IP Coho habitat is generally characterized by low-gradient channel areas, wide floodplains, and unconstrained channels that can meander across the floodplain. It is a measure of historical potential and does not reflect levees or other measures that currently constrain channels movement and floodplain inundation.

There are 115 miles of high IP Coho habitat within the County's Agricultural Lands. The greatest extent of high IP areas on Agricultural Lands is concentrated in the Nestucca River Watershed (24 miles); North Fork Nehalem River Watershed (11 miles); Tillamook River Watershed (24 miles); and the Trask River Watershed (15 miles).

There is 181 miles of high IP Coho habitat within the County's Non-Agricultural Lands. The greatest extent of high IP areas on Non-Agricultural Lands is concentrated in the Little Nestucca River Watershed (18 miles); Lower Nehalem River (15 miles); Nestucca River (28 miles); Sand Lake Watershed (31 miles); Tillamook River Watershed (32 miles); Trask River Watershed (14 miles); and Wilson River Watershed (15 miles).

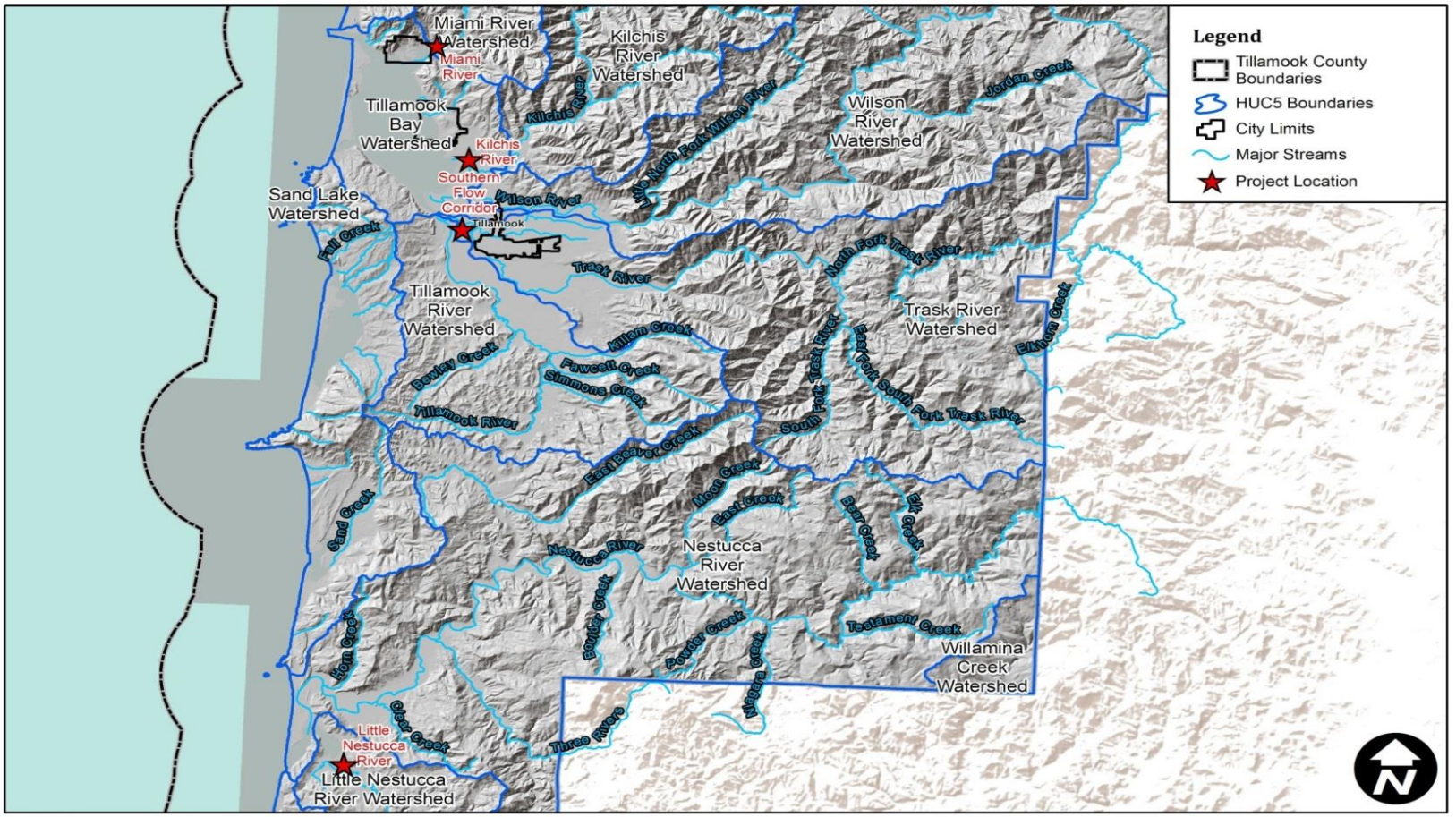
Sea level rise is a measure of the additional area inundated by the ocean under a scenario that assumes a 1 meter (~3-foot) rise in ocean water surface elevations. Overall sea level rise is forecasted to affect 20,790 acres within the County. Sea level rise impacts are most pronounced in the areas adjacent to estuaries and portions of lower river floodplains subject to tidal influence. The watersheds with the largest sea level rise impacts within Agricultural and Non-Agricultural Lands include the Lower Nehalem River Watershed; Nestucca River Watershed; Sand Lake Watershed; Tillamook Bay Watershed; Tillamook River Watershed; and the Trask River Watershed.

[4] Based on the Oregon Water and Environment Board (OWEB)'s OWRI database of restoration projects in Oregon. The OWEB database did not include some restoration projects that meet the criteria. These gaps will be addressed during the wetland assessment phase.

Table 7. Restoration Projects, Fish Habitat, and Sea Level Rise within Agricultural and Non-Agricultural Lands

Watershed (5th-Field HUC)	Restoration Areas (Acres)	Agricultural Lands High IP Coho Habitat (Miles)	Non-Agricultural Lands High IP Coho Habitat (Miles)	Agricultural Lands Sea Level Rise (1m) (Acres)	Non-Agricultural Lands Sea Level Rise (1m) (Acres)
Headwaters Nehalem River	-	n/a	1	n/a	-
Kilchis River	-	4	2	2	7
Little Nestucca River	96	8	18	784	564
Lower Nehalem River	-	6	15	1,032	2,989
Miami River	34	5	4	51	17
Middle Nehalem River	-	n/a	0.3	n/a	-
Necanicum River	-	n/a	0.4	n/a	33
Nestucca River	-	24	28	234	798
North Fork Nehalem River	-	11	9	-	798
Rock Creek	-	n/a	-	n/a	735
Salmon River	-	n/a	2	n/a	899
Salmonberry River	-	n/a	1	n/a	-
Sand Lake	-	7	31	20	4,067
Tillamook Bay	433	3	9	1,037	9,092
Tillamook River	-	24	32	1,999	372
Trask River	309	15	14	544	358
Willamina Creek	-	n/a	0.3	n/a	-
Wilson River	-	9	15	169	62
SUM TOTAL	**872**	**115**	**181**	**5,871**	**20,790**

Figure 9. Restoration Project Locations (Note: This figure does not include restoration projection locations in the northern portion of Tillamook County)



Agricultural and Non-Agricultural Lands: Historical Wetlands

Table 8 summarizes historical wetlands below HMT (likely tidally influenced) and above HMT (freshwater wetlands) for the County's Agricultural and Non-Agricultural Lands. As noted in the methods section, these areas have a high probability of containing historical tidal or freshwater wetlands that have been converted to areas that no longer function as wetlands. The estimate of historical wetlands presented here is conservative, and there are certainly other areas within Agricultural Lands that contain historical wetlands below HMT, but the data do not provide sufficient resolution to identify specific areas.

There are 694 acres of potential historical wetlands within the County's Agricultural Lands below HMT. The area of potential historical tidal wetlands within Agricultural Lands ranges from no acreage in the Sand Lake Watershed to 201 acres in the North Fork Nehalem Watershed.

There are 445 acres of potential historical wetlands within the County's Non-Agricultural Lands below HMT, which is less than the 694 acres identified on Agricultural Lands. The area of potential historical tidal wetlands within Non-Agricultural Lands ranges from 1 acre in the Miami River and Rock Creek Watersheds to 138 acres in the Sand Lake Watershed.

There are 2,900 acres of potential historical freshwater wetlands within the County's Agricultural Lands. The area of potential historical freshwater wetlands within Agricultural Lands ranges from 39 acres in the Kilchis River Watershed to 822 acres in the Trask River Watershed.

There are 3,608 acres of potential historical freshwater wetlands within the County's Non-Agricultural Lands. The area of potential historical freshwater wetlands within Non-Agricultural Lands ranges from 1 acre in the Rock Creek Watershed to 560 acres in the Trask River Watershed.

The potential historical wetlands identified in the inventory focuses on areas that are converted to non-wetland habitats. In addition to wetland loss there has also been loss of wetland function. As noted above, a large proportion of the NWI wetlands have been altered as a result of levees or other drainage modifications. The combined area of historical and modified NWI wetlands provides a perspective on potential areas where wetland functions can be restored or enhanced. Figures 9 and 10 summarize the watershed areas for combined historical and modified wetlands below HMT (likely tidally influenced) and above HMT (freshwater wetlands) on Agricultural Lands.

Table 8. Historical Wetlands below HMT and Freshwater Wetlands for Agricultural and Non-Agricultural Lands (n/a = No Agricultural Lands Present in Watershed)

Watershed (5th-Field HUC)	Agricultural Lands: Potential Historical Wetlands Below HMT (Acres)	Agricultural Lands: Potential Historical Freshwater Wetlands (Acres)	Non-Agricultural Lands: Potential Historical Wetlands Below HMT (Acres)	Non-Agricultural Lands: Historical Freshwater Wetlands (Acres)
Headwaters Nehalem River	n/a	n/a	-	36
Kilchis River	-	39	-	38
Little Nestucca River	27	96	10	268
Lower Nehalem River	191	312	65	272
Miami River	7	42	1	28
Middle Nehalem River	n/a	n/a	-	13
Necanicum River	n/a	n/a	25	85
Nestucca River	7	535	39	400
North Fork Nehalem River	201	239	15	231
Rock Creek	n/a	n/a	1	1
Salmon River	n/a	n/a	2	57
Salmonberry River	n/a	n/a	-	4
Sand Lake	-	54	138	596
Tillamook Bay	62	67	92	165
Tillamook River	134	568	22	510
Trask River	54	822	24	560
Willamina Creek	n/a	n/a	-	3
Wilson River	12	125	10	339
SUM TOTAL	**694**	**2,900**	**445**	**3,608**

Figure 10. Watershed Acreage for Combined Historical and Modified NWI Wetlands below HMT on Agricultural Lands

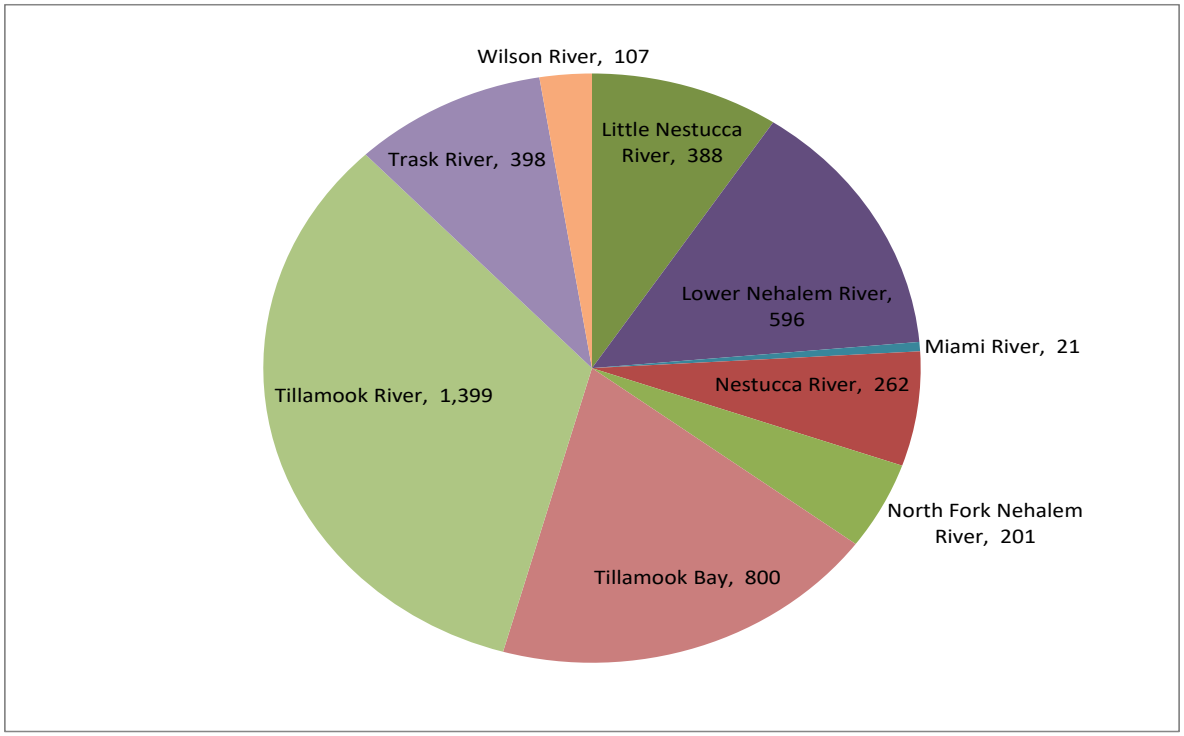
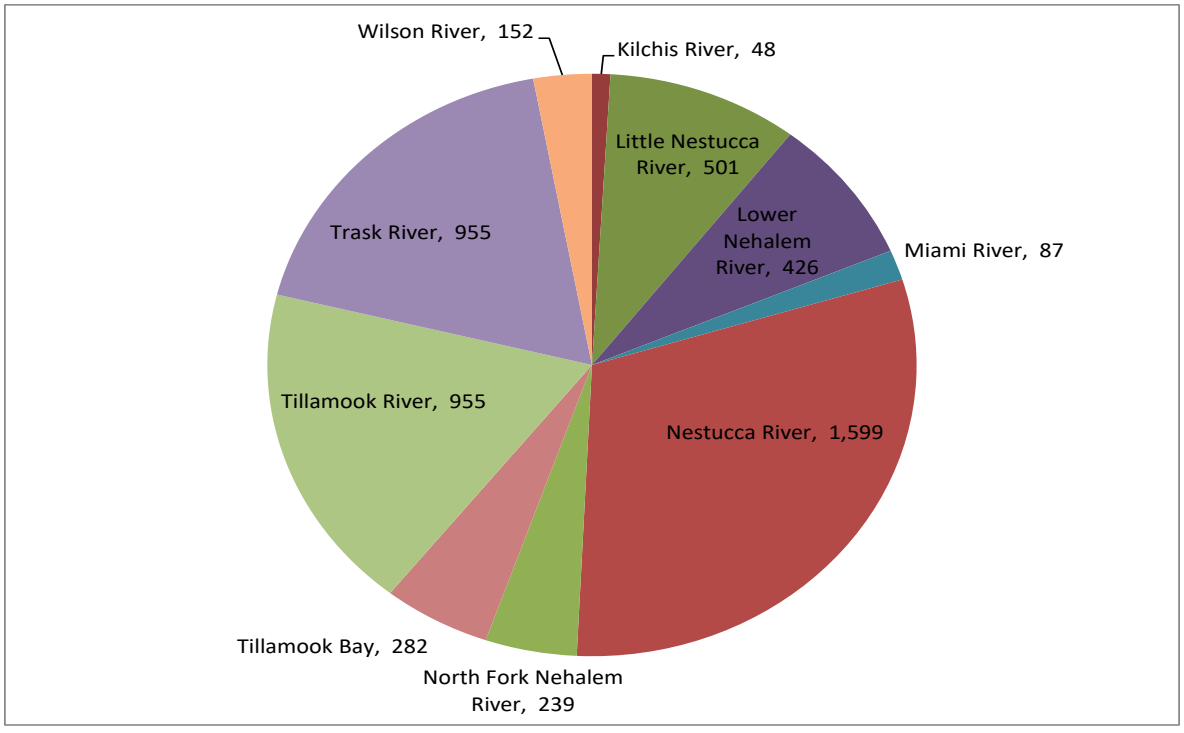


Figure 11. Watershed Acreage for Combined Historical and Modified NWI Freshwater Wetlands (above HMT) on Agricultural Lands



Agricultural Lands Inventory

As described in the methods above, and consistent with the wetland inventory, the agricultural inventory quantitatively describes current land uses and characteristics of EFU lands by watershed (at the 5th field HUC). Following an overview of EFU lands and their relationship with high value farmland, the agricultural lands inventory focused on six aspects of EFU lands:

1. Dairy operations, including the number of operations and permitted animals by watershed. The data on dairy operations are from the Oregon Department of Agriculture (ODA) Confined Animal Feedlot Operation (CAFO) program.
2. Land use and crops grown on EFU Lands by watershed. The data source is the United States Department of Agriculture Cropscape 2016 geospatial dataset.
3. Irrigation water rights on EFU lands by watershed. The data source is Oregon Water Resources Department database on water rights by point of use (POU).
4. Expected crop yields on EFU lands by watershed. The data source is the NRCS soil survey dataset, SSURGO, which is contains information about soil, including expected grass silage and pasture yields, as collected by the National Cooperative Soil Survey.
5. EFU lands in diking districts by watershed. Based on a data layer provided by the County.
6. Animal waste management potential on EFU lands by watershed. The data source is the NRCS soil survey dataset, SSURGO, which contains information about soil, including the capacity of soils to absorb liquid animal waste.

EFU and High Value Farmland Distribution

The Oregon legislature created the EFU zone to provide areas for continued practice of commercial agriculture, and is intended to be applied to areas with high-value farm soils. Currently there are 37,590 acres in the EFU zone. The number of acres in the EFU zone has been steady over time. For example, in 1978, there were approximately 35,500 acres in the EFU in Tillamook County (Tillamook County, 1982). The EFU acreage is consistent with data from the US Census of Agriculture, which found approximately 32,700 acres of cropland and pasture in the County in 2012 and approximately 39,000 acres of cropland and pasture in 2007.

In Tillamook County, there are approximately 29,000 acres of high value agricultural lands (defined by state statute primarily based on soil type). The distribution of EFU and high value agricultural acreage by watershed is shown in Table 9. As shown in the table, all but 84 acres of high value agricultural lands in the County are in the EFU zone, with no more than 25 acres in any one basin. This indicates that there may be limited potential to increase agricultural production outside EFU lands in order to compensate for conversion of EFU agricultural lands to other uses. However, as discussed below, there are lands outside the EFU zone that are used for managing animal waste. Also, there are approximately 8,590 acres of EFU lands that are not classified as high value agricultural lands based on soil type, which conversely may potentially indicate that these lands are marginal production for agriculture.

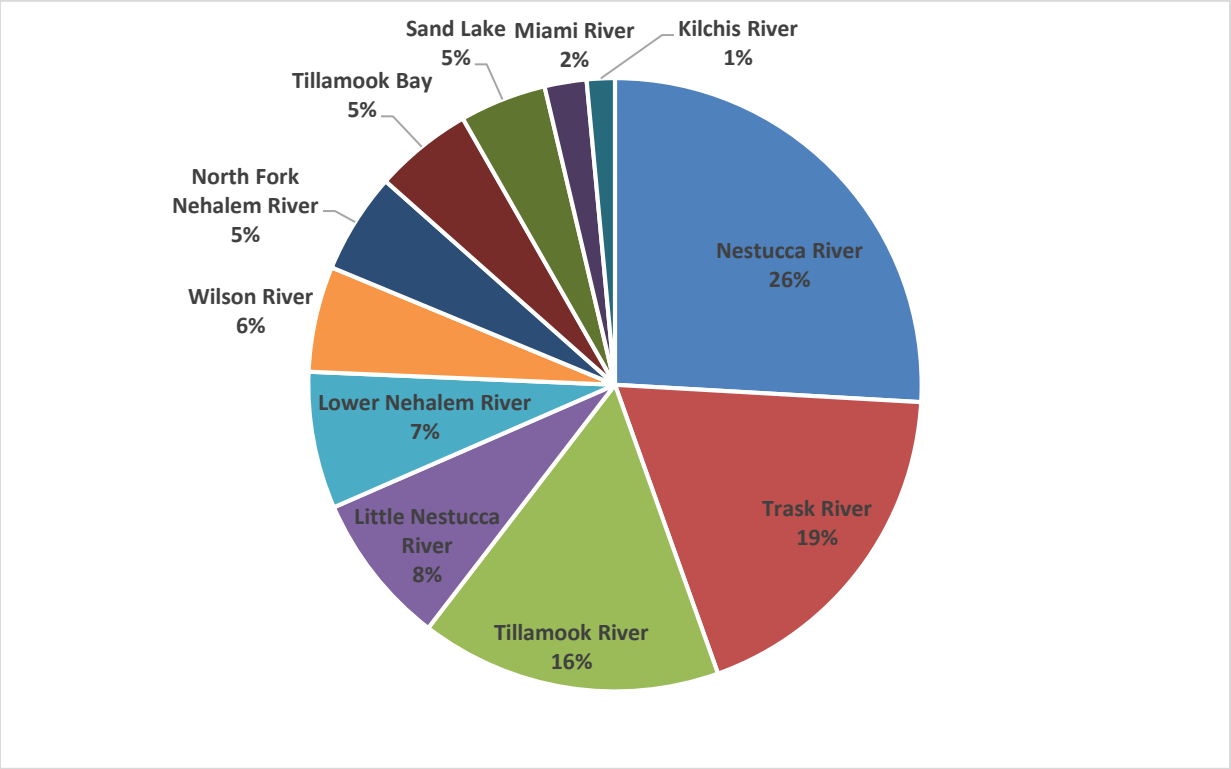
Table 9 and Figure 11 also highlight that the majority (22,700 acres or 60 percent) of EFU lands are in three watersheds: Nestucca River, Tillamook River, and Trask River. An additional 11,500 acres (31 percent) are in the Little Nestucca, Lower Nehalem, Wilson River, Sand Lake, and Tillamook Bay

watersheds. The remaining 1,390 acres of EFU lands are in the Miami River and Kilchis River watersheds. There are seven watersheds with no EFU lands: Headwaters Nehalem River, Middle Nehalem River, Necanicum River, Rock Creek, Salmon River, Salmonberry River, and Willamina Creek. As there are likewise no commercial dairies and only 4.6 acres of high value farmland in total across these seven watersheds, we conducted no further agricultural analysis of these watersheds.

Table 9. Distribution of EFU and High Value Farmland across Tillamook Watersheds

Watershed (5th field HUC)	EFU Lands		High Value Farmland in EFU		High Value Farmland Outside EFU	
	Acres	% of County Total	Acres	% of County Total	Acres	% of County Total
Nestucca River	9,736.20	26%	6,509.50	23%	15.6	19%
Trask River	7,008.40	19%	6,681.20	23%	12.2	15%
Tillamook River	5,967.50	16%	4,909.50	17%	13.3	16%
Little Nestucca River	3,021.20	8%	1,664.60	6%	1.8	2%
Lower Nehalem River	2,714.00	7%	2,073.50	7%	2.2	3%
Wilson River	2,094.00	6%	1,470.00	5%	25	30%
North Fork Nehalem River	1,993.80	5%	1,686.00	6%	2.1	2%
Tillamook Bay	1,948.10	5%	1,802.70	6%	0.8	1%
Sand Lake	1,718.20	5%	1,102.70	4%	5	6%
Miami River	831.3	2%	514.6	2%	0.4	1%
Kilchis River	556.6	1%	489.5	2%	0.8	1%
Headwaters Nehalem River	0	0%		0%	1	1%
Middle Nehalem River	0	0%		0%	0.4	1%
Necanicum River	0	0%		0%	0.6	1%
Rock Creek	0	0%		0%	0.4	1%
Salmon River	0	0%		0%		0%
Salmonberry River	0	0%		0%	1.8	2%
Willamina Creek	0	0%		0%	0.3	0%
SUM TOTAL	37,589.30	100%	28,903.90	100%	83.9	100%

Figure 12. Proportion EFU Lands by Watershed



Dairy Operations

Dairy farming has long provided the vast majority of agricultural value in Tillamook County. According to the 2012 Census of Agriculture, the market value of milk from cows was valued at $101.9 million. This is 87 percent of the 2012 total market value of all county agricultural products sold of $117.1 million. Recognizing the importance of the dairy industry to the stability of agriculture in the County, this section includes analysis of the spatial distribution of dairy farms and dairy animals across the County.

Using permit data from the ODA CAFO program, we present data in Table 10 and Figure 12 on the location of dairies and the number of permitted animals by watershed. Current data indicate that there are 174 CAFO dairy operations in Tillamook County, with 45,151 permitted animals. The actual number of animals on Tillamook CAFO operations may be less than the number of permitted animals. Based on count data from ODA inspections in 2016, there are approximately 40,500 cows in the County in CAFO operations, of which approximately 26,150 are adults and 14,300 are heifers/calves.[5] This roughly corresponds to the 2012 Census of Agriculture data that estimated approximately 25,000 milk cows and 18,900 'other cattle' that are not beef cows or milk cows.

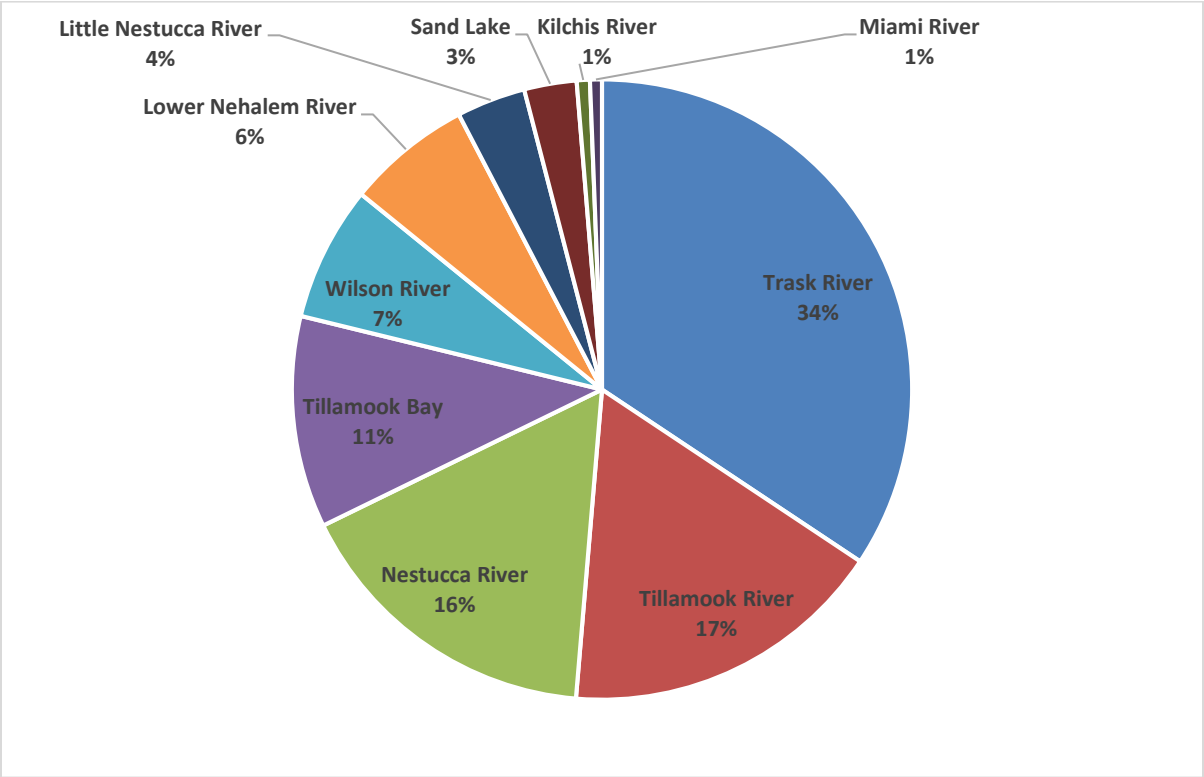
[5] Data from 2016 inspections identified 40,500 animals currently on the dairy CAFO operations, of which up to 150 may be horses, goats, beef cows, sheep/lambs (based on the number of permitted animals of these types on dairy CAFO operations).

Table 10. Distribution of Dairy Cows and Dairy Operations across Tillamook Watersheds

Watershed (5th Field HUC)	CAFO in EFU		CAFO Outside EFU	
	CAFO, # Operations	CAFO, # Permitted Cows	CAFO, # Operations	CAFO, # Permitted Cows
Trask River	52	15,508	1	105
Tillamook River	38	7,673		
Nestucca River	37	7,421	2	225
Tillamook Bay	16	4,985		
Wilson River	10	3,175		
Lower Nehalem River	8	2,940	1	135
Little Nestucca River	4	1,625		
Sand Lake	5	1,234		
Kilchis River	2	310		
Miami River	2	280		
North Fork Nehalem River				
Total	**174**	**45,151**	**4**	**465**

As shown in Figure 12, approximately one-third of permitted cows and CAFO operations are in the Trask River watershed. The Trask River and five other watersheds (Tillamook River, Nestucca River, Tillamook Bay, Wilson River, and Lower Nehalem River) account for 92 percent of all permitted animals and 93 percent of CAFO operations. Approximately 99 percent of permitted animals are located on farms with base of operations located in the EFU zone; only four CAFO operations with 465 permitted animals are located outside the EFU zone. However, as described in Table 11, some CAFO operations located in EFU lands also utilize lands outside the EFU zone for manure spreading.

Figure 13. Percent of Permitted Cows in CAFO Operations in Tillamook County by Watershed



For three watersheds in Tillamook County (Trask River, Tillamook River, and Tillamook Bay), the ODA CAFO program has mapped the lands that CAFO operations use to manage animal waste. This 'waste wastement' acreage is shown in Table 11 for the mapped watersheds (note, some acreage has also been mapped in the Wilson River and Kilchis River watersheds; these data are also included in Table 11). Of the mapped CAFO operations in the County, 87 percent of the lands used for managing animal waste are in the EFU zone. For a given watershed, this proportion may vary from approximately 80 percent (Tillamook River) to 100 percent (Kilchis River) reliance on EFU lands.

Table 11. Distribution of CAFO Manure Management Lands on EFU and non-EFU Zoned Lands

Watershed	In EFU (Acres)	Outside EFU (Acres)	% in EFU
Trask River	4413.8	450.5	91%
Tillamook River	2670.3	674.8	80%
Tillamook Bay	773.3	121.7	86%
Kilchis River	305.6	0.9	100%
Wilson River	135.1	16.3	89%
Nestucca River	N/A	N/A	N/A
Lower Nehalem River	N/A	N/A	N/A
Little Nestucca River	N/A	N/A	N/A
Sand Lake	N/A	N/A	N/A
Miami River	N/A	N/A	N/A
North Fork Nehalem River	N/A	N/A	N/A
5-Basin Total	8,298.20	1,264.30	87%

N/A: Not Available.

Land Use on EFU Lands

Table 12 shows results of an analysis of the USDA Cropscape geospatial data for crop acreage in Tillamook County. The Cropscape data is at a very coarse scale. The raw data showed over 22,000 acres of the approximately 37,600 EFU acres as natural vegetation (forest, wetland, scrubland, etc). As this seemed an anomaly to our project team, we reviewed aerial photos of the landscape in conjunction with the Cropscape data. This process revealed that many of the lands classified as natural vegetation communities were in fact diked and appeared to be used as cropland; over 11,820 acres of these lands were digitized as cropland, forming the new category "Digitized cropland" (see Figure 13, which highlights these digitized cropland areas for a farm in the Wilson River watershed).

In total, including the digitized cropland acreage, there are an estimated 24,650 acres of cropland farmed in the EFU zone. Nearly all of this land is hay, corn, grain, or pasture land supporting animal operations. The remainder of EFU lands are predominantly natural or developed, with some also categorized as barren or as water (see Figure 14). (Note that 'natural' lands, of which there are 10,200 acres in the EFU zone, include the following Cropscape categories: clover/wildflowers, deciduous forest, evergreen forest, herbaceous wetlands, mixed forest, shrubland, and woody wetlands). As shown in the last column of Table 12, the majority (62 percent) of EFU crop and pasture lands are in three watersheds: Trask River, Nestucca River, and Tillamook River (the same three watersheds that contain 67 percent of permitted dairy animals).

Figure 14. USDA Cropscape Data on Crops and Other Land Use in an Area of the Wilson River Watershed

Date: 6/27/2017
Scale: 1 inch = 450 feet
Data Source: ESRI, 2017; Tillamook County, 2017; ODF, 2016; USDA Cropland Data Layer, 2016

USDA Cropscape Mapping of Cropping Pattern at Victor Dairy, LLC

CASCADE ENVIRONMENTAL GROUP

0 200 400 800 Feet

Tillamook County SB1517 Pilot Project

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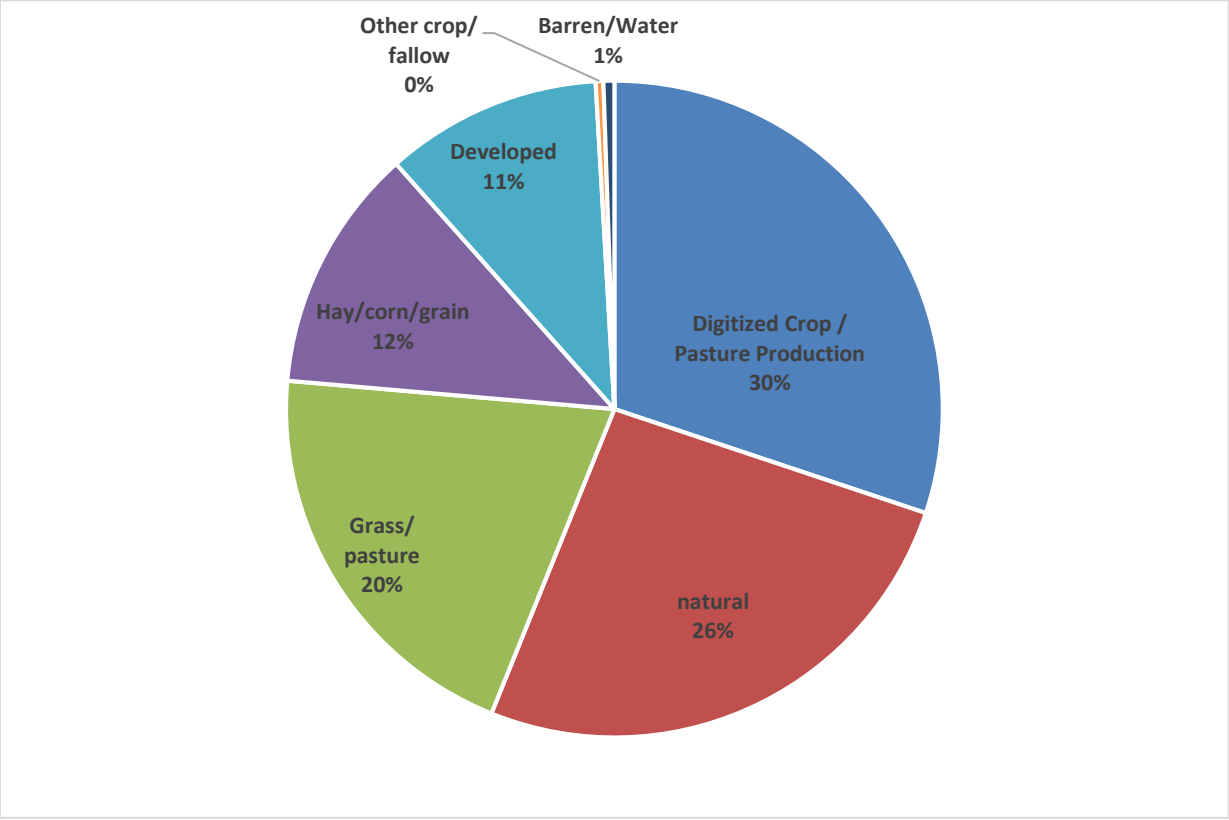
Table 12. Acres of Crop Type on EFU Lands by Watershed

Watershed (5th Field HUC)	Grass/ pasture	Hay/corn/ grain	Digitized Cropland	Other crop/ fallow	Total Crop/Pasture Acres	% of EFU Crop/Pasture Acres
Trask River	2,846.40	1,788.00	1,122.00	22.2	5,778.60	23%
Nestucca River	1,678.20	643.9	2,889.60	74.4	5,286.00	21%
Tillamook River	1,260.90	974	2,142.40	21.6	4,398.90	18%
North Fork Nehalem River	415.4	121.2	1,244.60	0.2	1,781.40	7%
Lower Nehalem River	447.9	326.1	990.7	1.3	1,766.00	7%
Little Nestucca River	286.5	71.6	1,089.20	4.5	1,451.90	6%
Wilson River	491.7	353.8	490	12	1,347.40	5%
Tillamook Bay	242.3	253.3	806.3	11.8	1,313.70	5%
Sand Lake	103.9	38.9	563.8	0.7	707.3	3%
Kilchis River	132.4	143.3	158.7	0.2	434.6	2%
Miami River	46.5	12.5	325.7	0	384.7	2%
SUM TOTAL	**7,952.00**	**4,726.60**	**11,822.90**	**149**	**24,650.50**	**100%**

Figure 15. Proportion of Land Use in EFU Zone Countywide



Outside the EFU zone, according to the raw Cropscape data, there are approximately 11,980 acres of cropland and pasture (non-EFU natural areas were not reviewed and digitized with aerial photos, so this may be an underestimate of crop/pasture acres on non-EFU lands).[6] In total then, our review of the Cropscape data identifies approximately 36,630 acres of cropland in the County, of which approximately 24,650 acres (67 percent) are within the EFU zone and 11,980 (33 percent) are located outside the EFU zone; within any given watershed approximately 41 percent to 90 percent of crop and pasturelands are within the EFU zone (see Table 13). (It is important to note, that as presented in Table 9, there are few high value agricultural lands with good soil quality outside the EFU zone).

For cross-reference with other data sources, the total County crop and farmland acreage roughly corresponds with data from the Census of agriculture: the average of the 2007 and 2012 Census of Agriculture estimate that, respectively, there were 39,000 acres and 32,700 acres of cropland and pasture in the County in those years. [7]

Table 13. Crop / Pasture Acreage on EFU Lands versus Non-EFU Lands by Watershed

Watershed (5th Field HUC)	Total Crop/Pasture Acres			EFU Lands as a % of Total County Crop/Pasture Acres
	EFU Lands	Non- EFU Lands	Tillamook County	
Trask River	5,778.60	2,663.30	8,441.90	68%
Nestucca River	5,286.00	875	6,161.00	86%
Tillamook River	4,398.90	1710.6	6,109.50	72%
North Fork Nehalem River	1,781.40	305.2	2,086.60	85%
Lower Nehalem River	1,766.00	1280.6	3,046.60	58%
Little Nestucca River	1,451.90	168.1	1,620.00	90%
Wilson River	1,347.40	1947.1	3,294.50	41%
Tillamook Bay	1,313.70	235.3	1,549.00	85%
Sand Lake	707.3	727.3	1,434.60	49%
Kilchis River	434.6	113.8	548.4	79%
Miami River	384.7	264.1	648.8	59%
SUM TOTAL	24,650.50	11,980.80	36,631.30	67%

[6] Of these 11,980 acres, 11,200 acres or 93 percent, are identified in Cropscape as grass or pasture lands and approximately 780 acres are in hay/corn/grain or other crops.

[7] Revised memo will include information on the zoning class for the 11,980 acres of crop and pasture located outside the EFU zone.

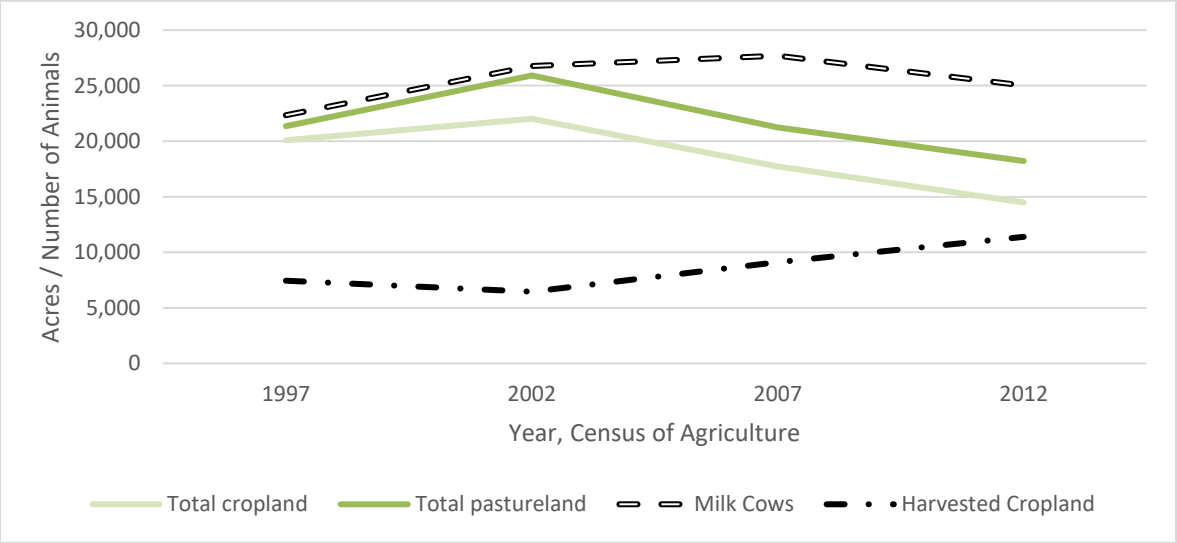
Table 14 presents the EFU crop/pasture acreage by watershed in another context: as a percent of total watershed area. As shown in Table 14, countywide, EFU acreage that is in crop and pastureland represents just 3 percent of total land area, varying from 0 percent to 11 percent, depending on the watershed.

Table 14. Crop / Pasture Acreage on EFU as a Proportion of Watershed Area

Watershed (5th Field HUC)	Watershed Acreage	Crop/Pasture in EFU	% Watershed in EFU Crop/Pasture
Trask River	90,666.50	5778.6	6%
Nestucca River	139,693.10	5286	4%
Tillamook River	39,360.80	4398.9	11%
North Fork Nehalem River	17,573.50	1781.4	10%
Lower Nehalem River	70,078.30	1766	3%
Little Nestucca River	32,413.40	1451.9	4%
Wilson River	118,634.50	1347.4	1%
Tillamook Bay	21,254.80	1313.7	6%
Sand Lake	53,885.00	707.3	1%
Kilchis River	41,279.80	434.6	1%
Miami River	23,051.80	384.7	2%
Other Watersheds	70,827.80	0	0%
Total	**718,719.30**	**24650.5**	**3%**

Figure 15 gives historical context from the US Census of Agriculture for milk cows and acreage over the last 20 years in Tillamook County. As shown by the dashed lines in the figure, agricultural outputs, in terms of the number of milk cows and harvested crop acres, has either been steady or slightly rising since 1997. However, as measured by the Census of Agriculture and shown with the solid lines, the agricultural land base in terms of the number of acres in pastureland or cropland has declined since 2002.

Figure 16. Acreage and Milk Animals Over Time in Tillamook County



Irrigation Water Rights on EFU Lands

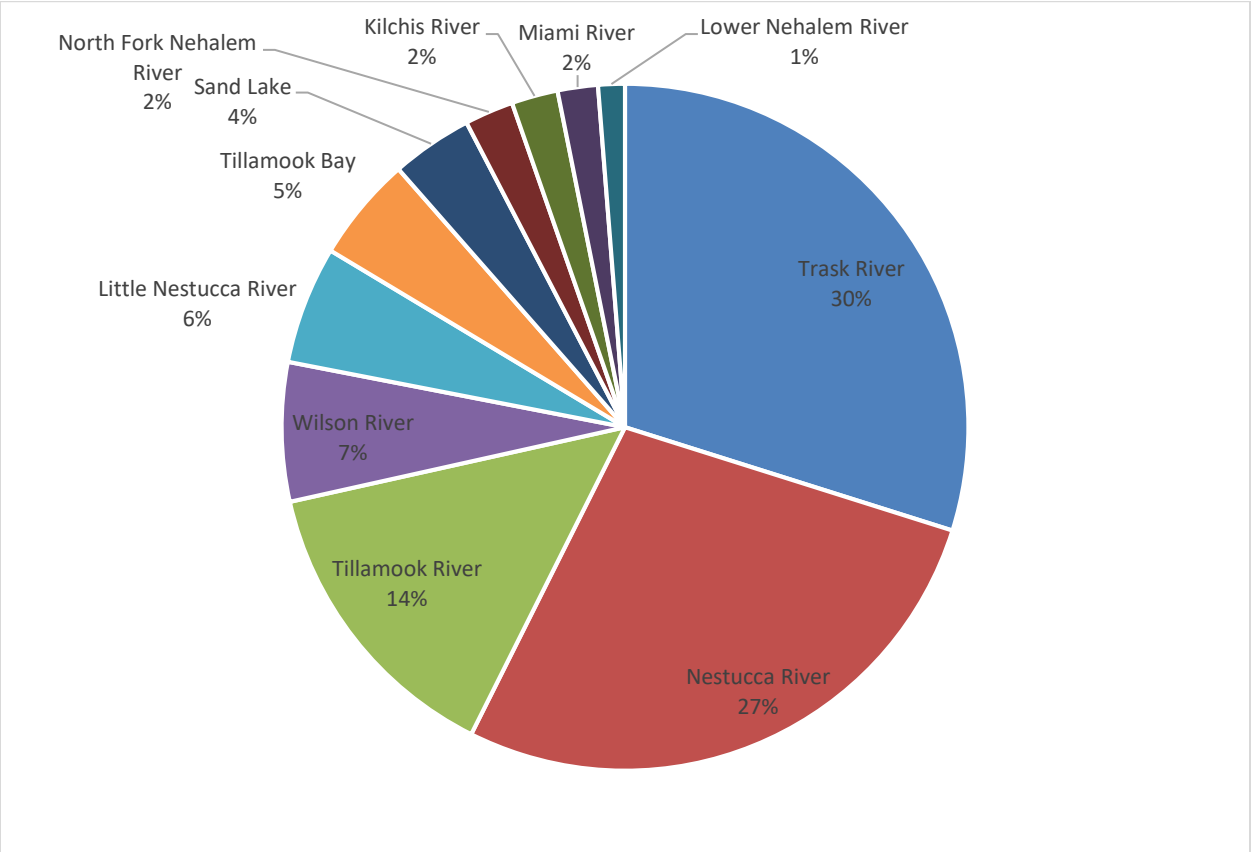
Table 15 presents the total acreage on EFU lands with irrigation water rights by watershed and crop type. As shown in the table, the Oregon Water Resources Department database indicates that there is a total of 7,250 acres with irrigation water rights.[8] However, based on Cropscape data, there are just over 6,220 acres of EFU crop/pasture lands with irrigation water rights, representing 25 percent of the total 24,650 acres of EFU crop/pasture lands. As shown in Figure 16, of EFU crop and pasture land with access to irrigation water, 71 percent are concentrated in the Trask River, Nestucca River, and Tillamook River watersheds (30 percent are in the Trask River watershed, 27 percent are in the Nestucca River watershed, and 14 percent are in the Tillamook River watershed).

[8] Water rights with the following use descriptions were included in this analysis: irrigation; supplemental irrigation; irrigation and domestic; irrigation, livestock, and domestic; and storage.

Table 15. Acres of Point of Use (POU) Irrigation Water Rights on EFU Lands by Land Use Type

5th field HUC	Barren	Developed	Crop/ Pasture	Natural Areas	Water	Total
Trask River	3.26	206.11	1,858.50	46.8	4.3	2,118.90
Nestucca River	7.37	195.46	1,712.80	129.6	0.94	2,046.20
Tillamook River	2.75	95.91	879	32.1	0.19	1,009.90
Wilson River	1.32	33.19	406.8	20.7	0.08	462.1
Little Nestucca River	0.45	23.12	345.2	9.3		378.1
Tillamook Bay	4.2	25.21	307.2	1.2	0.17	338
Sand Lake	1.54	33.03	238.3	31.7		304.5
North Fork Nehalem River		6.08	143.1	0		149.2
Kilchis River		5.15	135.9	20.4	0.26	161.7
Miami River	0.8	6.04	117.9	21.4		146.2
Lower Nehalem River	0.4	10.8	78.2	46.5		135.9
SUM TOTAL	**22.1**	**640.1**	**6,222.90**	**359.8**	**5.9**	**7,250.80**

Figure 17. Proportion of Water Rights on EFU Crop/Pasture Lands by Watershed



Yields on EFU Lands

The NRCS soil dataset provides information on the expected yields for irrigated and non-irrigated grass silage and pasture. Approximately 27,560 acres are rated for yield, (roughly corresponding to the 24,650 acres of crop and pasture land in the Cropscape dataset). The NRCS soil dataset provides yields in terms of tons of grass silage and Animal Unit Months (AUM's, a measure of the amount of forage required by one animal unit for one month) for pasture. We categorized the yield data into low, medium, and high yield levels using the yield cutoffs shown in Table 16. These cutoffs were based, as closely as possible, on distinct tiered classification as provided by NRCS. For example, for non-irrigated pasture, there are three classifications for Tillamook County: 5, 7, or 9 AUM, providing three clear levels of yield that reflect low, medium, high levels feasible within the county. For other yields, such as irrigated grass pasture, cutoffs were chosen such that there was at least one unit of yield difference between low and medium classifications to ensure clear differentiation in yield lands rated 'low'.

Table 16: Yield Classification by Crop

Crop Type	Yield Unit	Yield Classification		
		Low	Medium	High
Irrigated Pasture	AUM	N/A*	N/A*	13
Non Irrigated Pasture	AUM	5	7	9
Irrigated Grass Silage	Ton	3.0 – 4.0	5	5.5 – 6.0
Non-Irrigated Grass Silage	Ton	6	7	7.5 - 8.0

*All irrigated pasture yields on EFU lands in the database had a yield of 13.0 AUMs.

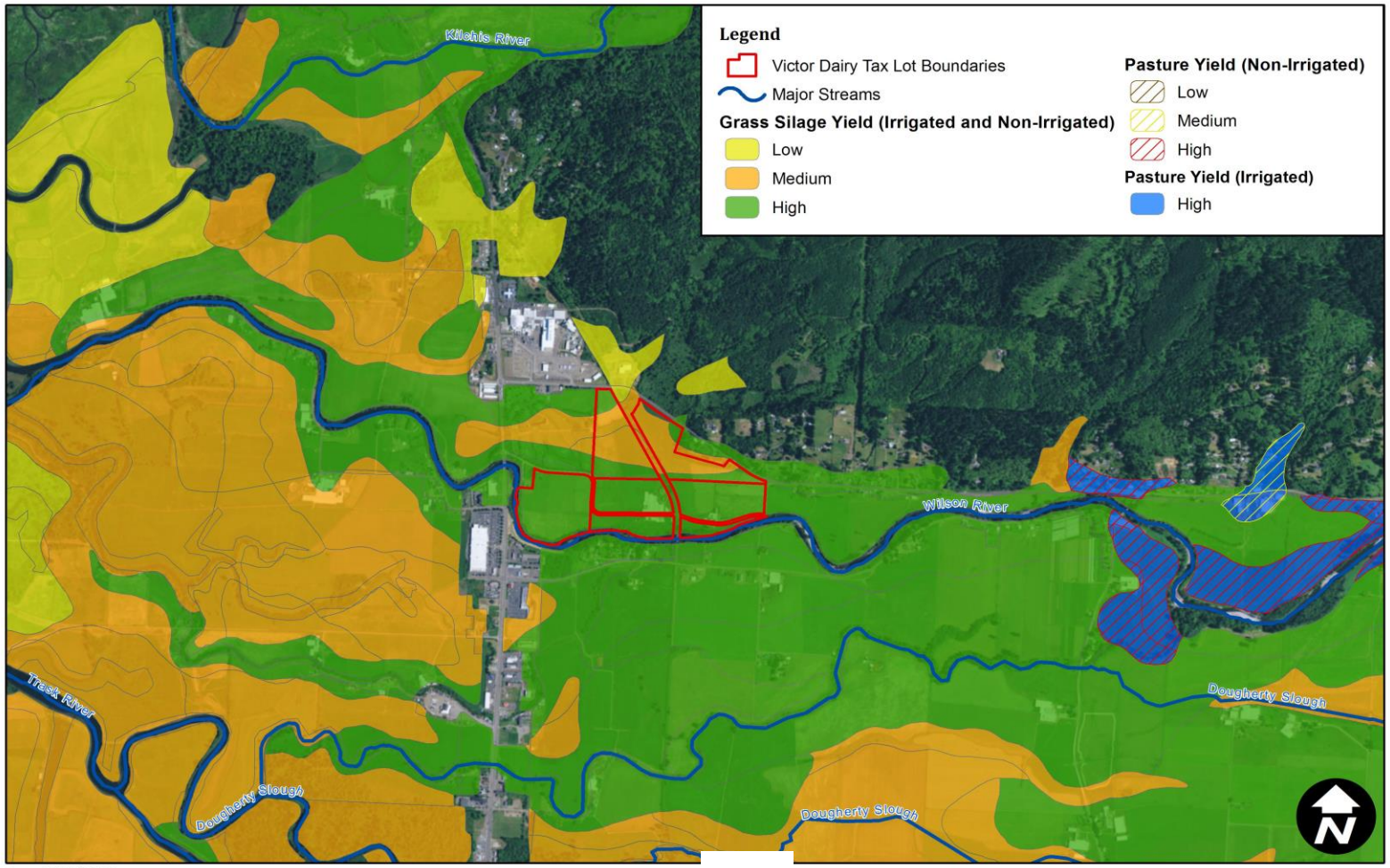
Most EFU lands have NRCS data on expected yields for just one of the four rated crop types (irrigated grass silage, irrigated pasture, non-irrigated grass silage, and non-irrigated pasture. As such, Table 17 shows the yield production potential for the EFU lands for either grass silage or pasture.[9] Of the 27,562 acres rated by NRCS for yield, 12,992 acres (47 percent) are rated high, approximately 11,404 acres (42 percent) are rated medium, and 3,165 acres (11 percent) are rated low. Figure 17 illustrates the yield data as provided by NRCS for an area along the Wilson River.

[9] There are approximately 5,260 acres of pasture or grass silage with ratings for both irrigated and non-irrigated expected yields, the yield rating for irrigated and non-irrigated production on these lands is the same (i.e., both high, both medium, or both low).

Table 17. Expected Grass Silage and Pasture Yield Level on EFU Lands

Watershed	High (Acres)	Medium (Acres)	Low (Acres)	Acreage with Yield Rating	Of Rated Lands, % Rated High or Medium
Trask River	3,725.10	2,268.10	706.8	483.6	93%
Nestucca River	3,038.40	2,131.30	755.1	1,662.10	82%
Tillamook River	1,698.20	2,925.80	260.1	1,882.60	88%
Wilson River	899.2	401.4	85.7	498.2	70%
Tillamook Bay	743.2	534.3	525.2	5,924.70	87%
Lower Nehalem River	680.1	980.6	222	1,683.10	94%
North Fork of Nehalem River	584	996.3	102.8	654.2	96%
Sand Lake	564.1	66.4	23.7	1,802.70	71%
Kilchis River	402.9	44.6	36.1	4,884.20	95%
Little Nestucca River	398	964.1	300	6,699.90	89%
Miami River	258.6	92.1	147.4	1,386.30	94%
Total	**12,991.70**	**11,404.90**	**3,164.90**	**27,561.50**	**89%**

Figure 18. Map of NRCS-Rated Expected Yields for Pasture and Grass Silage: Example of a Wilson River Farm



Date: 6/27/2017
Scale: 1 inch = 2,000 feet
Data Source: ESRI, 2017; Tillamook County, 2017; ODF, 2016; NRCS Soil Survey Data, 2017

Map X: NRCS Expected Yield for Pasture and Silage at Victor Dairy, LLC

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0 1,000 2,000 4,000 Feet

Tillamook County SB1517 Pilot Project

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Drainage and Diking Districts

As discussed in earlier sections of this memo, much of the EFU zone is in a floodplain and drainage of water is a constant management factor for agricultural operators in these areas. The NRCS soil dataset categorizes soils into seven classes of natural soil drainage (based on the frequency and duration of wet periods in the dominant condition): excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. Human management of water, either through drainage or irrigation, does not affect the drainage class, unless the morphology of the soil itself is changed through such management (Natural Resource Conservation Service, 2017), such as through compaction or development of a hardpan surface layer.

Table 18 presents an overview of soil drainage class by watershed, grouping the seven soil classes into four categories. We present drainage class only for the 27,562 acres that the NRCS has evaluated for crop or pasture yield. Across these EFU lands, 53 percent are well drained or moderately well drained, with the portion varying from 31 percent in Tillamook River watershed to 81 percent in the Kilchis River watershed.

Table 18. NRCS Soil Drainage Class on EFU Lands by Watershed

5th field HUC	Very Poorly Drained / Poorly Drained (Acres)	Somewhat Poorly Drained (Acres)	Well Drained/ Moderately Well Drained (Acres)	Excessively Drained/ Somewhat Excessively Drained (Acres)	Total (Acres)	% Well Drained / Moderately Well Drained
Kilchis River	36.8	20.2	390.6	36.1	483.57	81%
Little Nestucca River	878.8	118	665.4	-	1,662.12	40%
Lower Nehalem River	1,097.60	29.4	726	29.7	1,882.64	39%
Miami River	57.8	0.5	298	141.8	498.15	60%
Nestucca River	1,702.10	89.9	3,953.40	179.2	5,924.73	67%
North Fork Nehalem River	941.8	191.8	549.4	-	1,683.09	33%
Sand Lake	48.2	103.6	489.6	12.8	654.19	75%
Tillamook Bay	928.7	149.3	724.6	-	1,802.66	40%
Tillamook River	2,883.90	500.8	1,499.40	-	4,884.15	31%
Trask River	1,451.30	1,065.40	4,119.70	63.5	6,699.93	61%
Wilson River	225.9	86.1	1,065.70	8.6	1,386.28	77%
SUM TOTAL	**10,253.00**	**2,354.90**	**14,481.80**	**471.8**	**27,561.52**	**53%**

There are several drainage/diking districts in the County that manage drainage on approximately 2,216 acres of EFU lands. Table 19 summarizes EFU acreage in diking districts by watershed. Diking districts are located in the Trask, Tillamook Bay, Wilson River, and Kilchis River watersheds. Agricultural drainage elsewhere in the County is managed by the individual agricultural operator.

Table 19. EFU Lands in Diking Districts

5th field HUC	Acreage	% of EFU Diked Acreage
Trask River	1,066.90	48%
Tillamook Bay	787	36%
Wilson River	300.8	14%
Kilchis River	61.1	3%
Other watersheds	0	0%
SUM TOTAL	**2,215.90**	**100%**

Waste Management on EFU Lands

The NRCS dataset also includes rating of soils for the capacity to assimilate manure and food processing wastes. According to the NRCS, the ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The waste management assimilation capacity is classified into three categories by NRCS. As defined by NRCS (Natural Resource Conservation Service, 2017).

- "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected.
- "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected.
- "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

As shown in Table 20, of the 27,562 EFU lands identified as pasture or grass silage lands in the NRCS dataset, 8,283 acres are classified as 'somewhat limited' (30 percent) and 19,253 acres (70 percent) are classified as 'very limited' for disposal of animal waste. This highlights the challenge to dairy operators of managing animal waste on EFU lands in Tillamook County.

Table 20. Animal Waste Management Capacity (Acres)

Row Labels	Somewhat limited	Very limited	Total
Kilchis River	325.2	158.3	483.6
Little Nestucca River	169	1,493.20	1,662.10
Lower Nehalem River	597.9	1,284.80	1,882.60
Miami River	258.6	239.6	498.2
Nestucca River	2,674.30	3,250.40	5,924.70
North Fork of Nehalem River	415.4	1,267.60	1,683.10
Sand Lake	120.6	533.6	654.2
Tillamook Bay	244.5	1,558.20	1,802.70
Tillamook River	827.3	4,056.90	4,884.20
Trask River	2,170.20	4,504.90	6,699.90
Wilson River	480.4	905.9	1,386.30
Grand Total	**8,283.40**	**19,253.40**	**27,561.50**

Summary

In summary, the agricultural lands inventory highlights the following characteristics of EFU lands in Tillamook County:

1. EFU lands of 35,690 acres represent five percent of total land area in Tillamook County, and include nearly all high valued farmlands (as defined by State statue based primarily on soil type) in the County.

2. EFU lands are concentrated in the valley bottoms near rivers and streams. In addition to the river valleys, a large proportion (15.55%) of Tillamook County's agricultural lands is below HMT (11.62 feet, NAVD88).

3. EFU acreage that is in crop and pastureland, approximately 24,650 acres, represents three percent of total county land area, varying from zero percent to 11 percent of land area for any given watershed.

4. Approximately 11,980 acres of crop/pasture lands are located outside the EFU zone; this figure may underestimate the total non-EFU crop/pasture lands.

5. There are seven watersheds in the County with no EFU lands: Headwaters Nehalem River, Middle Nehalem River, Necanicum River, Rock Creek, Salmon River, Salmonberry River, and Willamina Creek. As such, we concentrate the inventory (and the remainder of the analysis for this project) on the other 11 watersheds in the County.

6. EFU lands are predominantly used to support dairy operations, including land for the operations themselves as well as lands for crops to feed animals and lands to spread manure. Countywide,

only four dairy operations are located outside the EFU zone, but numerous dairies do rely on pasture and croplands outside the EFU zone to manage animal waste (there are approximately 12,000 acres of pasturelands and croplands outside the EFU zone).

7. Approximately three quarters of EFU crop and pasturelands do not have access to supplemental irrigation water. However, given the current climate and growing conditions in the County, even non-irrigated yields are relatively high. In terms of yield potential, approximately 89 percent of EFU crop and pasture lands have medium to high expected yields for important forage crops such as grass silage and pasture.

8. The majority of dairy production (as measured by acreage of feed crops/pasture and number of permitted animals), irrigated water rights, and associated agricultural production value is in three watersheds: Trask River, Nestucca River, and Tillamook River.

9. Agricultural production, in terms of the number of milk cows and harvested cropland as measured by the Census, has increased slightly in the period 1997 to 2012. However, also based on Census data, the total cropland and pastureland has declined in the County since 2002.

10. Two management challenges to Tillamook County farmers include drainage of agricultural lands and animal waste disposal. These challenges are highlighted by inventory findings: based on soil class, approximately 47 percent of EFU crop and pasture lands have soils that are somewhat to very poorly drained, or are excessively drained. In addition, approximately 70 percent of EFU crop and pasture lands have soils that are rated by NRCS as ‘very limited’ for disposal of animal waste, with the remaining 30 percent of these lands rated ‘somewhat limited’.

References

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. (FWS/OBS-79/31.) U.S. Fish and Wildlife Service. Washington, DC.

Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal Services Center (CSC). 2012. NOAA Coastal Services Center Sea Level Rise Data: 1-6 ft Sea Level Rise Inundation Extent. Charleston, SC. Available at: http://www.csc.noaa.gov/slr

Ewald, M.J., and L.S. Brophy. 2012. Tidal Wetland Prioritization for the Tillamook Bay Estuary. Prepared for the Tillamook Estuaries Partnership, Garibaldi, Oregon. Green Point Consulting, Corvallis, Oregon.

Miller, Dr. Dan; Burnett, Dr. Kelly; Christiansen, Kelly; Clarke, Sharon. 2008. Coastal Landscape Analysis Modeling Study. Stream Intrinsic Potential. Oregon State University Corvallis Forestry Sciences Lab. Updated 9 April 2008. Corvallis, Oregon.

Natural Resource Conservation Service. (2017). *Web Soil Survey*. Retrieved from Natural Resource Conservation Service: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Oregon Department of State Lands. 2010. Using Tidal Data to Determine Highest Measured Time (HMT). October, 19, 2010. Salem, Oregon.

Oregon Department of State Lands. 2016. A Guide to the Removal-Fill Permit Process. Chapter 2: When is a Permit Required? December 2016. Salem, OR. Available at: http://www.oregon.gov/DSL/WW/Documents.

Oregon Water Resources Department. 2017. Oregon Water Right Points of Diversion. January 1, 1999 Available at: http://www.oregon.gov/owrd/Pages/maps/index.aspx#Water_Right_Data/GIS_Themes.

Pacific States Marine fisheries Commission. 2012. StreamNet Mixed Scale Hydrography (MSHv3.1) – Updated September, 2012. StreamNet Project. January 15, 2012.

Scranton, Russell. 2004. The Application of Geographic Information Systems for Delineation and Classification of Tidal Wetlands for Resource Management of Oregon's Coastal Watersheds. Oregon State University College of Oceanic & Atmospheric Sciences. July 2004.

Soil Survey Staff. Gridded Soil Survey Geographic (gSSURGO) Database for Oregon. United States Department of Agriculture, Natural Resources Conservation Service. Available online at https://gdg.sc.egov.usda.gov/. January 20, 2016.

Tillamook County. (1982). *Tillamook County Comprehensive Plan: Agricultural Lands (Goal 3).* Tillamook: Tillamook County.

U.S. Census Bureau, Geography Division. 2010. Processed TIGER 2010 Streets. Fort Worth Texas.

U. S. Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), Research and Development Division (RDD). Geospatial Information Branch (GIB), Spatial Analysis Research Section (SARS). 2017. 2016 Oregon Cropland Data Layer. NASS Marketing and Information Services Office, Washington, D.C. January 30, 2017

U. S. Department of Agriculture, Natural Resources Conservation Service. 2016. Field Indicators of Hydric Soils in the United States, Version 8.0. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils. U. S. Fish and Wildlife Service. 2016. National Wetlands Inventory website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/

U.S. Geological Survey, 2013, National Hydrography Geodatabase: The National Map viewer available on the World Wide Web (http://viewer.nationalmap.gov/viewer/nhd.html?p=nhd), accessed 1/1/2016.

U.S. Geological Survey, 2013, USGS NED n46w124 1/3 arc-second 2013 1 x 1 degree ArcGrid: U.S. Geological Survey.