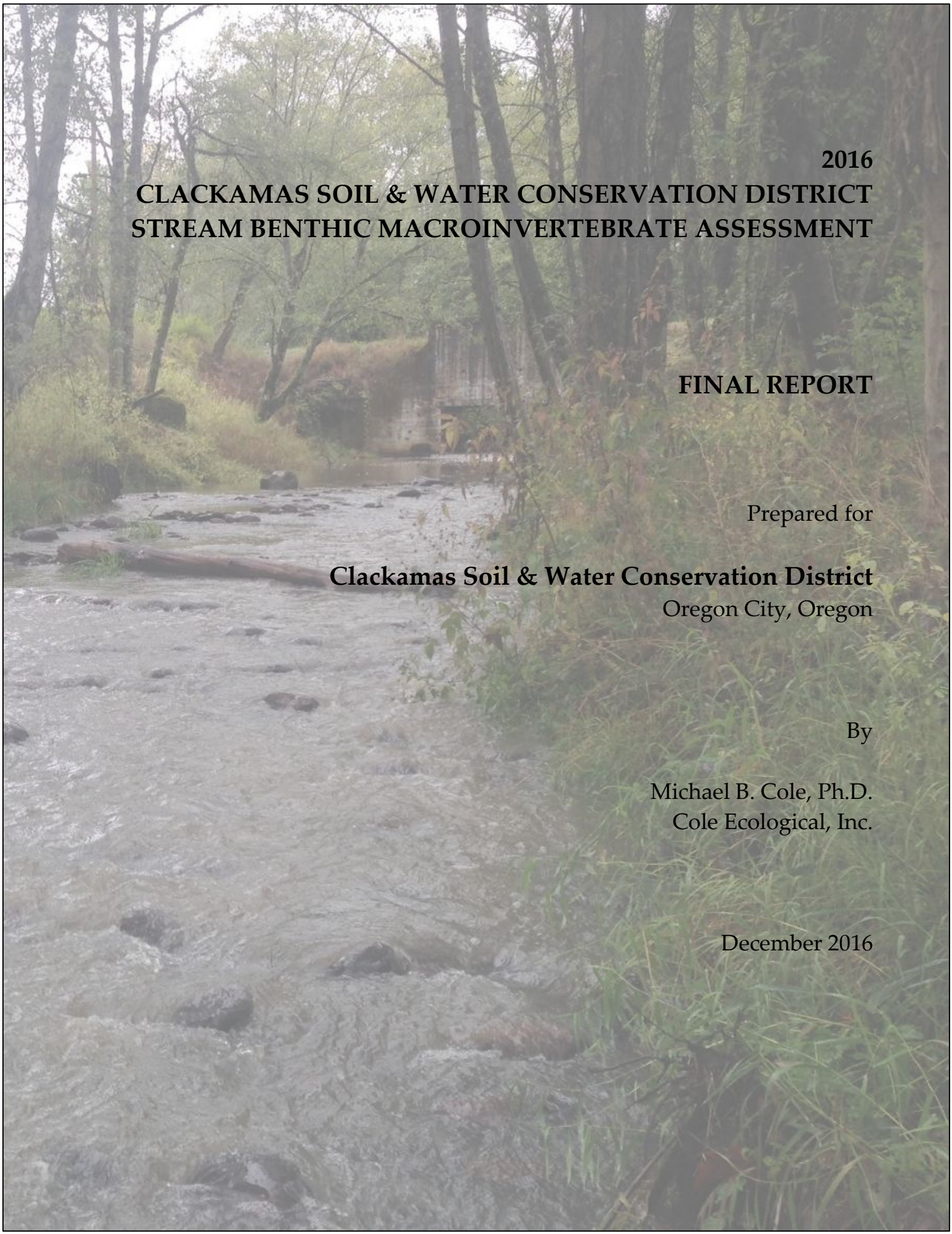


2016

CLACKAMAS SOIL & WATER CONSERVATION DISTRICT STREAM BENTHIC MACROINVERTEBRATE ASSESSMENT

FINAL REPORT

Prepared for

Clackamas Soil & Water Conservation District
Oregon City, Oregon

By

Michael B. Cole, Ph.D.
Cole Ecological, Inc.

December 2016

EXECUTIVE SUMMARY

- The Clackamas Soil and Water Conservation District assessed macroinvertebrate communities in fall 2016 to determine current ecological conditions in Doane, North Fork Deep, Noyer, and Tickle creeks. These streams were previously sampled by the SWCD in 2012. Two reaches on Doane Creek and one reach on each of the other four creeks were sampled. Tickle Creek was again selected to represent least-disturbed or reference conditions against which to compare conditions from the other four reaches.
- Clackamas SWCD staff sampled macroinvertebrate communities, physical habitat, and water chemistry from the five survey reaches on October 7, 2016. Macroinvertebrates were collected using the Oregon Department of Environmental Quality's (DEQ) Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams. Multimetric analysis, the Marine Western Coastal Forest (MWCF) Predictive Model, and Oregon DEQ temperature and fine sediment stressor models were used to analyze the macroinvertebrate data.
- Macroinvertebrate community conditions measured in 2016 were very similar to those measured in 2012. DEQ multimetric scores of sampled macroinvertebrate communities ranged from 10 to 38, indicating that macroinvertebrate community conditions range from severely to slightly disturbed across the survey reaches. The Tickle Creek reference site received the only multimetric index score corresponding to only slight disturbance to the macroinvertebrate community. The Deep, Noyer, and both Doane Creek samples once again received multimetric scores that indicated severely disturbed biological conditions.
- MWCF predictive model O/E scores also suggested severe disturbance across all four study reaches that had been classified as severely disturbed by the multimetric index. O/E scores at these four sites ranged narrowly from 0.238 to 0.357. The Tickle Creek reference reach, while scoring considerably higher than the other four sites, was sufficiently low to result in a "moderately disturbed" classification, in contrast to the slightly disturbed classification received by the

multimetric index. Fine-sediment stressor model results suggested that macroinvertebrate communities from each of the sampled reaches were likely showing fine-sediment-induced stress. Temperature stressor model results suggested that macroinvertebrate communities in the five reaches were likely showing elevated temperature stress, as macroinvertebrate assemblages from these reaches received inferred temperature stressor scores higher than the Willamette Valley threshold of 18.2 °C.

- The macroinvertebrate communities of the creeks assessed within the Clackamas County SWCD stand to benefit from improved stormwater and/or agricultural runoff management. One of the primary goals of the SWCD macroinvertebrate monitoring program is to assess the effects of agricultural runoff on the biology of area creeks. These data serve as a baseline against which to evaluate improvements to the macroinvertebrate community in response to the SWCD's efforts to curtail agricultural runoff into receiving waters and improve the quality of runoff entering into local creeks. Long-term biological monitoring of these streams should serve as an effective measure of the future success of these efforts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

As Portland, Oregon's popularity and population increase, so do the demands on regional and local resource managers to maintain and improve aquatic resource conditions, functions and values. The Clackamas County Soil and Water Conservation District (SWCD) is an agency whose mission is to help landowners become better stewards of the natural resources they manage. In 2012, the SWCD initiated a macroinvertebrate monitoring program in five stream reaches on public and private lands (Haxton and Cole 2012). The information and data obtained from the program are used to help track trends in ecological conditions of area streams, determine the success of water resource management efforts, and to help inform future work. The SWCD conducted a second year of monitoring in 2016, repeating sampling in the same five reaches first sampled in 2012. This report provides a detailed description of the methods, results, and interpretation of the assessment conducted in 2016.

STUDY AREA

The streams included in this study all occur in the lower Clackamas River basin in northern Clackamas County. All reaches occur within the Willamette Valley Ecoregion, a region dominated by wide and low-gradient stream and river valleys. Doane and Deep creeks each flow in a generally southwesterly direction towards the Clackamas River. The upper reaches of each of these systems occur on this wide valley floor. The lower reaches have cut deeply into the valley floor deposits along their course to the Clackamas River, creating v-shaped valleys that are presently forested. Noyer Creek, a small tributary to Doane Creek, flows southwesterly across the valley floor. Upper Tickle Creek occurs farthest east and at the highest elevation among the four study streams. The area is heavily dominated by agriculture, but also includes smaller proportions of urban and forested land uses.

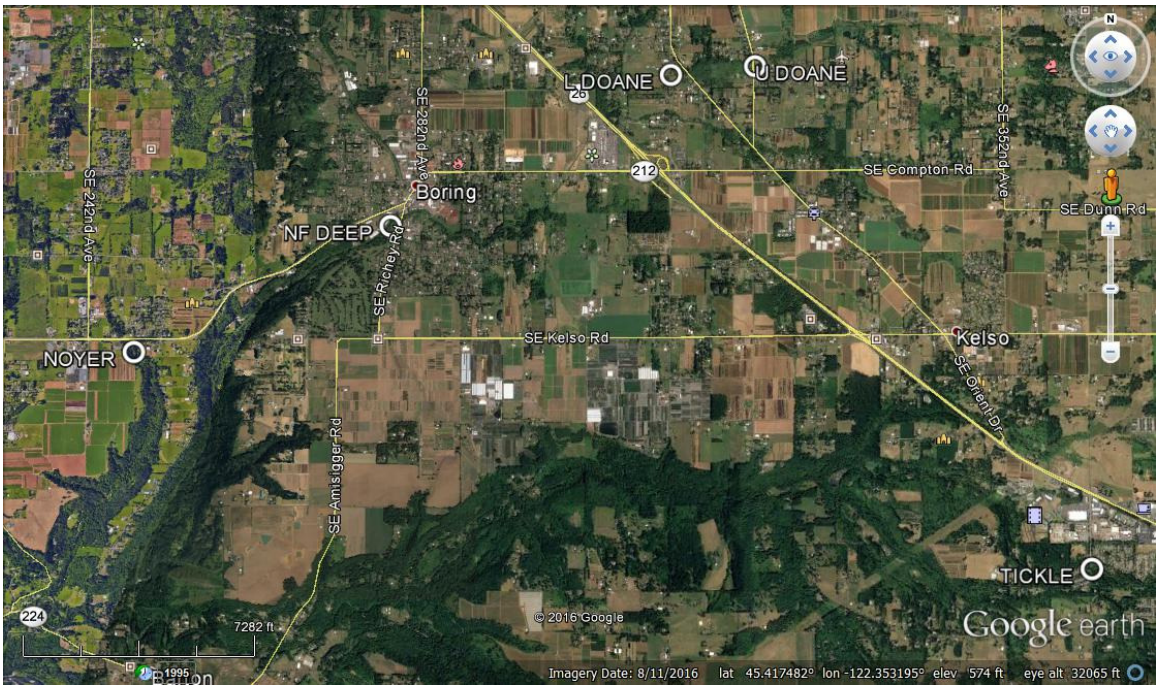


Figure 1. 2016 Clackamas Soil & Water Conservation District macroinvertebrate sample reaches.

METHODS

SAMPLE SITE SELECTION

The Clackamas County SWCD works with various landowners, public and private, in an effort to promote natural resource conservation. Five stream reaches were initially selected for sampling within the Clackamas County SWCD study area in 2012, when the first year of sampling was performed. A reach on Tickle Creek site was pre-determined to represent a least-disturbed or reference condition as it is within Tickle Creek Park and its immediate riparian area is protected from heavy development. The other four reaches were selected based on ease of accessibility via road crossings (Table 1). These same five reaches were sampled in 2016.

MACROINVERTEBRATE ASSESSMENT

Macroinvertebrate communities, physical habitat, and water chemistry were sampled from the 5 survey reaches on October 7, 2016 by Clackamas SWCD staff. First, each survey reach was marked and the reach length was measured. Each sample reach measured approximately 10 times the average bankfull width or 75-m, whichever length

was greater. Waypoints were acquired for the start and end of each reach using a GPS unit and the reach length was measured.

Table 1. Stream reaches sampled for macroinvertebrates, physical habitat, and water chemistry in the Clackamas Soil & Water Conservation District, Oregon, in the fall 2016.

Site ID	Stream	Location Description	Latitude	Longitude
UPPER DOANE	Doane Creek	At SE Revenue Rd.	45.44175	-122.33135
LOWER DOANE	Doane Creek	At SE 312th Ave.	45.441	-122.3418
NF DEEP	Deep Creek	At SE Richey Rd.	45.42777	-122.37659
NOYER	Noyer Creek	At Hwy 212	45.41677	-122.40801
TICKLE	Tickle Creek	At Duncan Rd.	45.39822	-122.2909

INSTREAM PHYSICAL HABITAT AND RIPARIAN ASSESSMENT

Habitat surveys were performed in the reaches following a modified Rapid Stream Assessment Technique (RSAT) which consisted of data collection from individual channel habitat units, three channel cross sections, and the adjacent riparian zone (Table 2). First, the valley type within each survey reach was broadly classified as U-type, V-type, ponded, or floodplain. A plan view of the reach was sketched as the survey was performed. The physical habitat data were then collected using the following procedures:

Habitat Units Survey

Three representative habitat units (primarily riffles) were identified and selected in each reach for macroinvertebrate sampling. To differentiate riffles from other habitat units, the following definitions were adapted from the Oregon Department of Fish and Wildlife's (ODFW) Methods for Stream Habitat Surveys (2002) and Armantrout (1998) and used for this study:

Pool: Water surface slope is usually zero. Pools are normally deeper and wider than aquatic habitats immediately upstream and downstream.

Glide: There is a general lack of consensus of the definition of glides (Hawkins et al. 1993). For the purposes of this study, a glide was defined as an area with generally uniform depth and flow with no surface turbulence. Glides have a low-gradient water

surface profile of 0–1% slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Glides are generally deeper than riffles with few major flow obstructions.

Riffle: Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Riffles generally have a broad, uniform cross section and a low-to-moderate water surface gradient, usually 0.5–2.0% slope and rarely up to 6%.

Rapids: Swift, turbulent flow including chutes and some hydraulic jumps swirling around boulders. Rapids often contain exposed substrate features composed of individual bedrock or boulders, boulder clusters, and partial bars. Rapids are moderately high gradient habitat, usually 2.0–4.0% slope and occasionally 7.0–8.0%. Rapids also include swift, turbulent, "sheeting" flow over smooth bedrock.

The following attributes were then measured or visually estimated in each channel unit sampled for macroinvertebrates. Substrate composition was visually estimated in each unit using substrate size classes adapted from the United States Environmental Protection Agency's (USEPA) Environmental Monitoring & Assessment Protocols (EMAP) protocols for wadeable streams (USEPA 2000). Percent actively eroding banks and percent undercut banks (both banks, combined) were each visually estimated. Water surface slope of each unit was measured with a clinometer. Additionally, all woody debris measuring at least 15 cm in diameter and 2 m in length was tallied for each sampled unit and the configuration, type, location, and size of root wads and pieces of wood were noted. Overhead cover was visually estimated with a spherical densiometer in four directions (upstream, downstream, right, and left) from the center of the stream at evenly spaced intervals along the length of the reach. Habitat features such as beaver activity, culverts, and potential fish passage barriers were noted by habitat unit.

Cross-section Surveys

Channel dimensions were measured at three transects occurring within each sample reach. The three habitat units were selected according to the following guidelines:

1. Three separate riffles were sampled if three or more riffles occurred in the reach.

2. If two riffles occurred in the reach, both riffles and a representative glide or pool (least preferred) were sampled. If riffles were of sufficient length (i.e. 10% of the reach length) then more than one set of cross-section measurements were made in the riffle to ensure that all measurements were taken from this habitat type.

3. If only one riffle occurred within the reach, two additional units that represented channel dimensions and substrate composition were sampled. If the riffle was longer than 20 m, then all three sets of measurements were taken from the riffle.

4. If no riffles occurred in the reach, three units that were representative of the channel dimensions and substrate composition occurring within the reach were sampled.

At each of the three channel cross sections, wetted width (WW), bankfull width (BFW), maximum bankfull height (BFHmax), the bankfull height at 25%, 50%, and 75% across the distance of the bankfull channel, and the flood-prone width (FPW) were measured with a tape measure and survey rod. From these channel-dimension data, width-to-depth and channel-entrenchment ratios were later calculated. Water depths were recorded at 10%, 30%, 50%, 70%, and 90% across the width of the wetted channel. Maximum bank height (left and right) and bank angles were visually estimated.

Pebble counts were performed in riffles when they represented an adequate amount of the stream channel area to allow measurement of at least 100 substrate particles along transects. If riffles occupied less than 10% of the total habitat area in the reach (e.g., if macroinvertebrate samples were collected from glides), then pebble counts occurred in glides. Pebble counts were performed using the "heel-to-toe" method, starting at the bankfull edge on one side of the channel and walking heel-to-toe to the other edge (USEPA 2000). With each step, the surveyor looked away and touched the streambed at the tip of their toe. The size class and embeddedness of each piece of streambed substrate was estimated until at least 100 particles were counted. Embeddedness is defined is the degree to which fine sediments surround coarse sediments on the streambed surface.

Riparian Surveys

Adjacent riparian conditions were characterized beyond the left and right banks separately and according to a number of attributes. The dominant plant community

Table 2. Environmental parameters measured in the field to characterize stream reaches in the Clackamas Soil & Water Conservation District, Oregon, in the fall 2016.

Variable	Quantitative or Categorical	Visual Estimate or Measured Variable
Reach length (m)	Q	M
Valley type	C	V
Channel unit gradient (%)	Q	M
Wetted width (m)	Q	M
Bankfull width (m)	Q	M
Bankfull height (m)	Q	M
Mean water depth (cm)	Q	M
Rapids (% of reach length)	Q	M
Riffles (% of reach length)	Q	M
Glides (% of reach length)	Q	M
Pools (% of reach length)	Q	M
Substrate composition	Q	M
Substrate embeddedness (%)	Q	M
Large wood tally	Q	M
Overhead canopy cover (%)	Q	M
Reach embeddedness (%)	Q	V
Eroding banks (%)	Q	V
Undercut banks (%)	Q	V
Mean riparian buffer width (m)	Q	V
Riparian zone tree cover (%)	Q	V
Non-native riparian vegetation cover (%)	Q	V
Dominant adjacent land use	C	V
Water temperature (°C)	Q	M
pH (pH units)	Q	M
Specific conductance (µS/cm)	Q	M
Dissolved oxygen (mg/L)	Q	M

type(s) (riparian forest, willow shrub-scrub, upland forest, etc.) occurring in the riparian zone to the edge of human-dominated activity was classified and recorded and the approximate width of each of these community types was visually estimated. The percent

vegetative cover of the canopy layer (>5 m high), shrub layer (0.5 to 5 m high), and groundcover layer (<0.5 m high) was estimated, as well as the percent cover of invasive or non-native species as a single estimate across all three vegetative layers. The dominant adjacent land use outside of the vegetated riparian buffer was noted, and then a cross-sectional diagram of the riparian zone was sketched.

MACROINVERTEBRATE COMMUNITY ASSESSMENT

Field Sampling

Macroinvertebrates were collected using the Oregon Department of Environmental Quality's (DEQ) Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams (DEQ 2003). An 8-kick composite sample was collected from riffles in reaches that had sufficient riffle habitat; glides were sampled reaches that lacked riffle habitat. Instream sampling points were selected to apportion the eight kick samples among as many as four habitat units. Macroinvertebrates were collected with a D-frame kicknet (30 cm wide, 500 µm mesh opening) from a 30 x 30 cm (1 x 1 ft.) area at each sampling point. Larger pieces of substrate, when encountered, were first hand-washed inside the net, and then placed outside of the sampled area. Then the area was thoroughly disturbed by hand (or by foot in deeper water) to a depth of ~10 cm.

The eight samples from the reach were composited and carefully washed through a 500 µm sieve to strain fine sediment and hand remove larger substrate and leaves after inspection for clinging macroinvertebrates. The composite sample was placed into one or more 1-L polyethylene wide-mouth bottles, labeled, and preserved with 80% denatured ethanol for later sorting and identification at the laboratory.

Sample Sorting and Macroinvertebrate Identification

Samples were sorted to remove a 500-organism subsample from each preserved sample following the procedures described in the DEQ Level 3 protocols (Water Quality Interagency Workgroup [WQIW], 1999) and using a Caton gridded tray, as described by Caton (1991). Contents of the sample were first emptied onto the gridded tray and then

floated with water to evenly distribute the sample material across the tray. Squares of material from the 30-square gridded tray were transferred to a Petri dish, which was examined under a dissecting microscope at 7–10X magnification to sort aquatic macroinvertebrates from the sample matrix. Macroinvertebrates were removed from each sample until at least 500 organisms were counted, or until the entire sample had been sorted. Following sample sorting, all macroinvertebrates were identified to the level of taxonomic resolution recommended for Level 3 macroinvertebrate assessments (WQIW 1999). Aquatic insects were keyed using Merritt, Cummins, and Berg (2008), Wiggins (1995), Stewart and Stark (2002), and a number of regional and taxa-specific keys.

DATA ANALYSIS

A number of analytical tools are available for assessing and quantifying macroinvertebrate community conditions in western Oregon streams. These tools include a multimetric index, predictive models, and several stressor models, as further described below. The existing tools employed by Oregon DEQ for analysis of macroinvertebrate data in western Oregon have been developed from and therefore are most appropriate for the assessment of assemblages collected from coarse substrates in riffle habitats. One of the five study reaches, lower Doane Creek, did not exhibit these characteristics deemed necessary for appropriate application of these tools, but for purposes of maintaining consistency in analysis and reporting among sites, we analyzed the data from this reach in the same manner as were data from the other reaches.

Both multimetric analysis and the Marine Western Coastal Forest (MWCF) Predictive Model were used to analyze the macroinvertebrate data. Multimetric analysis employs a set of metrics, each of which describes an attribute of the macroinvertebrate community that has been shown to be associated with one or more types of pollution or habitat degradation. Each community metric is converted to a standardized score; standardized scores of all metrics are then summed to produce a single multimetric score that is an index of overall biological integrity. Reference condition data are required to develop and use this type of assessment tool. Metric sets and standardized metric scoring criteria are developed and calibrated for specific community types, based on both geographic location and stream/habitat type. The DEQ has developed and currently

employs a 10-metric set for use with riffle samples from higher-gradient streams in western Oregon (WQIW 1999).

The DEQ 10-metric set includes six positive metrics that score higher with improved biological conditions, and four negative metrics that score lower with improved conditions (Table 3). The Modified Hilsenhoff Biotic Index (HBI), originally developed by Hilsenhoff (1982), computes an index to organic enrichment pollution based on the relative abundance of various taxa at a reach. Values of the index range from 1 to 10; higher scores are interpreted as an indication of a macroinvertebrate community more tolerant to fluctuations in water temperature, fine sediment inputs, and organic enrichment. Sensitive taxa are those that are intolerant of warm water temperatures, high sediment loads, and organic enrichment; tolerant taxa are adapted to persist under such adverse conditions. The DEQ taxa attribute coding system was used to assign these classifications to taxa in the data set (DEQ, unpublished information).

Metric values first were calculated for each riffle sample and then were converted to standardized scores using DEQ scoring criteria for riffle samples from western Oregon streams (Table 3). The standardized scores were summed to produce a multimetric score ranging between 10 and 50. Reaches were then assigned a level of disturbance based on these total scores.

PREDATOR is a predictive model that evaluates macroinvertebrate community conditions based on a comparison of observed (O) to expected (E) taxa (Hawkins et al. 2000, Hubler 2008). The observed taxa are those that occurred at the reach, whereas the expected taxa are those commonly occurring (>50% probability of occurrence) at reference reaches. The expected taxa, therefore, are taxa that are expected to have at least a 50% probability of occurring within a reach in the absence of disturbance. Biological condition is determined by comparing the O/E score to the distribution of reference reach O/E scores in the model. One major strength of PREDATOR over the multimetric approach is that a single predictive model can be constructed to assess biological conditions over a wide range of environmental gradients such as stream slope, longitude, or elevation, whereas separate multimetric tools would have to be developed to more accurately assess condition over this wide range of natural environmental gradients.

PREDATOR is able to predict taxonomic composition across a range of naturally occurring environmental gradients with discriminant functions models (DFMs). Discriminant functions analysis is used during the model building phase to identify the environmental variables that are statistically related to natural gradients in macroinvertebrate community composition (Hawkins et al. 2000). These "predictor variables" are then used in the resulting model to predict macroinvertebrate community composition in the absence of disturbance. The model assigns a probability of class membership of each test site to the different classes of test sites specified in the model based on the environmental predictor variables that are input into the model.

Once predictor variables and taxonomic data have been input into the model, the probability of occurrence of each taxon at a given test site (in the absence of disturbance) is calculated based on the frequency of occurrence of each taxon in each class of site weighted by the probability that the site belongs in each class. With this information, the model calculates the O/E score for each site. Using the MWCF biological condition thresholds (Hubler 2008), higher-gradient streams with O/E scores ≤0.85 (≤10th percentile of reference site scores) were classified as "most disturbed", 0.86 to 0.91 (>10th to 25th percentile) as "moderately disturbed", and 0.92 to 1.24 (25th to 95th percentile) as "least disturbed."

Stressor Identification

Weighted-average inference models were developed to reveal shifts in assemblage composition that implicate either substrate degradation (i.e. fine sediment pollution) or temperature pollution. These weighted-average inference models for temperature and sediment are to be used as screening tools to detect stress in wadeable Oregon streams. Inferred values at a test site are compared to conditions observed at regional reference sites to determine if there is a difference in assemblage-level preferences for temperature or fine sediment (Huff et al. 2006). The 90th percentile of the distribution of inferred temperature and fine-sediment values from regional reference sites is used to determine whether a particular site is potentially stressed by one or both of these attributes.

In the analysis for this study, temperature stress and fine-sediment stress weighted-average inference models were first run to derive estimates of inferred water temperatures and sediment levels in each study reach. The DEQ's thresholds of 18.4 °C for temperature and 19% of fine sediment (90th percentile of the distribution of DEQ Willamette Valley reference site scores) were used to determine whether each was functioning as a potential stressor in each sample reach (Huff et al. 2006).

Table 3. Metric set and scoring criteria (WQIW 1999) used to assess condition of macroinvertebrate communities in Clackamas SWCD assessment streams.

	Scoring Criteria		
Metric	**5**	**3**	**1**
	POSITIVE METRICS		
Taxa richness	>35	19–35	<19
Mayfly richness	>8	4–8	<4
Stonefly richness	>5	3–5	<3
Caddisfly richness	>8	4–8	<4
Number sensitive taxa	>4	2–4	<2
# Sediment sensitive taxa	≥2	1	0
	NEGATIVE METRICS		
Modified HBI[1]	<4.0	4.0–5.0	>5.0
% Tolerant taxa	<15	15–45	>45
% Sediment tolerant taxa	<10	10–25	>25
% Dominant	<20	20–40	>40

[1] Modified HBI = Modified Hilsenhoff Biotic Index

RESULTS

PHYSICAL HABITAT CONDITIONS

Four of the five stream reaches included in this study were characterized as higher-gradient reaches that supported a significant proportion of riffle habitat and a predominance of coarse substrate bed material. One reach, lower Doane Creek (LDOANE), had a channel gradient of less than 1%, supported primarily glide and pool habitat, and was dominated by hardpan and fine substrates. Across all reaches, wetted channel widths in 2016 ranged from 5.0 to 13.7 m (versus 1.7 m to 6.2 m in 2012), and bankfull widths ranged from 8.7 to 28.0 m (vs 3.4 m to 9.5 m in 2012). The larger wetted channel dimensions measured in 2016 largely result from this year's sampling occurring

during and immediately following a storm event. The larger bankfull channel dimensions measured in 2016 likely result from different interpretation of bankfull indicator locations between the 2012 and 2016 crews, as actual changes in channel dimensions between the two sampling years is highly unlikely (and not suggested by the 2016 site photos). Owing to these differences and to the incomplete collection of reach-wide habitat data in 2016, results from the 2012 habitat assessment are largely reported here to help more fully characterize physical habitat conditions in the sample reaches.

Streambank erosion in 2012 averaged 29% among all five reaches and was highest at the lower Doane Creek reach (LDOANE) at 47% eroding banks. Riparian buffer zones in 2012 were generally narrow at both of the Doane Creek reaches and at the Deep Creek reach (DEEPCK), as visual estimates ranged from 5 m at LDOANE, to 10m at Doane Creek upstream of SE Revenue Rd (DOANECK), and to 18 m at North Fork Deep Creek (DEEPCK). While 2016 riparian zone data were incomplete and precluded a full summary of current conditions, data collected and photographs suggest very similar conditions to 2021. The riparian widths at the Tickle Creek (TICKLE) and Noyer Creek (NOYER) reaches in 2012 were 40 m and 28 m, respectively. Tree cover in 2012 was highest at NOYER, as the presence of mature trees provided 95% coverage. By comparison, canopy cover in 2012 at the other sites ranged from 25% at LDOANE to 75% at TICKLE.

MACROINVERTEBRATE COMMUNITY CONDITIONS

DEQ multimetric scores of macroinvertebrate communities sampled in 2016 ranged from 10 to 38, indicating that macroinvertebrate community conditions vary from slightly to severely disturbed among the survey reaches (Table 5). The Tickle Creek reference site (TICKLE) received the only multimetric index score corresponding to only slight disturbance to the macroinvertebrate community. The lower Doane, upper Doane, NF Deep, and Noyer samples received multimetric scores of 14, 14, 18 and 19, respectively. All four of these scores indicate severely disturbed biological conditions. These results are entirely consistent with those from 2012 (Table 5).

Table 4. Environmental conditions of five stream reaches sampled in the Clackamas Soil & Water Conservation District, Oregon, in fall 2016. Greyed rows indicate conditions measured in 2012, while white rows indicate conditions re-measured in 2016.

						Summary Statistics			
Environmental parameter	L DOANE	UP DOANE	NF DEEP	NOYER	TICKLE	Mean	SD	Min	Max
Channel slope (%)	0.7	1.0	1.5	2.6	1.9	1.5	0.8	0.7	2.6
Wetted width (m)	11.7	8.7	28.0	21.7	17.7	10.7	3.6	5.0	13.7
Bankfull width (m)	3.8	3.4	9.1	6.2	9.5	17.5	7.7	8.7	28.0
Percent pools	14.7	0	27	0	39	16.1	17.1	0	39
Percent glides/runs	78.7	84	31	22.7	21	47.5	31.2	21	84
Percent riffles	6.7	16	42	77.3	40	36.4	27.5	6.7	77.3
Percent other	0	0	0	0	0	0	0	0	0
Percent coarse substrate	8.4	94.7	100	96.2	100	79.9	40	8.4	100
Percent fine substrate	34.6	5.3	0	3.8	0	8.7	14.6	0	34.6
Substrate embeddedness	41.9	22.4	12.1	13	8.8	19.6	13.4	8.8	41.9
Eroding banks	47	21	28	24	23	29	11	21	47
Undercut banks	37	57	39	0	24	31	21	0	57
Large wood tally (#/m)	0	0.04	0.03	0	0.13	0.04	0.05	0	0.13
Overhead cover (%)	81	85	87	95	85	87	5	81	95
Mean riparian width (m)	5	10	18	28	40	20	14	5	40
Riparian zone tree cover (%)	25	43	53	95	75	58	27	25	95
Riparian zone non-native Veg. Cover (%)	60	50	33	30	30	41	14	30	60
Water temperature (°C)	57.0	56.8	57.2	56.3	56.0	56.6	0.5	56.0	57.2
pH	7.0	7.0	6.9	6.6	7.1	91.8	34.0	33.2	121.8
Conductivity (µS/cm)	99.8	101.3	102.9	121.8	33.16	6.9	0.2	6.6	7.1

Table 5. Macroinvertebrate community multimetric scores and PREDATOR MWCF O/E scores from samples collected from five stream reaches in the Clackamas Soil & Water Conservation District, Oregon, in the fall 2012 and 2016.

Site	Multimetric Index Score		MMI Disturbance Class		PREDATOR MWCF O/E Score		O/E Disturbance Class	
	2012	2016	2012	2016	2012	2016	2012	2016
LOWER DOANE	12	14	SEVERE	N/A (pool)	0.485	0.268	MOST	MOST
UPPER DOANE	10	14	SEVERE	SEVERE	0.485	0.268	MOST	MOST
NF DEEP	18	18	SEVERE	SEVERE	0.437	0.357	MOST	MOST
NOYER	12	10	SEVERE	SEVERE	0.243	0.238	MOST	MOST
TICKLE	36	38	SLIGHT	SLIGHT	0.776	0.863	MOST	MOD

Individual measures of community condition (based on individual metrics) differed widely between the Tickle reference sample and the four test-reach samples. Among the four test reaches, total taxa richness ranged from 12 in Noyer Creek to 17 in NF Deep Creek, while 40 taxa were sampled from Tickle Creek (Figure 2). Mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) richness was also similar among the four test-reach samples, ranging from 0 to 3. These three insect orders, collectively referred to as "EPT taxa," are generally regarded as sensitive to disturbance or pollution. In contrast, the Tickle Creek reference reach supported 24 EPT taxa, the highest number among the study sites by a large margin. As in 2012, the Noyer Creek reach once again supported the highest percentages of tolerant taxa (69.9%) and sediment tolerant taxa (69.9%) relative to the five-sample group means of 40.1% and 29.2% respectively.

Also consistent with 2012, MWCF predictive model O/E scores once again suggested severe disturbance across all four study reaches that had been classified as severely disturbed by the multimetric index. Scores at these four sites ranged narrowly from 0.268 to 0.357 (Table 5). The Tickle Creek reference reach scored considerably higher than the range of O/E scores among the other four sites and received a "moderately disturbed" classification (Table 5). This result suggests slightly more severe disturbance to the ecology in the reach than did the multimetric score.

Fine-sediment stressor model results suggested that macroinvertebrate communities from each of the four test reaches were likely showing fine-sediment-induced stress (Table 6). These reaches received an inferred fine sediment score higher than the Willamette Valley threshold of 15.9%, corresponding to "fair" community conditions in relation to sensitivity to elevated sediment loads.

Temperature stressor model results suggested that macroinvertebrate communities in all five reaches are likely showing elevated temperature stress (Table 6), as macroinvertebrate assemblages from each of these reaches received inferred temperature stressor scores higher than the Willamette Valley threshold of 18.2 °C (Huff et al. 2006).

Table 6. Macroinvertebrate community stressor model results from samples collected from five stream reaches in the Clackamas Soil & Water Conservation District, Oregon, in fall 2012 and 2016.

	Fine Sediment			Temperature		
Site	2012 Inferred % Sed	2016 Inferred % Sed	2016 FSS Class	2012 Inferred Temp	2016 Inferred Temp	2016 Condition Class
LOWER DOANE	47.1	55.6	Poor	20.9	25.5	Poor
UPPER DOANE	51.4	65.2	Poor	24.4	32.1	Poor
NF DEEP	30.4	28.1	Poor	21.5	22.7	Poor
NOYER	50.3	19.0	Poor	21.1	17.1	Poor
TICKLE	19.8	15.9	Fair	20.4	19.3	Poor

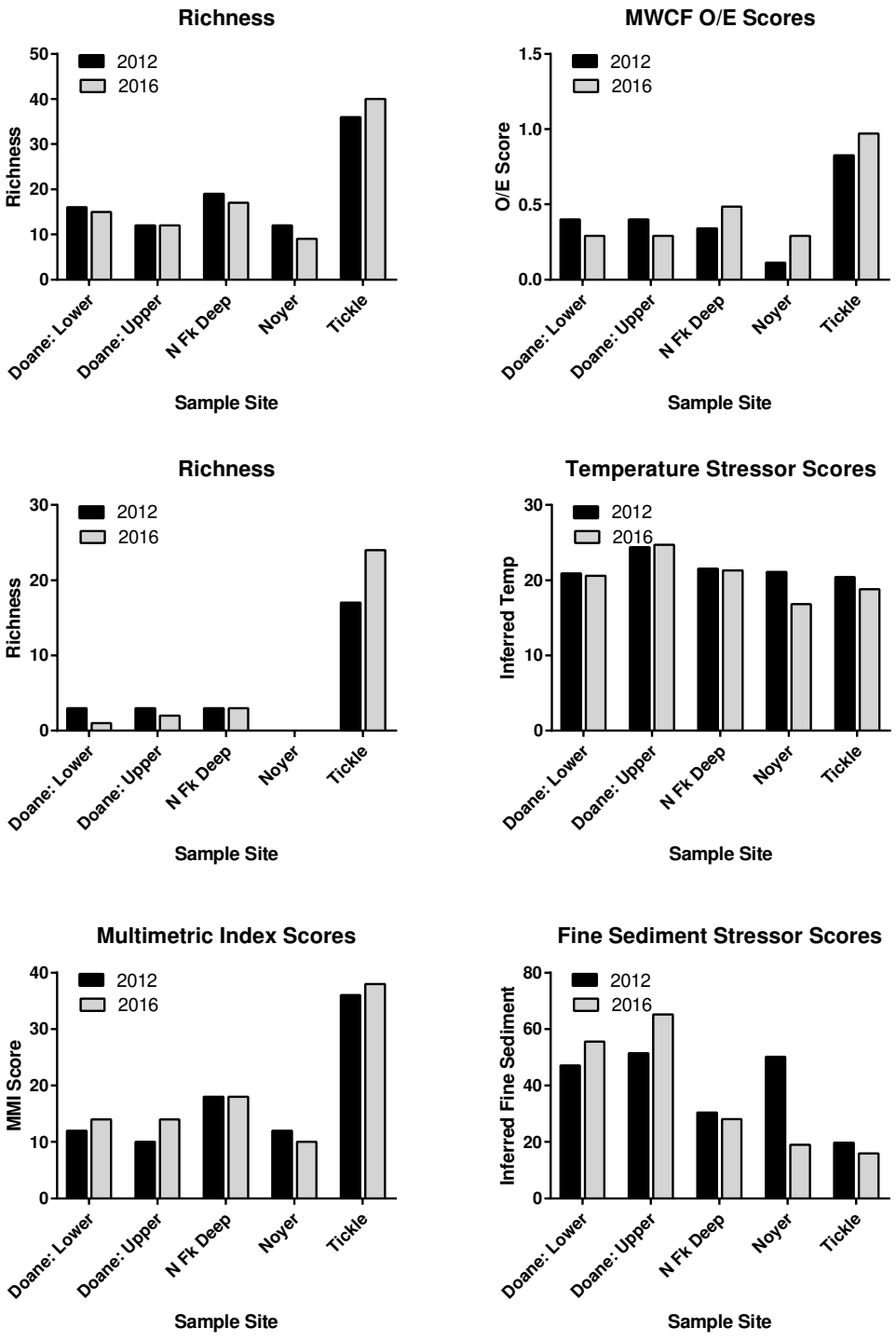


Figure 2. Summary of select metrics, multimetric scores, PREDATOR O/E scores, and temperature and sediment stressor model scores from five macroinvertebrate samples collected in the Clackamas Soil & Water Conservation District in fall 2012 and 2016.

REACH DESCRIPTIONS

NORTH FORK DEEP CREEK (DEEP)

The survey reach on North Fork Deep Creek is located downstream of SE Richey Road in Boring, OR. The channel had a relatively average gradient among the five surveyed (1.5% slope). The site was one of the larger streams of the study (2012: WW= 6.2 m, BFW=9.1 m) and provided heterogeneous habitat with pool, riffle, and glide types present in relatively even proportions (Table 4). Riffle substrate consisted entirely of coarse material, with no substrate smaller than fine gravel measured in pebble counts. Substrate embeddedness was 12.1% in 2012. Bank erosion was present in 2012, averaging 28% of the bank length throughout the reach. The riparian canopy was dominated by alder and maples species, with a mean overhead canopy cover of 87%. The 2012 mean riparian width was 18 m, close to the mean width among all sites of 20 m.

Seventeen macroinvertebrate taxa were sampled from this reach in 2016, the second highest taxa richness observed among the SWCD reaches, yet substantially lower total richness than supported by the Tickle Creek reach. A multimetric score of 18 and a MWCF O/E score of 0.357 suggest a biological community under significant duress. While 2012 substrate embeddedness values from this reach were relatively low, stressor model results implicate both elevated water temperature and sediment loads as potential stressors to aquatic life in Deep Creek.

DOANE CREEK (UPPER DOANE)

The upper survey reach on Doane Creek is located along a private driveway, upstream of SE Revenue Road. The channel in this survey reach is narrow, incised, and predominantly straight with only riffle and glide habitat types present. In 2012, instream physical habitat in this reach consisted primarily of glides (84% of the reach length) and included 16% riffle habitat. The dominant bed condition is coarse gravel and cobble with some accumulations of fine sediment. Riffle substrate in 2012 was comprised primarily of cobble (35.4%) and coarse gravels (46.0%) with 22% substrate embeddedness by fine materials. Overhead cover averaged 85% through the reach in 2012. The riparian area

along the left bank (facing downstream) of the survey reach is limited to a small strip of short vegetation and a few small trees. The right-bank riparian zone is slightly wider and contains a higher tree density. Where the creek flows away from the driveway, the riparian area is more extensive.

The macroinvertebrate sample collected in this reach in 2016 was classified as severely disturbed with a western Oregon multimetric index score of 14. The reach received a similar classification of "most disturbed" using the MWCF PREDATOR. DEQ stressor model results indicated that macroinvertebrate communities show compositional indications of stress induced by both elevated water temperatures and elevated sediment deposition. Based on these results and field substrate data from the physical habitat survey, both stream temperature and sediment were classified as likely stressors to aquatic communities in this reach.

DOANE CREEK (LOWER DOANE)

The lower survey reach on Doane Creek is located upstream of SE 312th Avenue. This small (2012: WW= 1.7 m, BFW = 3.8 m), lower-gradient channel exhibits a morphology dominated by slow-moving glides with small proportions of riffle and pool habitat. The creek runs through open pasture with obvious channel straightening. In 2012, active bank erosion was observed along 47% of the survey reach with notable channel incision throughout.

Instream physical habitat consisted of 78.7% glides in 2012, and overall reach bed substrate conditions were dominated by fine sediment. In 2012, riffle substrate was dominated by hardpan (55.1%) and sand (32.7%). Lower Doane's channel gradient was the lowest among the five reaches surveyed. Measured at only 0.7% in 2012, it is likely that this reach has historically lacked sufficient quantities of coarse substrate necessary for the development of significant riffle habitat. In 2012, only 8.4% of the pebble count was categorized as coarse substrate, well below the mean value of 79.9% among all sampled reaches. Substrate embeddedness for the lower Doane sample habitat was 41.9%, the highest embeddedness observed in sample riffles among all surveyed reaches. The riparian area adjacent to the reach is very narrow, with primarily blackberry thickets

with small alders present. The riparian zone was the narrowest among the five survey reaches, averaging only 5 m on each bank.

Macroinvertebrate communities were classified as severely disturbed using the western Oregon multimetric index, and as "most disturbed" using the MWCF model. DEQ stressor model results suggest that macroinvertebrate communities show indications of stress induced by both elevated water temperatures and elevated fine sediment deposition. Based on these results and field substrate data, both stream temperature and fine sediment are likely stressors to aquatic biological communities in this reach. Because pool habitat was sampled in this reach, condition classifications and stressor results are not relevant and should be interpreted cautiously.

NOYER CREEK (NOYER)

The survey reach on Noyer Creek is located in a broad, steep valley located downstream of OR Highway 212 (Clackamas-Boring Highway). This higher-gradient stream is dominated by riffle habitat intersected by glides, but has no pool formation, possibly due to lack of in-channel large wood. Areas of moderate erosion were observed and dispersed along both banks.

Streambed conditions were dominated in 2012 by large gravel and cobble with overall reach embeddedness (the degree to which fine sediment surrounds larger substrate) estimated at 18%. In 2012, pebble counts within the riffle habitats revealed a 96.4% coarse substrate composite and only 3.8% of the bed material consisting of sand or fine sediment. The riparian zone width averaged 28 m on each bank in 2012; an abundance of mature trees provide overhead cover averaging 95% throughout the reach. This coverage was the highest among all of the survey reaches.

The 2016 macroinvertebrate sample from this reach received a multimetric score of 10, corresponding to a severely disturbed condition, and a MWCF model score of 0.238, corresponding to a "most disturbed" biological condition. As in 2012, Noyer Creek was the only sample in the study to lack EPT taxa and was dominated by Oligochaetes (worms) that are known to be highly sediment tolerant. DEQ stressor models suggested

that the macroinvertebrate community in this reach is currently stressed by elevated water temperatures and is showing stress related to elevated fine sediment loading.

TICKLE CREEK (TICKLE)

The survey reach on Tickle Creek is located upstream of Duncan Road, along the western end of Tickle Creek Trail in Sandy. The stream runs through a rather long stretch of public park land and shows the least amount of streamside development among the five study sites. For these reasons, this reach was selected to represent a "least disturbed" or "reference" site for comparison with the other reaches in the assessment. Tickle Creek's channel was the largest among the study sites (2012: WW= 5.6 m, BFW = 9.5 m). Channel gradient was 1.9% in the reach, and the reach supported a relatively heterogeneous habitat composition, with 40% riffle habitat, 39% pool habitat and 21% glide habitat measured in 2012. Some bank erosion was observed in places throughout the reach in 2012. Substrate within the sampled riffles was heavily dominated by coarse substrates (2012: 73.4% coarse gravel, 24.8% cobble and 1.8% fine gravel). Pebble count embeddedness in 2012 was 8.8%, the lowest among the surveyed reaches.

The riparian zone buffer width along this reach was estimated at 40 m in 2012, the widest intact riparian zone among all sites. Overhead channel cover averaged 85% and the riparian vegetation was dominated by a variety of native trees and dense understory. Non-native vegetation was observed, but at a lower percentage than in all but one (NOYER) of the other more impacted survey reaches.

Forty macroinvertebrate taxa occurred in the Tickle Creek sample, the highest taxa richness observed among the SWCD reaches. Twenty-four EPT taxa were observed including 10 mayfly taxa, 8 stonefly taxa, and 6 caddisfly taxa. Among all samples collected, only the Tickle sample supported sensitive taxa. Three sensitive taxa were present: Capniidae and *Leuctra* stoneflies and the mayfly *Cinygma*. The reach supported the lowest percentage of sediment tolerant taxa within the sample group. Overall, the macroinvertebrate community was classified as slightly impaired by the western Oregon multimetric index, but was classified as "moderately disturbed" using the MWCF model. This disparity likely results from the O/E model not accounting for additional EPT taxa

that occurred at the site, but were not predicted by the model to have at least a 50% probability of occurring there. When several such taxa occur at a site, as was the case at Tickle, the O/E scores will be low relative to multimetric index measures that are less dependent of the actual taxonomic composition in a sample.

DEQ stressor models suggested that the macroinvertebrate community in this reach is likely stressed by elevated water temperatures and to a lesser degree by elevated fine sediment loading. However, the inferred values for each were the lowest among the five study reaches. This was particularly evident for fine sediment, as the inferred value for this reach was 15.9% relative to an average of 36.8% among the other four study sites. Given the relatively low fine sediment stressor score and the results of the physical habitat surveys, fine sediment is unlikely to be exerting a significant stress on the macroinvertebrate communities in this section of Tickle Creek. This result is largely consistent with the 2012 results.

\

DISCUSSION

Excepting the Tickle Creek reference reach, streams sampled in this study continue to support degraded macroinvertebrate communities, as evaluated by both the multimetric index and the MWCF predictive model. As in 2012, samples from test sites supported no taxa classified as sensitive to disturbance, while all supported numerous taxa that are able to tolerate elevated sediment loads, increased water temperatures, periods of sustained high or low flows, and other perturbations. Mayflies, stoneflies, and caddisflies were poorly represented, if not altogether absent, from samples collected from the test sites.

Study results from the Noyer Creek reach were particularly noteworthy and were consistent between 2012 and 2016. Environmental conditions observed and measured at this study reach suggest a physical and riparian condition capable of supporting a macroinvertebrate community considerably less stressed than that measured. These results warrant further investigation to identify the cause(s) of this measured biological stress. Other water quality parameters that were not addressed with this assessment may

need to be explored in order to identify factors contributing to the degraded macroinvertebrate community condition.

Prior to initiating this program in 2012, Noyer Creek was last sampled in 2003 (Cole 2004), when reaches in the upper, middle, and lower portions of the creek were sampled. Results in the upper creek were similar to those obtained in this study in both 2012 and 2016, as the upper creek received a multimetric score of 12 (Cole 2004). Interestingly, downstream conditions improved significantly in the 2003 study, as multimetric scores improved from 12 in the upper reach to 22 in the middle reach to 32 in the lower reach. The 2003 results suggest significant abatement of the stressor along the length of the reach. *Further study could determine whether this longitudinal trend of improving conditions still exists and could identify potential stressors through a more comprehensive water quality assessment.*

North Fork Deep Creek was also sampled in 2003 (Cole 2004). The uppermost site location in the 2003 study closely corresponded to the 2012/2016 study site on this creek. In both studies (2003 and again 2012/2016), this reach was classified by the multimetric index as severely disturbed. In the 2003 study, conditions improved to moderately disturbed in the mid-reaches of North Fork Deep Creek, suggesting an impairment of similar nature and as well as a similar longitudinal trend in improvement as measured in Noyer Creek in 2003 (Cole 2004). *Once again, further investigation would be necessary to determine whether these same trends occur to this day and to identify the probable cause(s) of the measured degradation.*

Results from lower Doane Creek should be interpreted with caution because this section of Doane Creek potentially never provided riffle habitat with coarse substrate necessary for proper application of the assessment tools employed in this study. This section of Doane Creek occurs in a wide, low-gradient valley, where a highly sinuous channel potentially dominated by organic and fine inorganic material was the naturally occurring condition. Macroinvertebrate assemblages in such habitats, even under undisturbed conditions, would be expected to differ significantly from those occurring in riffles of higher-gradient reaches, the habitat type currently targeted in benthic bioassessment studies in Oregon. Consequently, the condition classes assigned by the

assessment tools may not accurately reflect current conditions relative to a true reference condition for this stream type. Nonetheless, the quantitative results of the tools are helpful for tracking trends in conditions at the lower Doane reach over time.

Recovery of macroinvertebrate communities is dependent on identifying and improving stream conditions and functions that are currently compromised. Riparian zone improvements and protection are among the most beneficial stream restoration approaches available. Because riparian zones provide a number of important functions, including sediment and pollutant retention, shading, food sources, bank stability, and large wood inputs, streams and the biological communities they support derive many benefits from these areas. The two reaches assessed on Doane Creek are examples of areas where riparian improvement could prove beneficial.

The macroinvertebrate communities of the creeks assessed within the Clackamas SWCD, like those in many urban, suburban and rural streams also stand to benefit from improved stormwater and/or agricultural runoff management. One of the primary goals of the SWCD macroinvertebrate monitoring program is to assess the effects of agricultural runoff on the biology of area creeks. These data serve as a baseline against which to evaluate improvements to the macroinvertebrate community in response to the SWCD's efforts to curtail agricultural runoff into receiving waters and to improve the quality of runoff entering into local creeks. Continued monitoring of these area creeks should serve as an effective measure of the long-term success of these efforts.

LITERATURE CITED

Armantrout, N. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, MD.

Caton L. 1991. Improved subsampling methods for the EPA "Rapid Bioassessment" benthic protocols. Bulletin of the North American Benthological Society 8:317-319.

Cole, M. 2002. Assessment of macroinvertebrate communities in relation to land use, physical habitat, and water quality in the Tualatin River Basin, Oregon. Unpublished report prepared for Clean Water Services, Hillsboro, Oregon 38 pp.

Cole, M. B. 2004. Baseline Assessment of Stream Habitat and Macroinvertebrate Communities in and Adjacent to the Damascus Area Urban Growth Boundary Expansion, Oregon. Unpublished report prepared for Metro, Portland, Oregon.

Department of Environmental Quality (DEQ). 2003. Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams. Unpublished methods manual. Oregon Department of Environmental Quality, Portland, OR.

Hawkins, C. P., J. L. Kershner, P. A. Bisson, M. D. Bryant, L. M. Decker, S. V. Gregory, D. A. McCullough, C. K. Overton, G. H. Reeves, R. J. Steedman, and M. K. Young. 1993. A hierarchical approach to classifying stream habitat features at the channel unit scale. Fisheries 18 (6): 3-12.

Hawkins, C. P., R. H. Norris, J. L. Hogue, and J. W. Feminella. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Ecological Applications 10(5): 1456-1477.

Haxton, N., and M. Cole. 2012. 2012 Stream Benthic Macroinvertebrate Assessment for the Clackamas SWCD. Unpublished report prepared by ABR, Inc. Forest Grove, OR.

Hilsenhoff, W. L. 1982. Using a biotic index to evaluate water quality in streams. Technical Bulletin No. 132. Department of Natural Resources, Madison, WI.

Hubler, S. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams. Unpublished report prepared by the Oregon Department of Environmental Quality, Watershed Assessment Section. 51 pp.

Huff, D. D., S. L. Hubler, Y. Pan, and D. L. Drake. 2006. Detecting shifts in macroinvertebrate assemblage requirements: Implicating causes of impairment in streams. Oregon Department of Environmental Quality. DEQ06-LAB-0068-TR Version 1.1 37 pp.

Lemke, J.L., M. B. Cole, and J. Dvorsky. 2012a. Assessment of Benthic Macroinvertebrate Communities and Geomorphic Conditions in Streams of Clackamas County Service District No. 1, Clackamas County, OR. Unpublished report prepared for Clackamas Water Environment Services, Clackamas, OR.

Lemke, J.L., M. B. Cole, and J. Dvorsky. 2012b. Assessment of Benthic Macroinvertebrate Communities and Geomorphic Conditions in Streams of the Surface Water Management Agency of Clackamas County, OR. Unpublished report prepared for Clackamas Water Environment Services, Clackamas, OR.

Merritt, R. W., K. W. Cummins, and M.B. Berg (eds.). 2007. An introduction to the aquatic insects of North America. Fourth Edition. Kendall/Hunt Publishing Co., Dubuque, IA. 1158 pp.

Oregon Department of Fish and Wildlife (ODFW). 2002. Methods for Stream Habitat Surveys. Unpublished technical document by the Oregon Department of Fish and Wildlife, Salem, OR.

Rosgen, D. 1996. Applied River Morphology. Wildlands Hydrology. Pagosa Springs, Colorado.

Stewart, K.W. and B.P. Stark, 2002. Nymphs of North American stonefly genera (Plecoptera), 2nd ed. The Caddis Press, Columbus, OH, 510 pp.

U.S. Environmental Protection Agency (USEPA). 2000. Western Pilot Study Field Operations

Manual for Wadeable Streams. U.S. Environmental Protection Agency, Regional Ecology Branch, Western Ecology Division, Corvallis, Oregon. May 2000.

Water Quality Interagency Workgroup (WQIW). 1999. Chapter 12: Stream macroinvertebrate protocol, Oregon plan for salmon and watersheds. Water Quality Monitoring Guide Book, Version 1.03. Water Quality Interagency Workgroup for the Oregon Plan.

Wiggins, G.B., 1995. Larvae of the North American caddisfly genera (Trichoptera), 2nd ed. University of Toronto Press, Toronto.

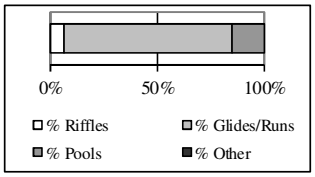
Reach Assessment Summary

Stream Name:	**lower Doane Creek**	Site ID:	LDOANE
Location:	At SE 312th Ave.	Reach ID:	LDOANE
County, State:	Clackamas, Oregon	Latitude:	45.441
Date sampled:	10/7/2016	Longitude:	-122.3418
Field Personnel:		Reach Length:	75m

Physical and Chemical Conditions Summary

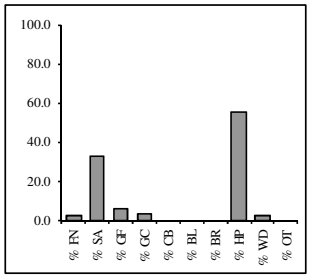
Instream Physical Characteristics

Reach Gradient (%)	0.7
Wetted Width (m)	10.0
Bankfull Width (m)	11.7
% Riffles	6.7
% Glides/Runs	78.7
% Pools	14.7
% Other	0



Substrate

% Fines (FN)	1.9
% Sand (SA)	32.7
% Gravel, Fine (GF)	5.6
% Gravel, Coarse (GC)	2.8
% Cobble (CB)	0.0
% Boulder (BL)	0.0
% Bedrock (BR)	0.0
% Hardpan (HP)	55.1
% Wood	1.9
% Other (OT)	0.0
% Embeddedness	41.9
Large Wood Tally (pieces/m)	0.00
Eroding Banks (%)	47
Undercut Banks (%)	37



Riparian Zone Characteristics

Overhead Cover (%)	81
Riparian Buffer Width (m)	5
Riparian Zone Tree Cover (%)	25
Riparian Zone Non-Native Cover (%)	60
Dom Adjacent Land Use	Res

Embeddedness

Canopy Cover

Chemical Characteristics

Water Temperature (°F)	57.0
pH	7.0
Conductivity (µS/cm)	99.8
Time of measurement	14:05

2016 Reach Photo

Yellow highlight = 2012 measurement

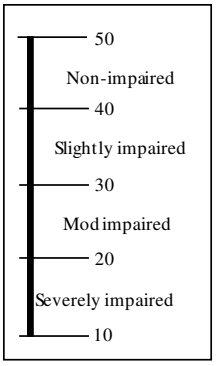
Biological Conditions Summary

Lab Sample ID: 16-127-05 Habitat(s) Sampled: Pools

Sample Method: OR DEQ 8-kick composite

DEQ Metric Scores

	Raw	Stand.
Richness	12	1
Mayfly Richness	0	1
Stonefly	0	1
Caddisfly	1	1
# Sensitive Taxa	0	1
# Sed Sens Taxa	0	1
Modified HBI	7.2	1
% Tolerant Taxa	33.8	3
% Sed Tol Taxa	32.7	1
% Dominant (1)	38.3	3
TOTAL		**14**



PREDATOR MWCF O/E Score:

MWCF

Sample	O/E Score	Classification
Original	0.268	most disturbed

Stressor Scores

Temperature Stress:	25.5
Fine Sediment Stress:	55.6

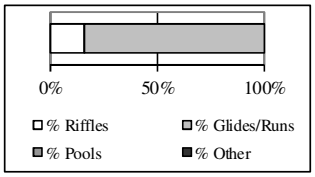
Reach Assessment Summary

Stream Name:	**Doane Creek**	Site ID:	DOANECK
Location:	At SE Revenue Rd.	Reach ID:	DOANECK
County, State:	Clackamas, Oregon	Latitude:	45.44175
Date sampled:	10/7/2016	Longitude:	-122.33135
Field Personnel:		Reach Length:	75m

Physical and Chemical Conditions Summary

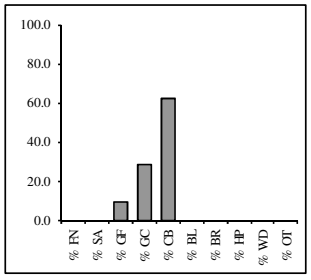
Instream Physical Characteristics

Reach Gradient (%)	1.0
Wetted Width (m)	5.0
Bankfull Width (m)	8.7
% Riffles	16.0
% Glides/Runs	84.0
% Pools	0.0
% Other	0



Substrate

% Fines (FN)	0.0
% Sand (SA)	0.0
% Gravel, Fine (GF)	9.3
% Gravel, Coarse (GC)	28.7
% Cobble (CB)	62.0
% Boulder (BL)	0.0
% Bedrock (BR)	0.0
% Hardpan (HP)	0.0
% Wood	0.0
% Other (OT)	0.0
% Embeddedness	22.4
Large Wood Tally (pieces/m)	0.04
Eroding Banks (%)	21
Undercut Banks (%)	57



Embeddedness

Riparian Zone Characteristics

Overhead Cover (%)	85
Riparian Buffer Width (m)	38
Riparian Zone Tree Cover (%)	47
Riparian Zone Non-Native Cover (%)	5
Dom Adjacent Land Use	Res

Canopy Cover

Chemical Characteristics

Water Temperature (°F)	56.8
pH	6.95
Conductivity (µS/cm)	101.3
Time of measurement	13:25

2016 Reach Photo

Yellow highlight = 2012 measurement

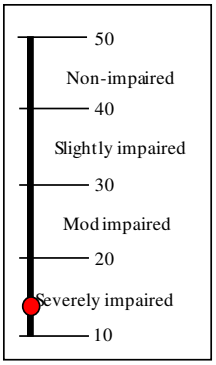
Biological Conditions Summary

Lab Sample ID: 16-127-04 Habitat(s) Sampled: Riffles

Sample Method: OR DEQ 8-kick composite

DEQ Metric Scores

	Raw	Stand.
Richness	12	1
Mayfly Richness	1	1
Stonefly	0	1
Caddisfly	1	1
# Sensitive Taxa	0	1
# Sed Sens Taxa	0	1
Modified HBI	6.5	1
% Tolerant Taxa	54.0	1
% Sed Tol Taxa	19.5	3
% Dominant (1)	32.6	3
TOTAL	pool sample	**14**



PREDATOR MWCF O/E Score:

MWCF

Sample	O/E Score	Classification
Original	0.268	most disturbed

Stressor Scores

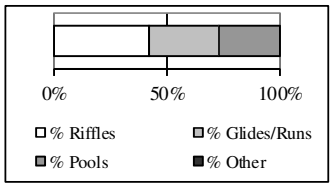
Temperature Stress:	32.1
Fine Sediment Stress:	65.2

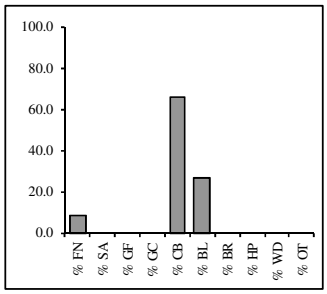
Reach Assessment Summary

Stream Name:	**N F Deep Creek**	Site ID:	DEEPCK
Location:	At SE Richey Rd.	Reach ID:	DEEPCK
County, State:	Clackamas, Oregon	Latitude:	45.42777
Date sampled:	10/7/2016	Longitude:	-122.37659
Field Personnel:		Reach Length:	75 m

Physical and Chemical Conditions Summary

Instream Physical Characteristics	
Reach Gradient (%)	1.5
Wetted Width (m)	13.7
Bankfull Width (m)	28.0
% Riffles	42.0
% Glides/Runs	31.0
% Pools	27.0
% Other	0
Substrate	
% Fines (FN)	7.8
% Sand (SA)	0.0
% Gravel, Fine (GF)	0.0
% Gravel, Coarse (GC)	0.0
% Cobble (CB)	65.7
% Boulder (BL)	26.5
% Bedrock (BR)	0.0
% Hardpan (HP)	0.0
% Wood	0.0
% Other (OT)	0.0
% Embeddedness	12.1
Large Wood Tally (pieces/m)	0.03
Eroding Banks (%)	28
Undercut Banks (%)	39
Riparian Zone Characteristics	
Overhead Cover (%)	87
Riparian Buffer Width (m)	18
Riparian Zone Tree Cover (%)	53
Riparian Zone Non-Native Cover (%)	33
Dom Adjacent Land Use	Urb
Chemical Characteristics	
Water Temperature (°F)	57.2
pH	6.91
Conductivity (µS/cm)	102.9
Time of measurement	11:45





Embeddedness

Canopy Cover

2016 Reach Photo

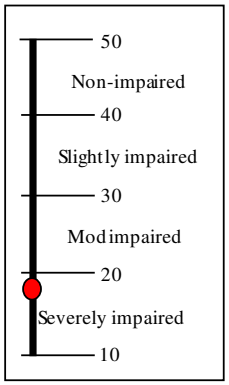
Yellow highlight = 2012 measurement

Biological Conditions Summary

Lab Sample ID: 16-127-02 Habitat(s) Sampled: Riffles

Sample Method: OR DEQ 8-kick composite

DEQ Metric Scores	Raw	Stand.
Richness	17	1
Mayfly Richness	2	1
Stonefly	0	1
Caddisfly	1	1
# Sensitive Taxa	0	1
# Sed Sens Taxa	0	1
Modified HBI	6.1	1
% Tolerant Taxa	13.7	5
% Sed Tol Taxa	13.3	3
% Dominant (1)	30.2	3
TOTAL		**18**



PREDATOR MWCF O/E Score:

MWCF		
Sample	O/E Score	Classification
Original	0.357	most disturbed

Stressor Scores	
Temperature Stress:	22.7
Fine Sediment Stress:	28.1

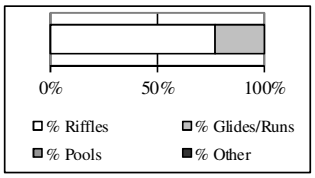
Reach Assessment Summary

Stream Name:	**Noyer Creek**	Site ID:	NOYER
Location:	At Hwy 212	Reach ID:	NOYER
County, State:	Clackamas, Oregon	Latitude:	45.41677
Date sampled:	10/7/2016	Longitude:	-122.40801
Field Personnel:		Reach Length:	75m

Physical and Chemical Conditions Summary

Instream Physical Characteristics

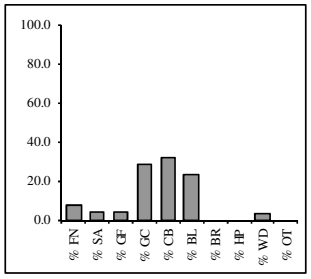
Reach Gradient (%)	2.6
Wetted Width (m)	13.7
Bankfull Width (m)	21.7
% Riffles	77.3
% Glides/Runs	22.7
% Pools	0.0
% Other	0



2016 Reach Photo

Substrate

% Fines (FN)	7.2
% Sand (SA)	3.6
% Gravel, Fine (GF)	3.6
% Gravel, Coarse (GC)	27.9
% Cobble (CB)	31.5
% Boulder (BL)	23.4
% Bedrock (BR)	0.0
% Hardpan (HP)	0.0
% Wood	2.7
% Other (OT)	0.0
% Embeddedness	13.0
Large Wood Tally (pieces/m)	0.00
Eroding Banks (%)	24
Undercut Banks (%)	0



Embeddedness

Canopy Cover

Yellow highlight = 2012 measurement

Riparian Zone Characteristics

Overhead Cover (%)	95
Riparian Buffer Width (m)	25
Riparian Zone Tree Cover (%)	80
Riparian Zone Non-Native Cover (%)	10
Dom Adjacent Land Use	Com

Chemical Characteristics

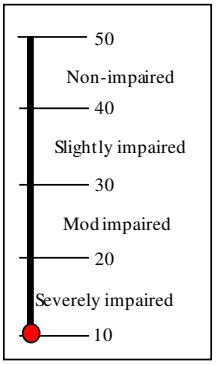
Water Temperature (°F)	56.3
pH	6.64
Conductivity (µS/cm)	121.8
Time of measurement	10:44

Biological Conditions Summary

Lab Sample ID: 16-127-01 Habitat(s) Sampled: Riffles

Sample Method: OR DEQ 8-kick composite

DEQ Metric Scores	Raw	Stand.
Richness	9	1
Mayfly Richness	0	1
Stonefly	0	1
Caddisfly	0	1
# Sensitive Taxa	0	1
# Sed Sens Taxa	0	1
Modified HBI	5.7	1
% Tolerant Taxa	69.9	1
% Sed Tol Taxa	69.9	1
% Dominant (1)	69.4	1
TOTAL		**10**



PREDATOR MWCF O/E Score:

MWCF		
Sample	O/E Score	Classification
Original	0.238	most disturbed

Stressor Scores	
Temperature Stress:	17.1
Fine Sediment Stress:	19

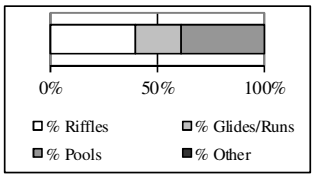
Reach Assessment Summary

Stream Name:	**Tickle Creek**	Site ID:	TICKLE
Location:	At Duncan Rd.	Reach ID:	TICKLE
County, State:	Clackamas, Oregon	Latitude:	45.39822
Date sampled:	10/7/2016	Longitude:	-122.2909
Field Personnel:		Reach Length:	75 m

Physical and Chemical Conditions Summary

Instream Physical Characteristics

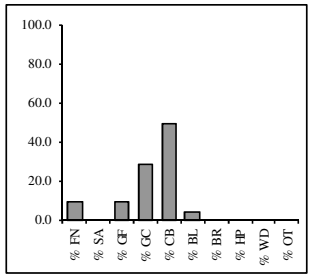
Reach Gradient (%)	1.9
Wetted Width (m)	11.0
Bankfull Width (m)	17.7
% Riffles	50.0
% Glides/Runs	26.3
% Pools	48.8
% Other	0



2016 Reach Photo

Substrate

% Fines (FN)	9.1
% Sand (SA)	0.0
% Gravel, Fine (GF)	9.1
% Gravel, Coarse (GC)	28.4
% Cobble (CB)	49.4
% Boulder (BL)	4.0
% Bedrock (BR)	0.0
% Hardpan (HP)	0.0
% Wood	0.0
% Other (OT)	0.0
% Embeddedness	8.8
Large Wood Tally (pieces/m)	0.13
Eroding Banks (%)	23
Undercut Banks (%)	24



Riparian Zone Characteristics

Overhead Cover (%)	85
Riparian Buffer Width (m)	30
Riparian Zone Tree Cover (%)	75
Riparian Zone Non-Native Cover (%)	10
Dom Adjacent Land Use	Urb

Embeddedness

Canopy Cover

Yellow highlight = 2012 measurement

Chemical Characteristics

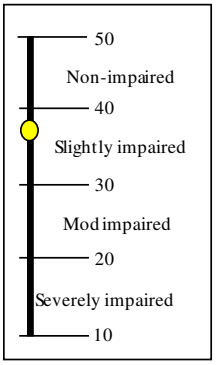
Water Temperature (°F)	56.0
pH	7.05
Conductivity (µS/cm)	33.16
Time of measurement	14:40

Biological Conditions Summary

Lab Sample ID: 16-127-03 Habitat(s) Sampled: Riffles

Sample Method: OR DEQ 8-kick composite

DEQ Metric Scores	Raw	Stand.
Richness	40	5
Mayfly Richness	10	5
Stonefly	8	5
Caddisfly	6	3
# Sensitive Taxa	3	3
# Sed Sens Taxa	1	3
Modified HBI	4.2	3
% Tolerant Taxa	29.3	3
% Sed Tol Taxa	10.6	3
% Dominant (1)	13.2	5
TOTAL		**38**



PREDATOR MWCF O/E Score:

MWCF		
Sample	O/E Score	Classification
Original	0.863	mod disturbed

Stressor Scores	
Temperature Stress:	19.3
Fine Sediment Stress:	15.9