CITY COUNCIL WORKSHOP MEETING AGENDA
Monday, February 2, 2015, 4:30 PM
City Municipal Center, 616 NE 4th Avenue

I. CALL TO ORDER

II. ROLL CALL

III. PUBLIC COMMENTS

IV. WORKSHOP TOPICS

A. 2014 Financial Review
Details: This presentation is to review the financial performance of the City from the perspective of budget to actual, investment performance and status of short and long term debt. The presentation also will provide an economic overview both nationally and regionally to provide context as well as provide the outlook for the next year.
Presenter: Cathy Huber Nickerson, Finance Director
Recommended Action: For information only.

Financial Performance 2014 4th Qtr

B. 2015 Limited General Obligation Bonds Discussion
Details: This presentation is to discuss the potential sizing of the 2015 Limited General Obligation Bonds approve by City Council by Ordinance 2710 on July 21, 2014. Next steps will also be discussed.
Presenter: Cathy Huber Nickerson, Finance Director
Recommended Action: City Council will discuss with final estimates and current market conditions the final size of the bond at the City Council Workshop on February 17, 2015.

2015 Limited General Obligation Bond

C. City of Camas Utility Billing Proposed Changes - Phase II
Details: This presentation will review the next round of proposed changes to Utility Billing practices including budget billing, low income assistance, filing of property liens and abandonment of service. Other items to discuss will include possible new fees, and elimination of payment extensions.
Presenter: Cathy Huber Nickerson, Finance Director
Recommended Action: Staff will present a draft ordinance at the next City Council Workshop on February 17, 2015 for consideration.

Utility Code Changes Phase 2

D. Ordinance No.15-003 Ratifying and Approving Various Loans with the State of Washington

Details: In updating all the City's debt files, it was discovered twelve loans were not approved by an ordinance with a public hearing preceeding the motion. Rather these loans were approved through Consent with the City Administrator's signature. It is the opinion of Bond Counsel for the City to correct the procedural approval of the loans with a motion of City Council to ratify the existing loans by Ordinance signed by the Mayor. Staff has developed a new process for all future loans and will review this new process during the Council Workshop. The draft ordinance ratifying the loans is available for City Council's review prior to the Workshop.

Presenter: Cathy Huber Nickerson, Finance Director

Recommended Action: The Ordinance will be presented to City Council on February 17, 2015 for consideration and a recommendation for a motion to approve.

Ord 15-003 - Ordinance ratifying LoansCity of Camas

E. Lacamas Lake Water Quality Status

Details: Council requested an update on the Lacamas Lake water quality status and testing. Currently there is no active testing on Lacamas Lake or tributary systems. The last update by Clark County was the Monitoring Report Lacamas Lake Annual Data Summary for 2007 (see attached). In 2010-11, the Department of Ecology gathered data in the Lacamas Basin tributaries to support work on developing a Total Maximum Daily Load (TMDL) for the basin. Discussion with Ecology anticipates that the TMDL will not be ready for public involvement and comment until 2017. Based on a discussion with Clark County staff, an effort similar to the 2007 study would cost in the neighborhood of $10,000 to $15,000 and may be helpful in developing trends in water quality over time. County staff noted that there is an active Vancouver Lake stakeholder group, which has similar concerns on algae, but there is not currently a stakeholder group for Lacamas Lake.

Presenter: Eric Levison, Retiring Public Works Director

Recommended Action: For information only.

2004 Lacamas Lake Nutrient Loading and In-Lake Condition

2007 Lacamas Lake Monitoring summary

2011 Lacamas Creek Water Quality Study

F. Department of Ecology Water Quality Standards Rulemaking

Details: The Department of Ecology has initiated a rule making process to update WAC 173-201A to include Human Health Criteria (HHC) for 96 toxic chemicals to protect human health. The rule update includes new limits for the 96 toxic substances and implementation tools for Ecology to use in conjunction with the National Pollutant Discharge Elimination System (NPDES). This rule will affect all NPDES permitted dischargers, both public and private, for wastewater and stormwater. The Governor is also proposing legislation to work toward removing toxic substances at the source. These changes are driven by Federal Clean Water requirements. Staff will provide an update on the rulemaking process.

Presenter: Eric Levison, Retiring Public Works Director

Recommended Action: For information only.

Water Quality Standards Rule Making

Water Quality Standards Update Background

Water Quality Standards Update Appendix B Chemicals

G. Wastewater Treatment Plant NPDES Permit Update and Consultant Services

Details: The City has recently received a Draft National Pollutant Discharge Elimination System (NPDES) Permit from the Department of Ecology for the wastewater treatment plant. Staff has begun a review of the Draft Permit and will provide the City Council with a brief update on key provisions. A copy of the cover letter from Ecology is attached for reference that briefly describes the anticipated process Ecology will use to issue a Final Permit. Additionally, as proposed and discussed with Council at the October 20, 2014 Workshop, Gray & Osborne is assisting staff with a technical review of the Draft Permit and has provided the City with the attached Proposal for NPDES Permit Review assistance.

Presenter: Steve Wall, Public Works Director

Recommended Action: For information only. It is anticipated the Gray & Osborne Proposal will be included on the February 17, 2015 Consent Agenda for Council consideration.

NPDES Permit Review - G&O Proposal

Draft NPDES Permit Cover Letter

H. Jones Creek 2015 Timber Sale Professional Services Proposal

Details: The City opened bids for the Jones Creek 2015 Timber Sale on January 15, 2015. The highest bidder was High Cascade, Inc. in an amount of $468,061. The bid award will be on the Consent Agenda at the February 2, 2015 City Council Regular Meeting for consideration. Additionally, AKS Engineering and Forestry has submitted the attached Proposal in the amount of $85,500 to provide construction administration and turbidity monitoring services for the project.

Presenter: Steve Wall, Public Works Director

Recommended Action: For information only. It is anticipated the AKS Engineering and Forestry Proposal will be included on the February 17, 2015 Consent Agenda for Council consideration.

Jones 2015 Construction Services Proposal AKS

I. Public Works Miscellaneous and Updates

J. Lake Hills Subdivision Final Plat (File #FP14-05)

Details: Lake Hills Subdivision (file #SUB12-01) received preliminary plat approval April 6, 2013; to subdivide approximately 18.1 acres of residentially zoned land (R-10) into 53 single-family lots, with 11 lots along NW Lake Road and 42 lots that will be accessed from Hood Street. The property includes 2.6 acres of open space and will provide a local connector trail between NW Lake Road and Hood Street.

Presenter: Sarah Fox, Senior Planner

Recommended Action: Set a date for a final decision on February 17, 2015.

Lake Hills Final Plat Drawing

K. 2035 Vision Statement

Details: Over the past six months, under the guidance of the Vision Steering Committee, hundreds of community members have participated in two rounds of Camas 2035 outreach activities. The purpose of the first round was to identify Camas' strengths and understand what citizens value about Camas today. The purpose of the second round of outreach efforts was to validate the draft vision statement. On January 8, 2015, at the second vision summit, the participants discussed the survey results, and affirmed that the draft vision was a true reflection of their input. At the Planning Conference, Council discussed the vision statement and recommended amendments. The attached statement includes those recommendations.

Presenter: Phil Bourquin, Community Development Director; and Sarah Fox, Senior Planner

Recommended Action: Discuss the vision statement and direct the City Attorney to prepare a resolution to adopt the vision at the City Council meeting on February 17, 2015.

Camas Vision Revised

Camas2035 Outreach Summary 1-6-15

L. 2015 ADA Ramp and Sidewalk Improvements

Details: Bids were open on Tuesday, January 27, 2015 for Project S-598, 2015 ADA Ramp and Sidewalk Improvements. The successful low bidder is Schmid and Sons, Inc. in the amount of $21,676.21. This project addresses ADA access requests that have been identified by citizens of Camas. Included in these improvements are replacement of rough sidewalks adjacent Crown Park on NE 15th Avenue and ADA parking and access improvements at Oak Park Neighborhood Park on SE 8th Avenue. $15,000 is budgeted for ADA improvements in 2015. The finance department will propose the reconciliation of the additional cost in an upcoming omnibus.

Presenter: James Carothers, Engineering Manager

Recommended Action: Staff recommends awarding this project to Schmid and Sons on the February 2nd Consent Agenda

215 ADA Improvements Bids

215 ADA Improvements Plan View

M. NW Friberg and Goodwin Street Improvements

Details: Change Order No. 3 for project S-566 NW Friberg and Goodwin Street Improvements includes 13 additional required items totaling $68,732.37, to the Contractor, McDonald Excavating, Inc. These items include an upgrade to the electrical service for the traffic signal, installation of over 15,000 square yards of geotechnical fabric to reinforce the underlying subgrade, the relocation of several utilities to accommodate a traffic signal pole, installation of irrigation piping not shown in the plans, extra saw-cutting above the bid quantity, and additional gabion rock, pipe fittings, and other miscellaneous items outside the scope of the original bid. A more detailed explanation of these additional items is provided on the attached change order. Also attached is a funding memorandum with the updated expenditures for the project. While the change orders total approximately $156,000 or 3.8% of the original contract amount, the bid item overruns will total approximately $291,000. The majority of these bid overruns are due to an underestimated amount of flagging time and the overexcavation and backfill of unsuitable roadway base. The overall additional costs above the bid items is nearly 10% of the original construction bid awarded. Payment for the additional cost of this project will be proposed as part of the general obligation bond to be presented to Council by the Finance Department.

Presenter: James Carothers, Engineering Manager

Recommended Action: Staff recommends approval of this change order on the February 2nd Consent Agenda.

S-83 Pay Est No. 3 Final

Retainage Payment

Contractor reimbursement

N. Community Development Miscellaneous and Updates

O. City Administrator Miscellaneous Updates and Scheduling

V. COUNCIL COMMENTS AND REPORTS

VI. PUBLIC COMMENTS

VII. ADJOURNMENT

NOTE: The City of Camas welcomes and encourages the participation of all of its citizens in the public meeting process. A special effort will be made to ensure that a person with special needs has the opportunity to participate. For more information, please call 360.834.6864.

FINANCIAL PERFORMANCE

City of Camas

An Overview of 2014 Financial Performance

Agenda

- General Economy during 4th Quarter of 2014
- Highlights
- Revenue
- Expenditures
- Investments
- Debt
- Items to Note
- Fund Balance
- Outlook

4th Quarter Economy

Indicators

Avg. Mortgage Rate LOWER 4.02% v 4.51 % at the end of 2013.

Unemployment LOWER 5.6% v. 6.7% at the end of 2013.

Retail Sales (% chg yr) LOWER 3.2% v. 3.7% at the end of 2013.

CPI LOWER 0.7% v. 1.5% (national) at the end of 2013.

Avg. Gas Prices LOWER $2.04 v. $3.32 at the end of 2013.

*Portland and Seattle CPI not yet available

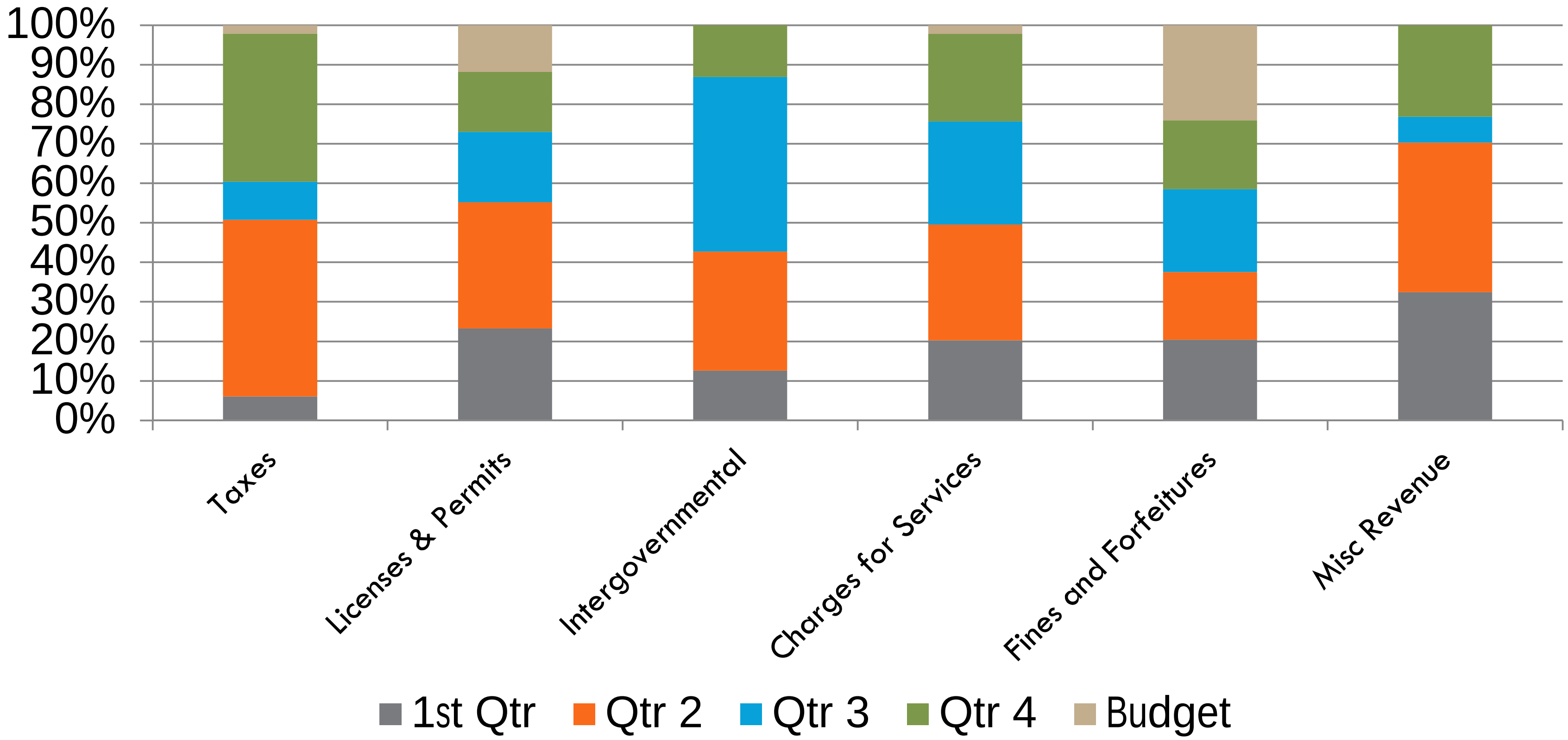
- Home values increased but still have significant ways to go to rise to prerecession levels.
- Retail slowed with construction spending supporting sales tax revenue.
- Cheap gas prices are helping consumer sentiment but wages are a drag on growth.
- Inflation is in check with cheap commodities.
- Sharing of revenue from the State and the Feds continues to decline.
- Watch on Fed curtailing easing and mortgage rates.

General Fund Highlights

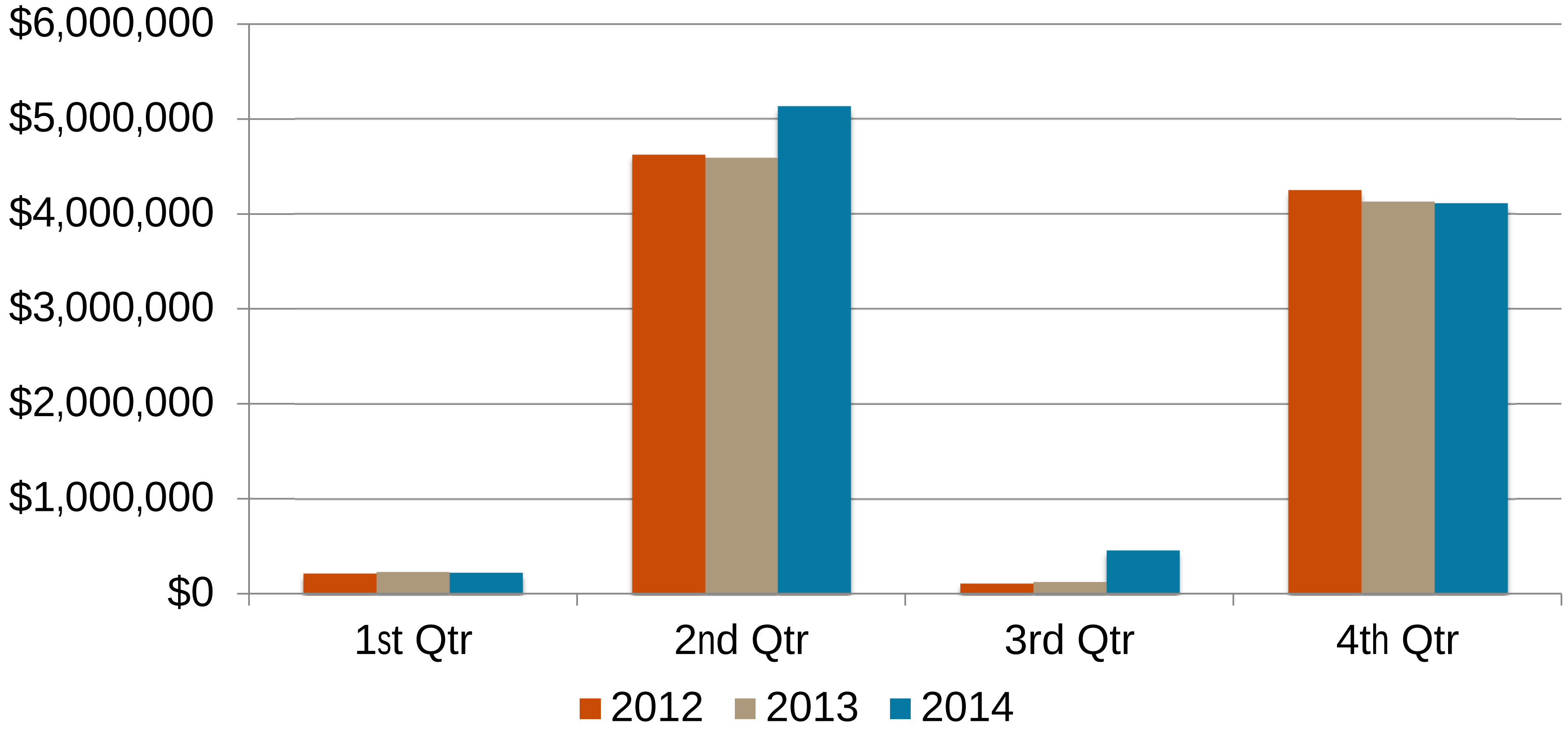
	2014 First Quarter	2014 Second Quarter	2014 Third Quarter	2014 Fourth Quarter
Net revenues (less transfers)	$1,576,626	$7,106,760	$2,471,587	$5,708,866
Net expenditures (less transfers)	$3,738,568	$3,315,944	$3,264,712	$3,495,868
Net Cash Flow	($2,161,942)	$3,790,816	($793,125)	$2,212,998
% of Budget Spent	22%	43.8%	74.6%	99.4%
Overall Cash and Investments for All Funds	$11,756,434	$17,527,057	$16,765,338	$19,020,591

This table illustrates the cash flow of the General Fund.

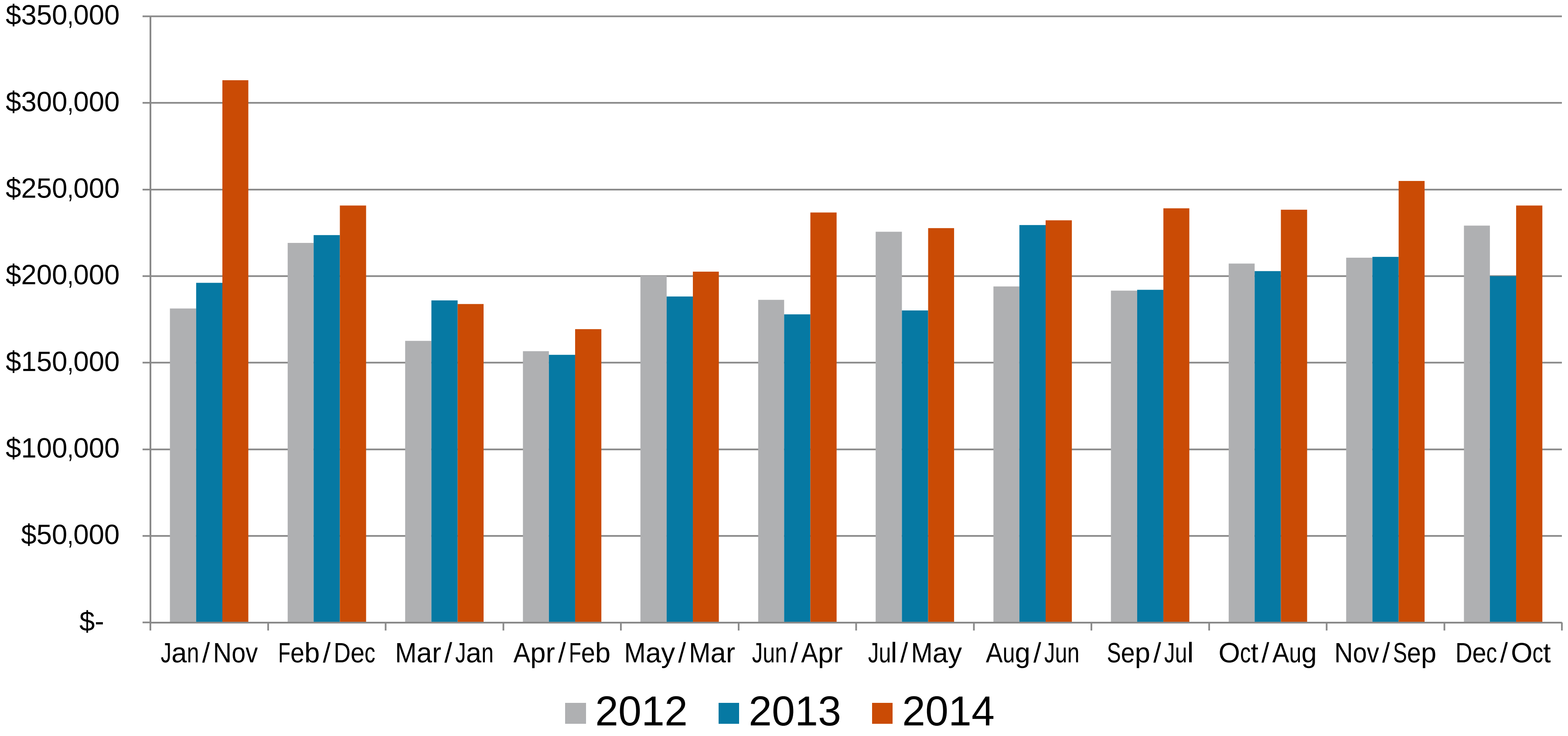
General Fund Revenues



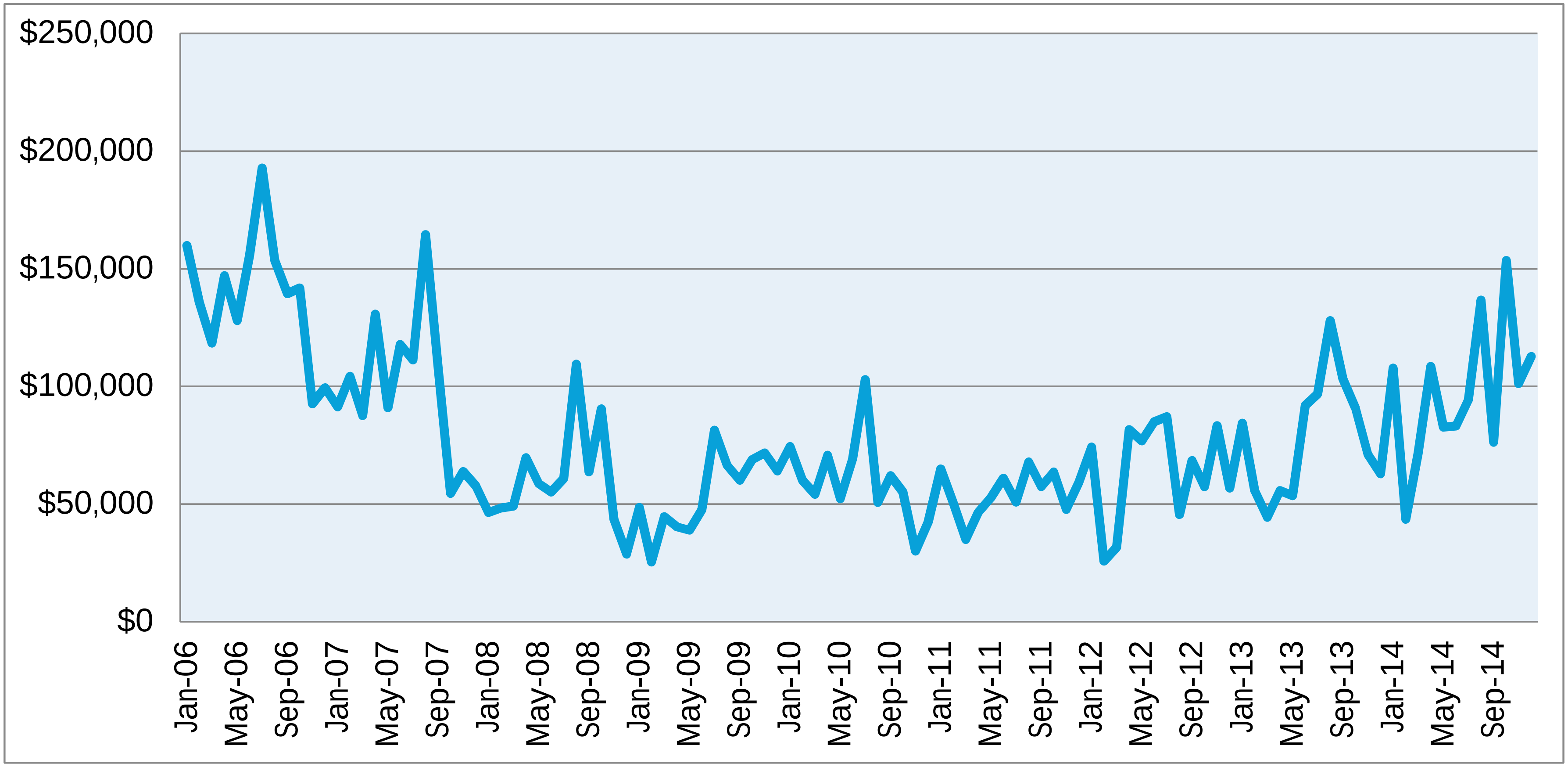
Property Tax Collections



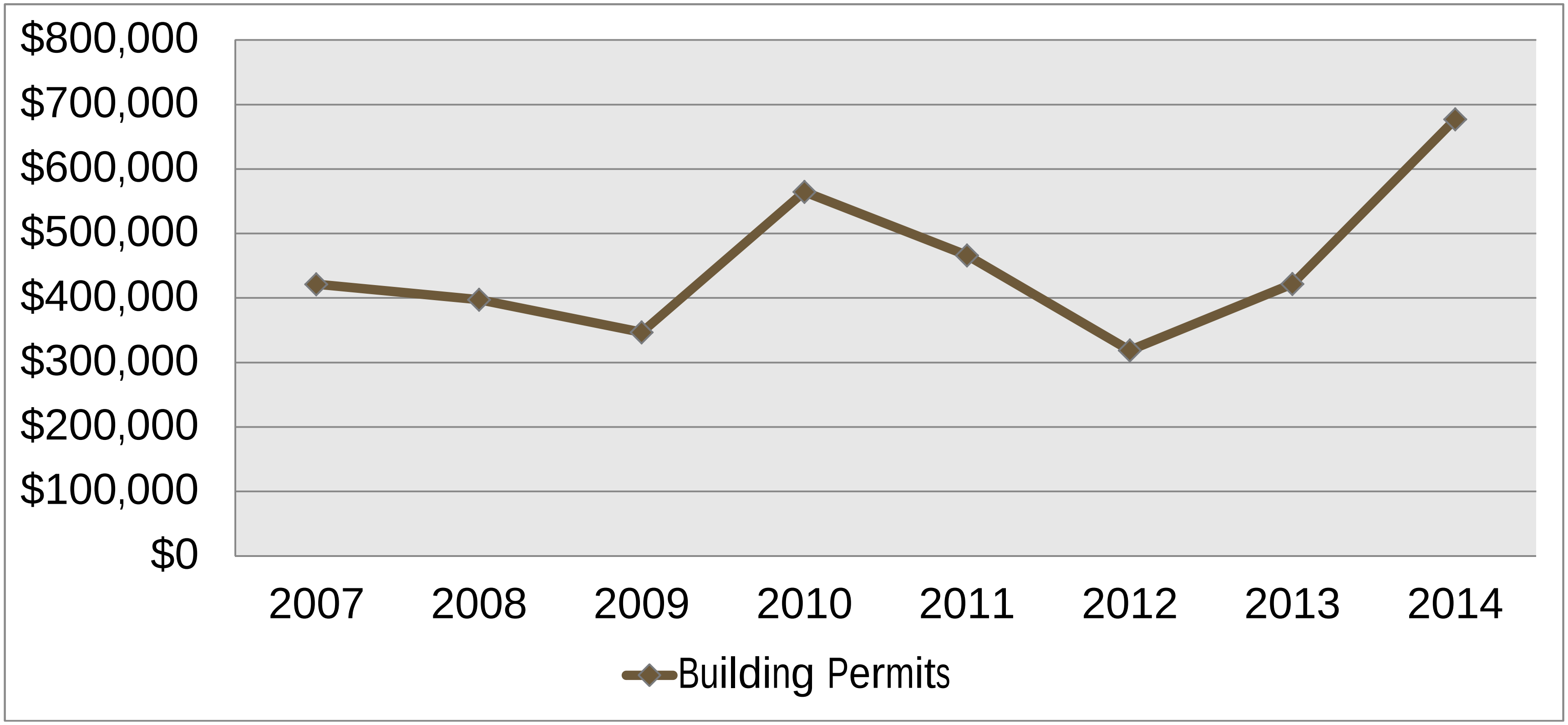
Sales and Use Tax



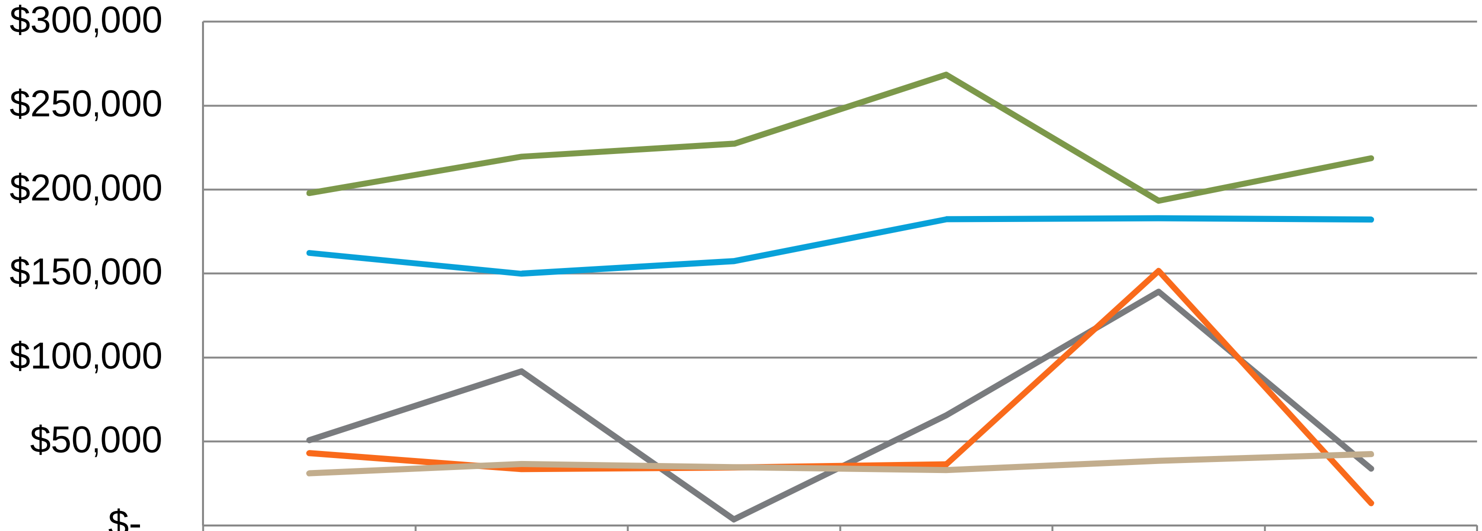
Real Estate Excise Tax



Building Permits

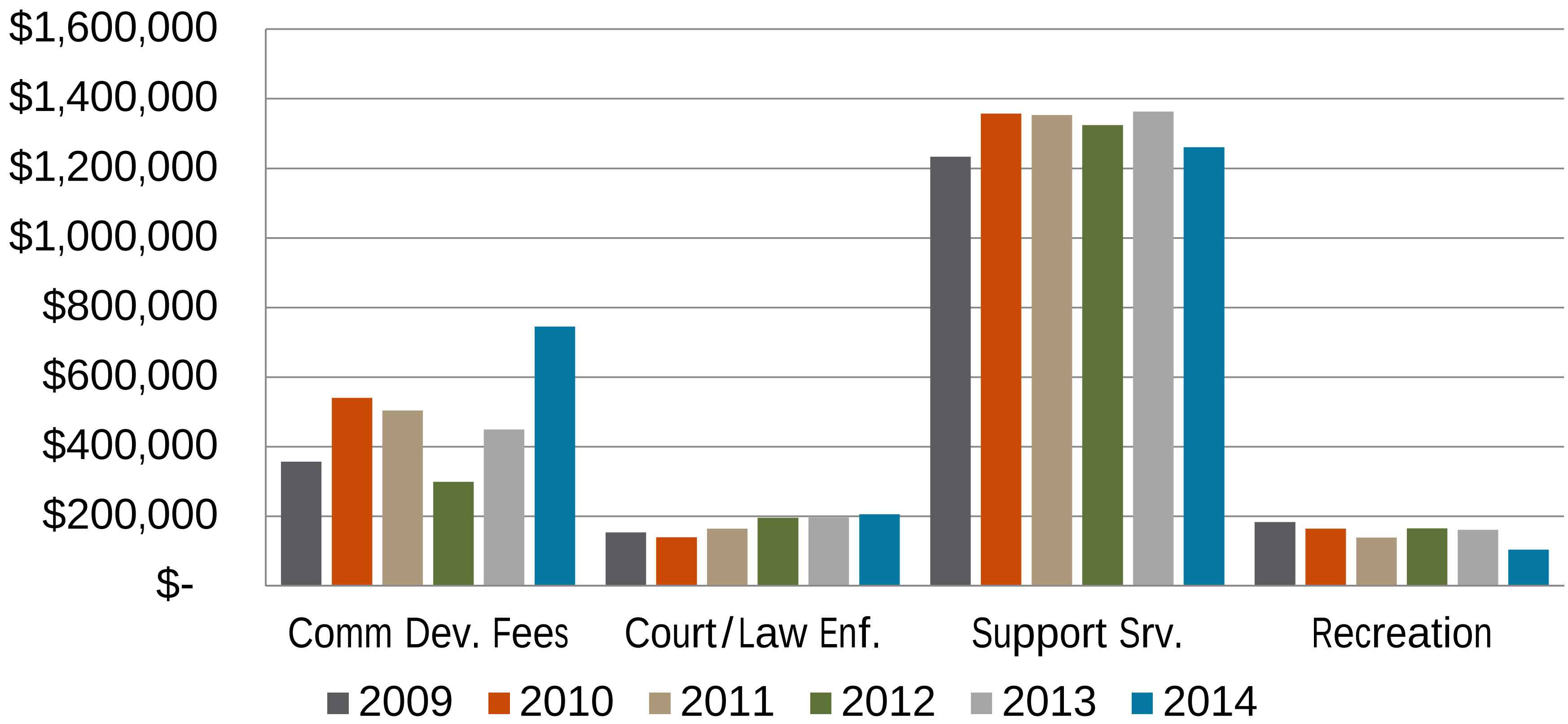


Intergovernmental

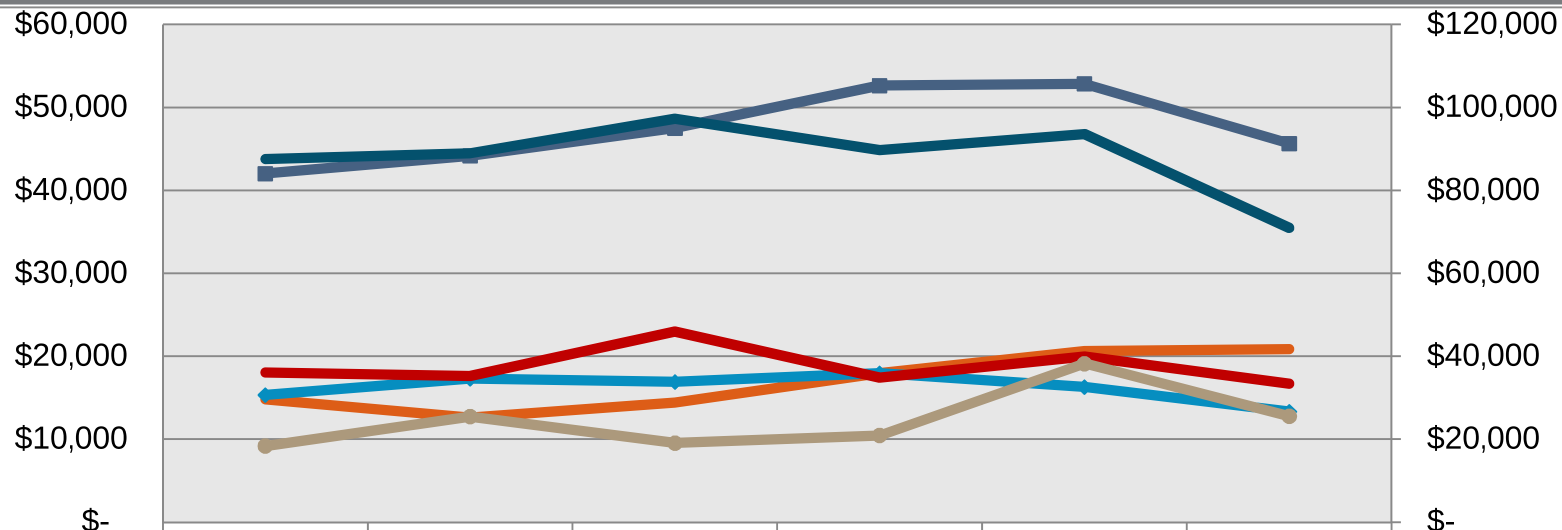


	2009	2010	2011	2012	2013	2014
Federal Grants	$50,702	$91,665	$3,435	$65,355	$139,267	$33,802
State Grants/Shared Rev.	$42,894	$33,434	$34,361	$36,273	$151,539	$13,175
PUD Priv. Tax	$162,335	$149,782	$157,352	$182,203	$182,739	$182,004
Liquor Revenue	$197,816	$219,575	$227,268	$268,411	$193,371	$218,734
Fire Premium Tax	$31,032	$36,432	$34,521	$32,866	$38,286	$42,398

Charges for Services

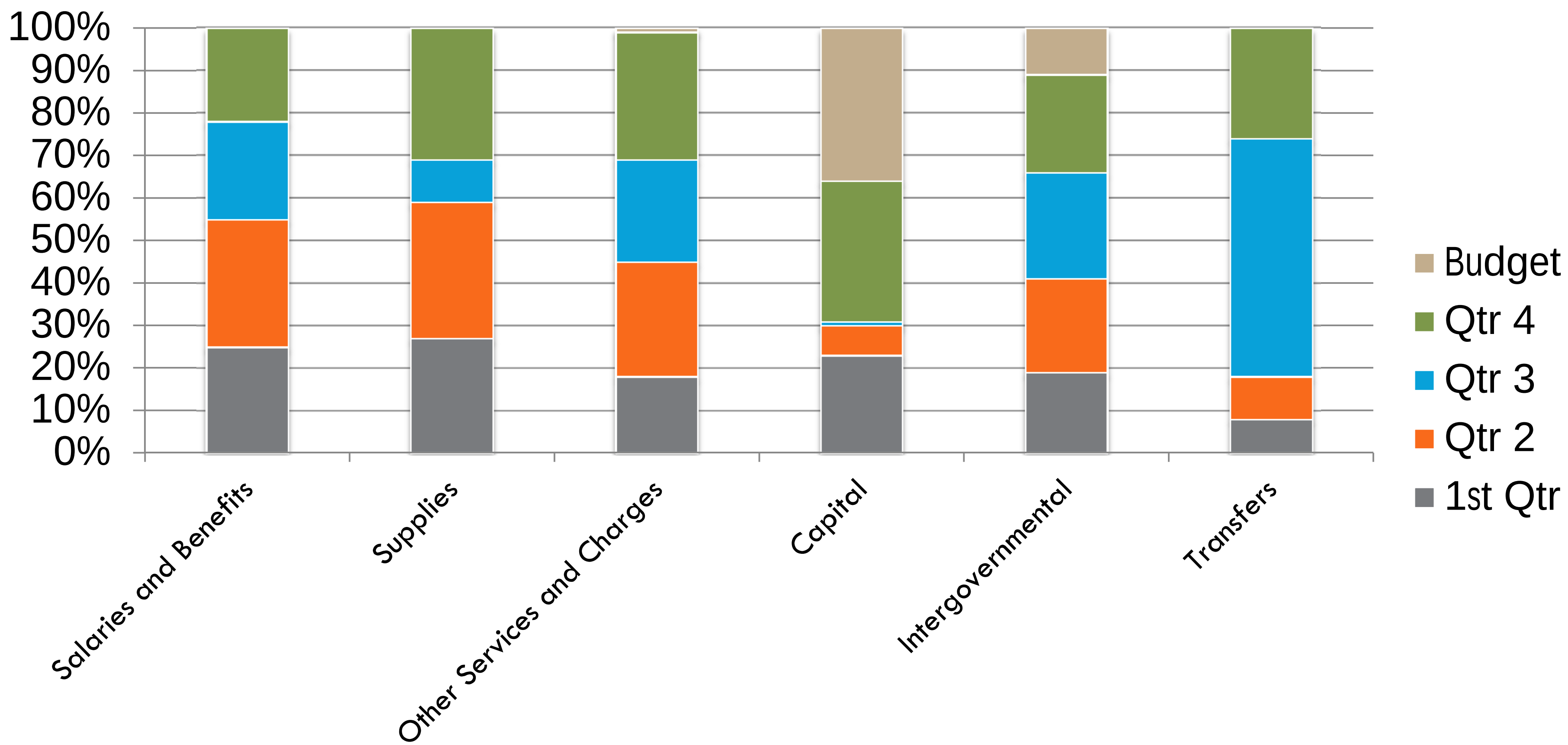


Fines and Forfeitures

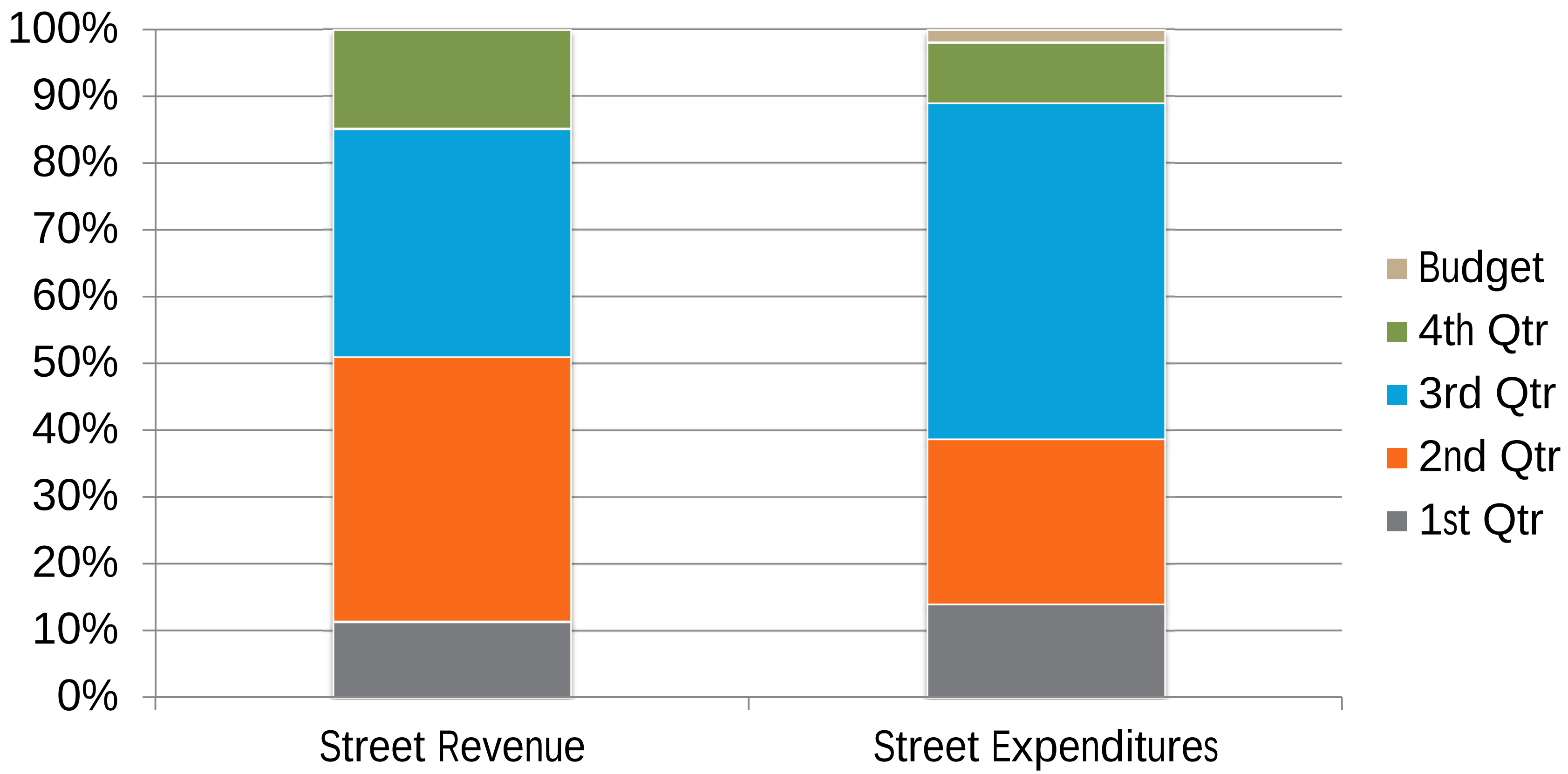


	2009	2010	2011	2012	2013	2014
Other Traffic	$14,791	$12,601	$14,428	$17,948	$20,609	$20,874
Non-Traffic	$15,334	$17,294	$16,906	$17,956	$16,294	$13,327
Parking Viol.	$18,050	$17,626	$22,983	$17,427	$19,956	$16,689
DWI	$9,173	$12,730	$9,538	$10,460	$19,117	$12,776
Crim Costs/EHM	$42,031	$44,178	$47,504	$52,630	$52,848	$45,665
Traffic Infractions	$87,582	$88,946	$97,268	$89,735	$93,544	$70,967

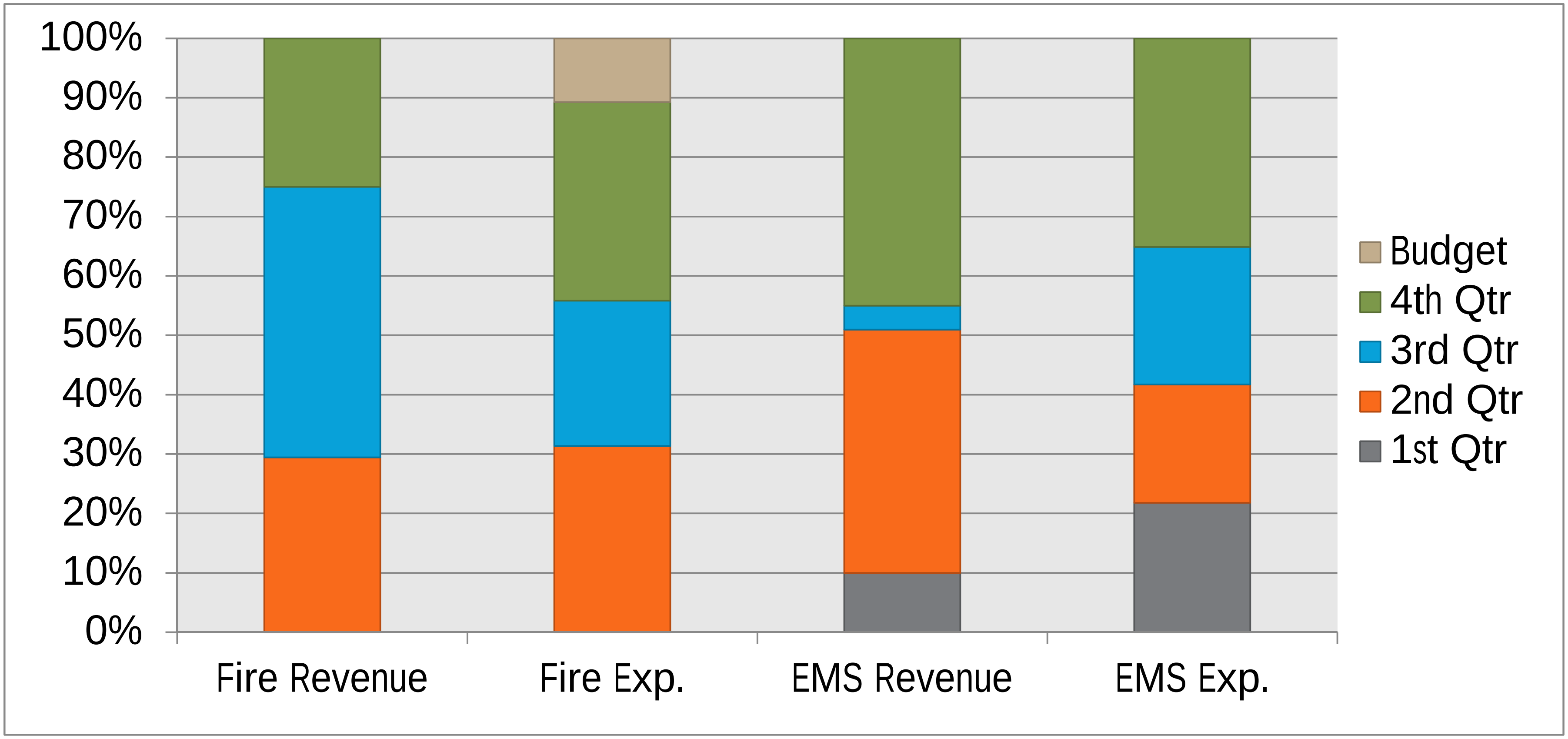
General Fund Expenditures



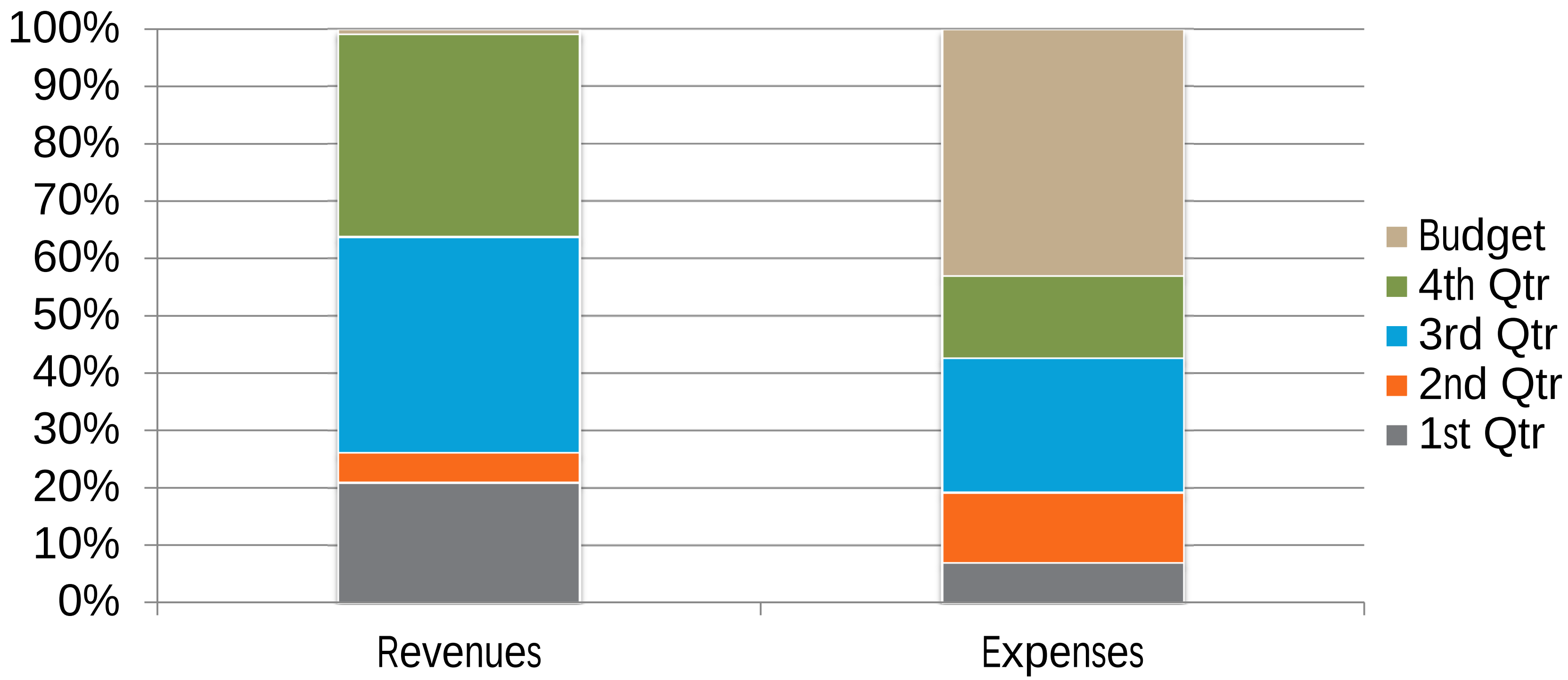
Streets


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Street Revenue
Street Expenditures
Budget
4th Qtr
3rd Qtr
2nd Qtr
1st Qtr

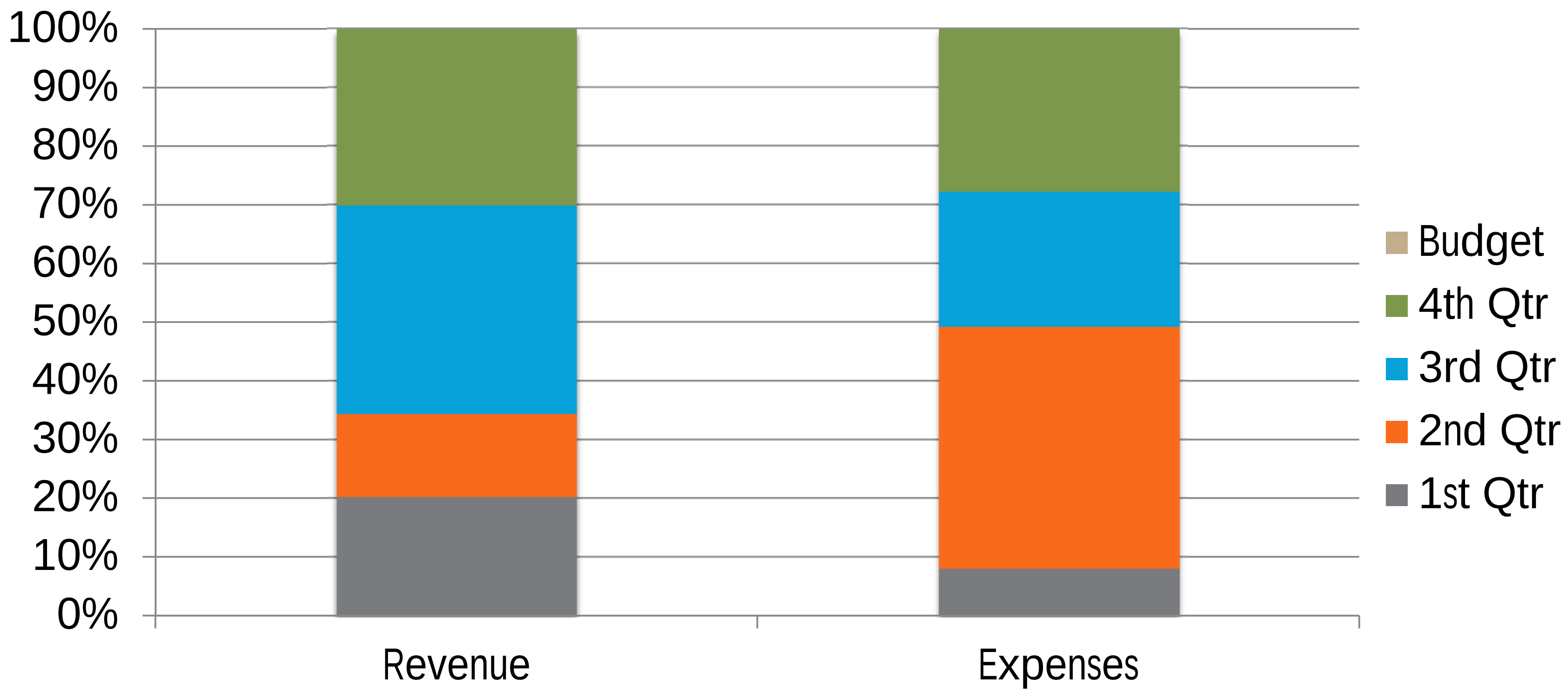
Camas/Washougal Fire and EMS



Storm Drainage

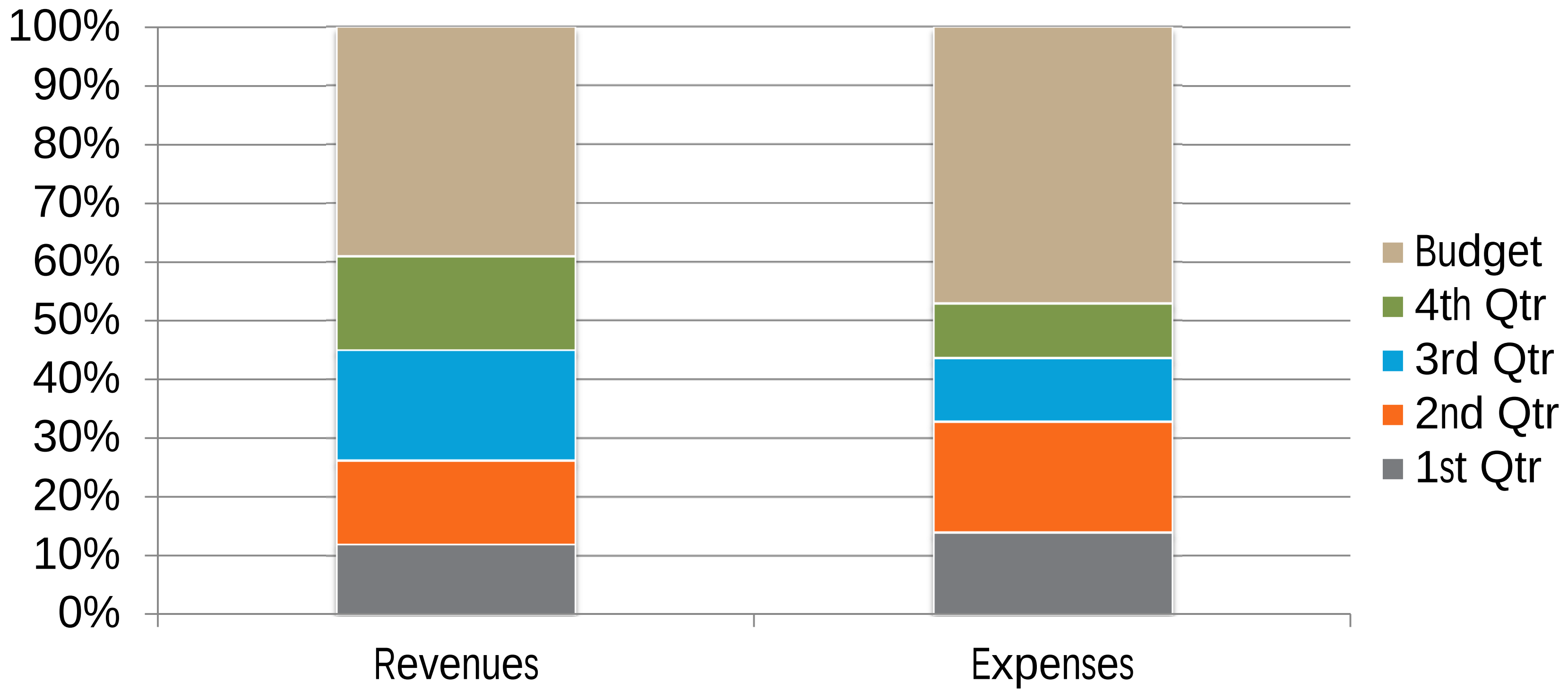


Sanitary



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Revenue
Expenses
Budget
4th Qtr
3rd Qtr
2nd Qtr
1st Qtr

Water / Sewer



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Revenues
Expenses
Budget
4th Qtr
3rd Qtr
2nd Qtr
1st Qtr

Capital Projects – as of Dec. 31st
Budget to Date

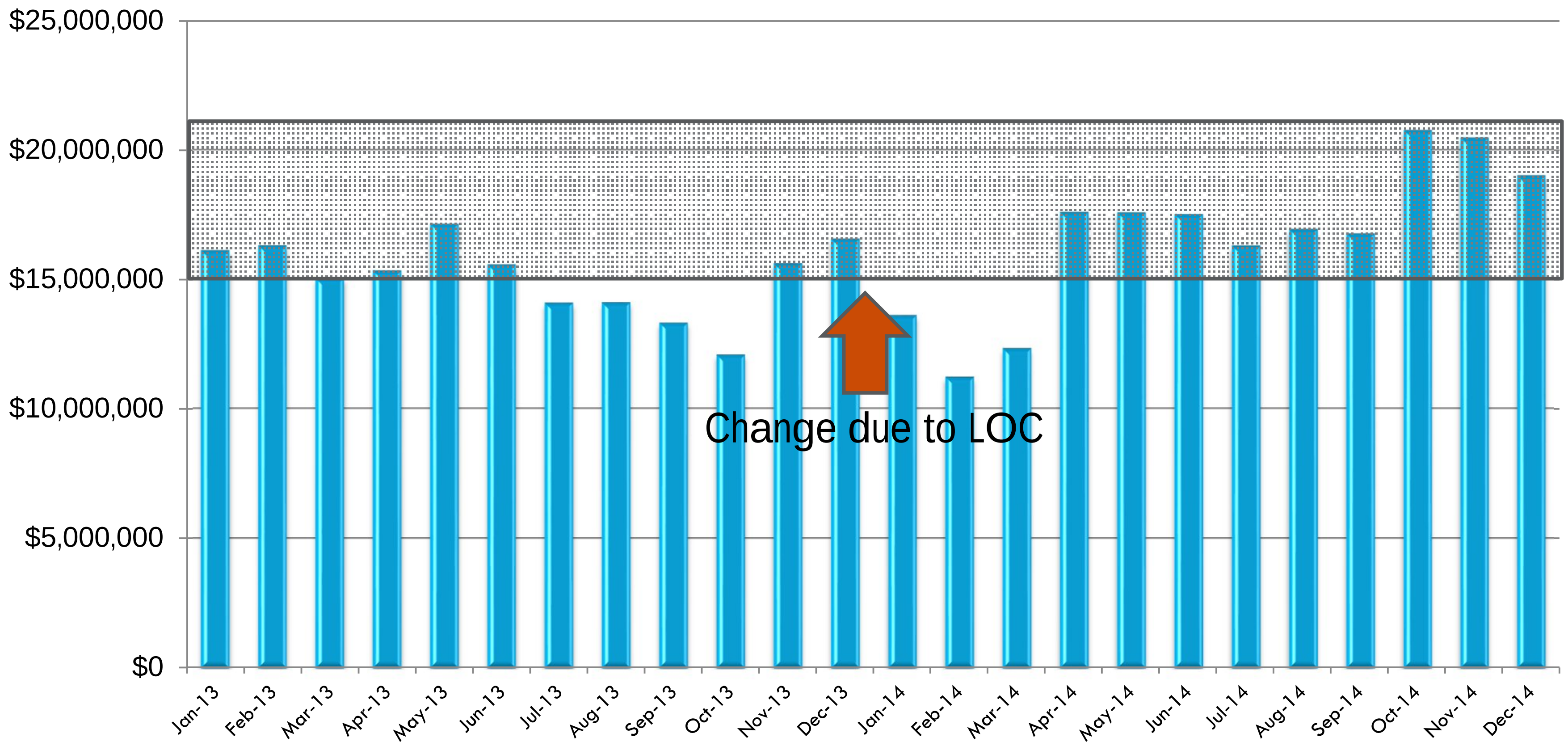
Govt. Projects

Street Preservation	92%
NW 38th Ave. Phase II	82%
Friberg/Strunk	92%
NW 18th Pedestrian Trail	100%
NW Brady	2%
Open Space Acquisition	7%
Drewfs Farm Park Design	29%
Heritage Boat Launch	46%
NW 6th/Norwood Intersection	8%
Camas Pool	100%
Trails	0%
Park Improvements	72%

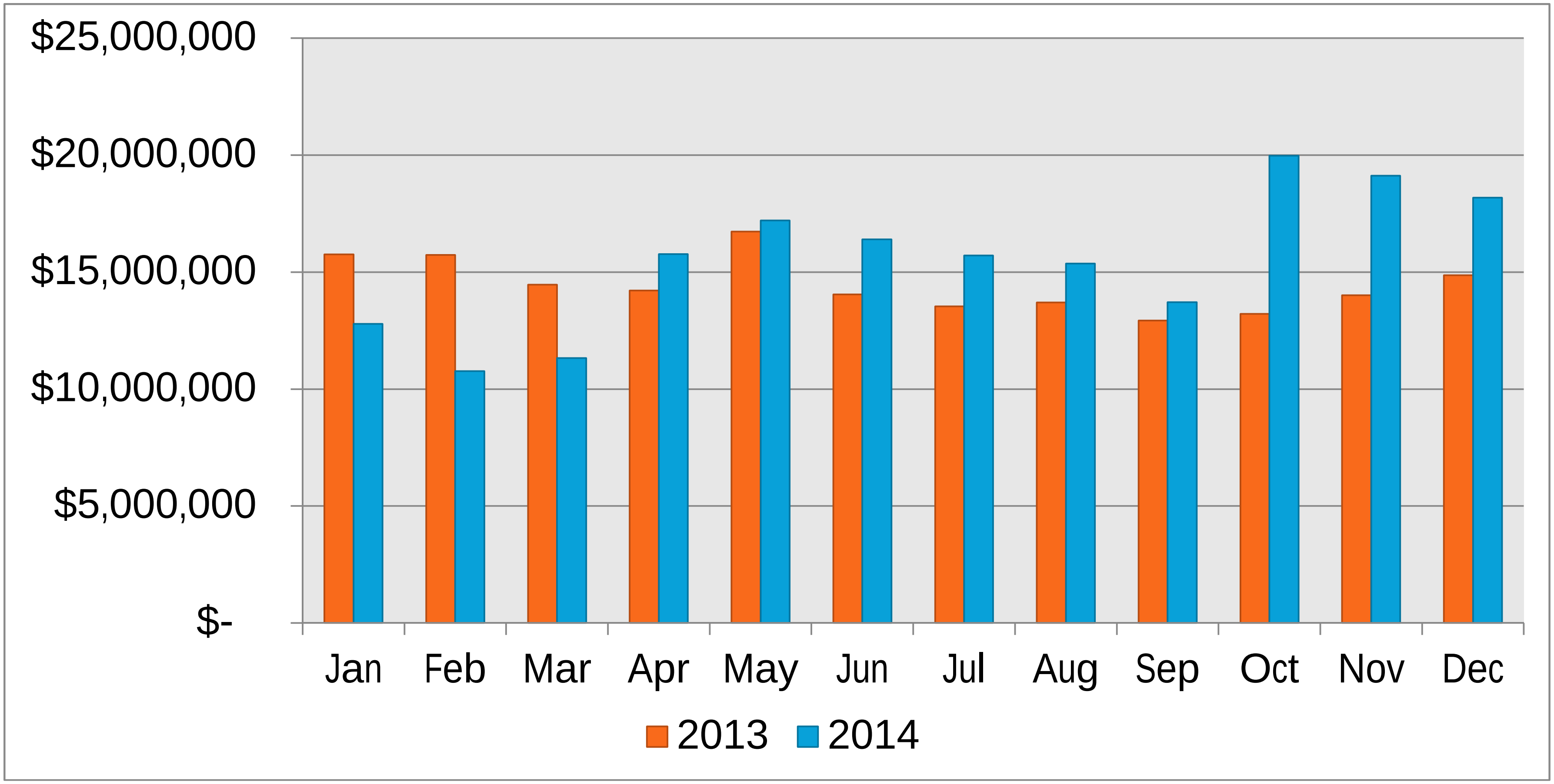
Utility Projects

NW 18th Pedestrian Trail	100%
Vactor Facility	100%
Storm Water Projects	27%
WWTP	74%
544 Pressure Zone	42%
Gregg Reservoir	1%
BNSF Bridge	126%
Sanitary Sewer Bypass Line	1%
Sewer Projects	17%

Cash and Cash Equivalent Assets



Investment Portfolio Balance



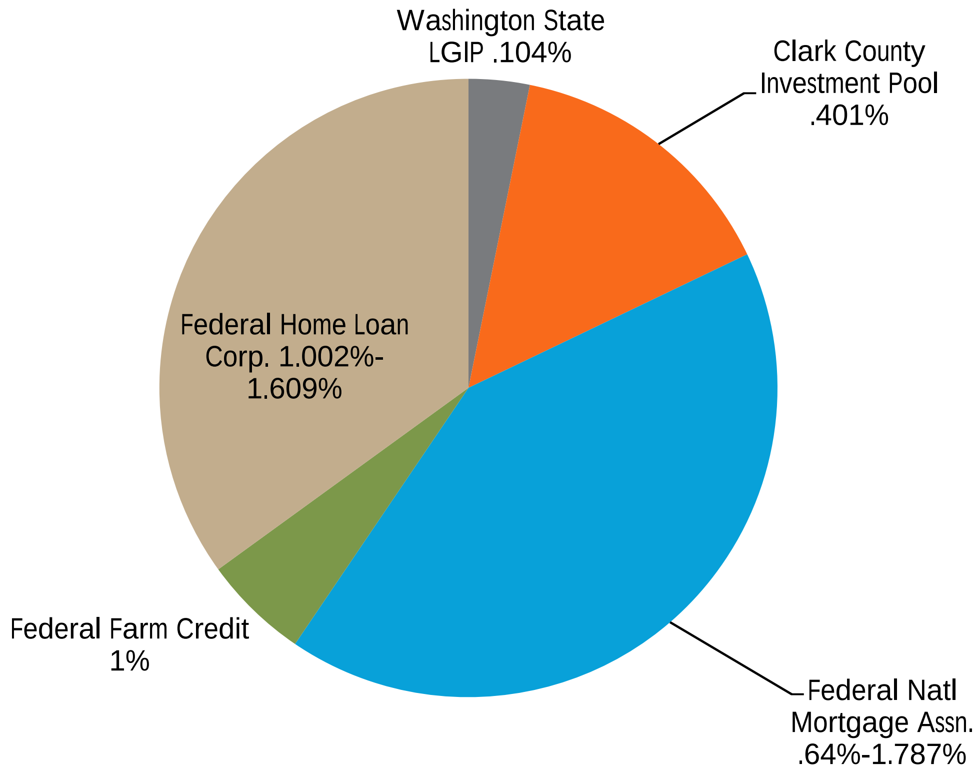
Investment Portfolio

1st Quarter Portfolio
$11,328,541
25% on demand
Return 3/31 .73%

2nd Quarter Portfolio
$16,401,583
30% on demand
Return 6/30 1.03%

3rd Quarter Portfolio
$13,719,420
28% on demand
Return 1.04%

4th Quarter Portfolio
$17,921,511
18% on demand
Return 0.98%



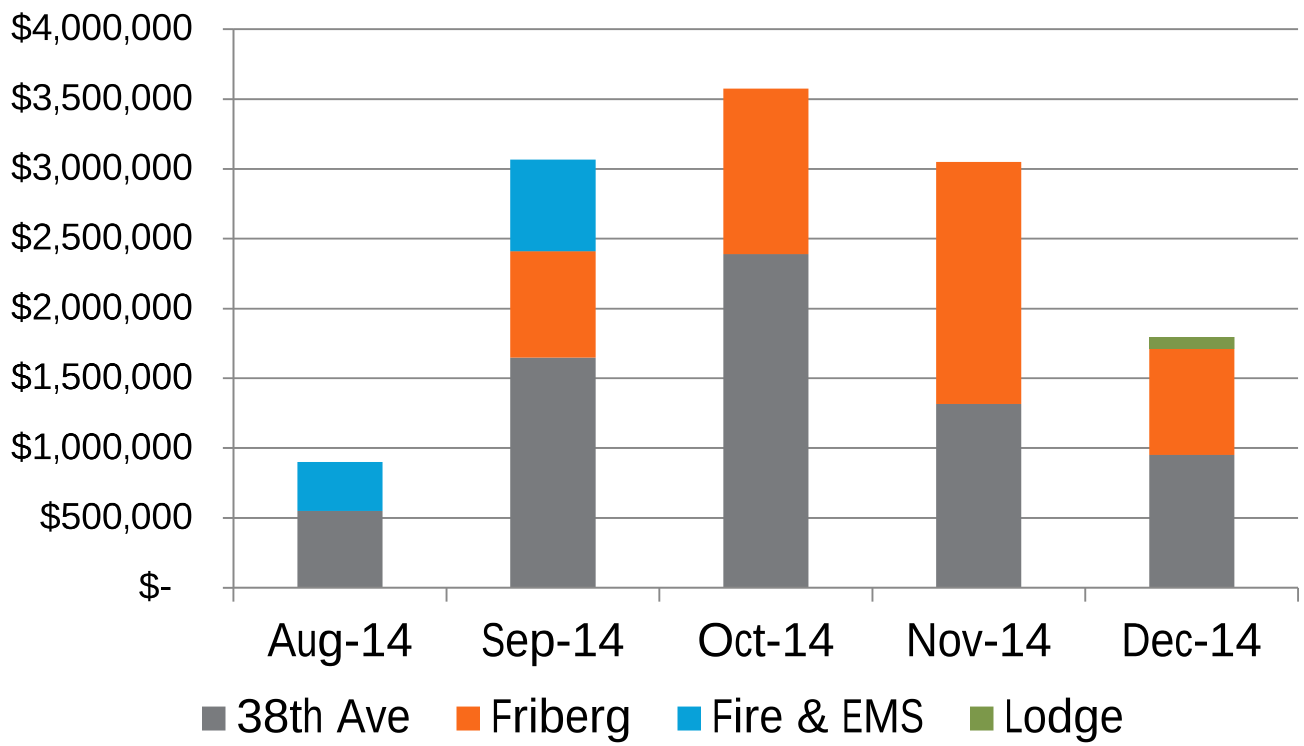
Line of Credit

Interest Paid in 2014 $6,745

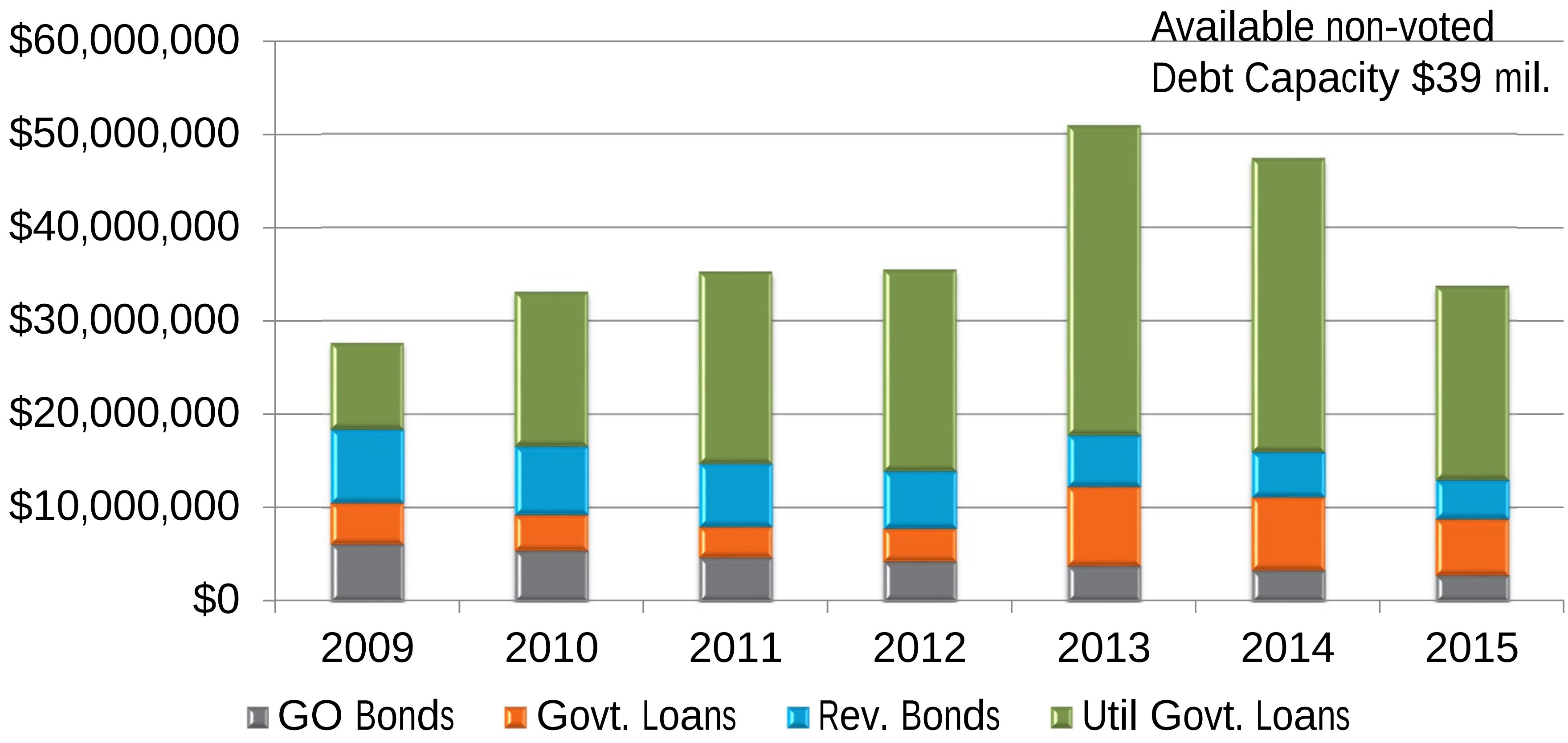
Interest Rate 0.863% avg.

Commitment Fee in 2014 $5,079

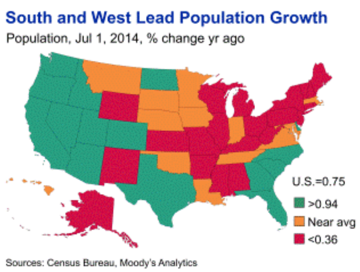
Fee Rate 0.25%

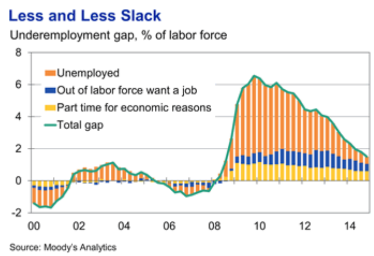


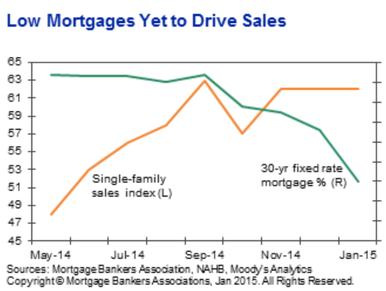
Debt Outstanding

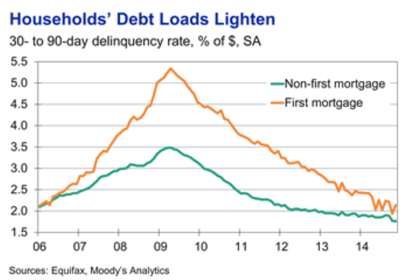


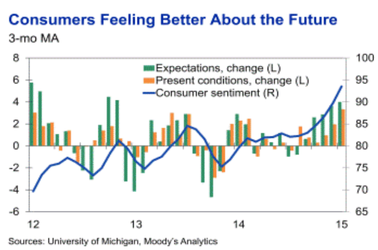
Outlook











- Homebuilding is expected to accelerate in 2015.
- Consumer Confidence is improving but has a ways to go.
- Job growth is improving but wage growth is slow to improve.
- Good news is the economy is on a path to full employment by mid-2016.
- Caution: softening global economy, business investment is slow, and Federal Reserve will raise rates at some point.

2015 Limited General Obligation Bond

City of Camas

Status of Limited GO Bond

- Standard and Poor's rated the City AA+
- City Council approved the bond issue in Ordinance 2710 on July 21,2014 for an amount not to exceed $10,500,000
- Council requested prior to the sale of bonds, a presentation informing Council as to the projects and the payment plan for the debt service.

Current Needs

LED Lights	$2,000,000
6th and Norwood	$2,000,000
Friberg/Strunk	$1,000,000
38th Ave. Phase II	$500,000
Parker	$500,000
Annex Building	$300,000
Fire Truck	$500,000

- These projects are currently being scoped and the estimates will be fine tuned for City Council Workshop on February 17th.

LED Lights

PROJECT DESCRIPTION

- This project would replace all City street lights with LED bulbs. It would also light two city streets currently lacking street lighting.

- Costs: $2,500,000
- Grant: ($500,000)
- Net Costs: $2,000,000

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $145,000

- Energy and Maintenance savings ($117,000)
- CPU Incentives
  One-Time (257,000)

Projected breakeven
18 years

6th and Norwood Street Project

PROJECT DESCRIPTION

- This project is currently sized to be an intersection and pavement on 6th Avenue. The project scope could change the estimate.
- Costs: $2,000,000

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $145,000
- Payments from REET 1 and/or Transportation Impact Fees

Friberg/Strunk Construction

PROJECT DESCRIPTION

- These funds would closeout the project.
- Costs: $1,000,000
- Staff is working to pull together better estimates on the project requirements for the City Council Workshop on February 17, 2014

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $72,500
- Payments from REET 1 and/or Transportation Impact Fees

38th Avenue Phase II

PROJECT DESCRIPTION

- These funds would be used to closeout the project.
- Costs $500,000
- Staff is working to pull together better estimates on the project requirements for the City Council Workshop on February 17, 2014

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $36,250
- Payments from REET 1 and/or Transportation Impact Fees

Parker Road

PROJECT DESCRIPTION

- This project is to design, permit and right of way acquisition for Parker Road from 16th to Pacific Rim Drive.
- Costs $500,000
- Staff is working to pull together better estimates on the project requirements for the City Council Workshop on February 17, 2014

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $36,250
- Payments from REET 1 and/or Transportation Impact Fees

Annex Building

PROJECT DESCRIPTION

- This project is acquire a building currently rented by the City.
- An appraisal would be required to size the project.

- Costs: $300,000
  based upon current assessed values

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $22,000

- Current rent ($12,000)
- Rent from existing tenant ($12,000)

Fire Truck

PROJECT DESCRIPTION

- This project is acquire a new fire truck to replacing an aging apparatus.
- Costs $500,000

DEBT SERVICE PLAN

- 20 year bonds
- Debt Service early estimate: $36,250
- Currently, the City of Camas will payoff debt service for an existing fire truck. The current debt service is $66,000/year.
- City of Washougal would pay their proportionate share

Next Steps

- February 9
  - Final Preliminary Official Statement (POS)
  - Update call to Standard and Poor's
- February 17
  - City Council to see final projections
  - Updated rating
- February 23
  - Finalize POS sent
- March 3
  - Review market conditions
- March 4
  - Pricing of Series 2015 Bonds and sign Bond Purchase Agreement
- March 18
  - Closing and receive proceeds

Questions

Utility Code Changes Phase 2

City of Camas

Finance Department

Utility Billing Changes Update

- Council authorized Phase I Utility Code Changes on October 7, 2014 – Ordinance 2711
- 2 Billing Cycles have followed with improving outcomes – fewer shut-offs
- Changes included:
  - Basic Service Charges
  - No Door Hangers
  - Longer Grace Period
  - Notification to both Landlord and Renter
  - One Leak Adjustment every 5 years

Phase II

- 7 Changes Proposed
  - Budget Billing
  - Low-Income Assistance
  - Abandonment of Service
  - Service Callout Fees
  - Account Set-Up Fees
  - No Payment Extensions
  - Recorded Property Liens

Budget Billing

- Low Income Qualification
- Enrollment for Budget Billing or average annual utilities
- True-Up at the end of the year
- Intended for Fixed Income customers with low income

Low-Income Assistance

- Partner with external social aid agency to provide:
  - Confirmation of Low Income
  - Assist with utility bill
  - Assist in finding future options to meet payment dates
- City funds program through Utility Rates

Abandonment of Service

- Service disconnected longer than 5 years could be considered abandoned
- Billing would cease
- Customers wishing to reconnect would be required to pay the current system development charges

Service Callout Fees

- Service calls for the Water Crew could incur a nominal service fee for:
  - Check a meter read
  - Check for a leak
  - Help locate a meter box
- This fee would be included on the City Fee Schedule

Account Setup Fees

- New customers would pay a nominal fee to start their utility customer
- Intent is to cover the staffing costs
  - Time involved is increasing especially for rental accounts
- Fee to be included on the City's Fee Schedule

No Payment Extensions (Promises)

- Utility customers would no longer be allowed to request an extension for payment to avoid disconnection of services
- No Municipal Code Change

Recorded Property Liens

- Lien property for unpaid utility bills after a certain $ amount
- Discontinue sending accounts to a Collection Agency
- Pass thru all Lien Fees charged by the County
- Provide an online title check connection through a third party – paid by the title companies

Questions

CITY OF CAMAS, WASHINGTON

ORDINANCE NO. 15-003

AN ORDINANCE of the City of Camas, Washington, ratifying and approving various loans with the State of Washington.

WHEREAS, the City of Camas, Washington (the "City") entered into various loans with the State of Washington (the "State") between 1997 and 2012 and the City Council approved each loan by motion; and

WHEREAS, it is in the interest of the City for the City Council to ratify these loans by ordinance;

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF CAMAS, WASHINGTON, DO ORDAIN AS FOLLOWS:

Section 1. Ratifying and Approving the Loans. The City Council hereby ratifies and approves the City entering into the following loans with the State and the execution of the loan agreements for each loan:

Type of Loan	Year	Project	Original Amount	Source of Repayment
Public Works Trust Fund Loan	1997	Parker Street Project	$ 900,000.00	General Obligation
Public Works Trust Fund Loan	1999	Wastewater Treatment Plant Upgrade	3,195,000.00	Sewer Utility
Public Works Trust Fund Loan	2001	1st Street Improvements	613,731.00	General Obligation
Department of Ecology Loan	2001	Wastewater Treatment Plant Upgrade	8,163,523.00	Sewer Utility
Community Economic Revitalization Board Loan	2001	Fisher Basin Waterline	600,000.00	Water Utility
Public Works Trust Fund Loan	2003	1st Street Improvements	2,522,398.08	General Obligation
Public Works Trust Fund Loan	2007	Wastewater Treatment Plant Upgrade	1,000,000.00	Sewer Utility
Public Works Trust Fund Loan	2008	Wastewater Treatment Plant Upgrade	10,000,000.00	Sewer Utility

Type of Loan	Year	Project	Original Amount	Source of Repayment
Drinking Water State Revolving Fund Loan	2009	Camas Well #14 Construction	$ 663,000.00	Water Utility
Department of Ecology	2011	Wastewater Treatment Plant Upgrade	5,168,026.26	Sewer Utility
Drinking Water State Revolving Fund Loan	2012	544 Ft. Pressure Zone Project	7,920,792.00	Water Utility
Public Works Trust Fund Loan	2012	Sanitary Sewer Transmission Main	3,740,000.00	Sewer Utility

Section 2. Effective Date of Ordinance. This ordinance shall take effect and be in force from and after its passage and five days following its publication as required by law.

PASSED by the City Council and APPROVED by the Mayor of the City of Camas, Washington, at an open public meeting thereof, this ____ day of ____________, 2015.

____
Mayor

ATTEST:

____
City Clerk

CERTIFICATION

I, the undersigned, City Clerk of the City of Camas, Washington (the "City"), hereby certify as follows:

1. The attached copy of Ordinance No. ____ (the "Ordinance") is a full, true and correct copy of an ordinance duly passed at a regular meeting of the City Council of the City held at the regular meeting place thereof on __________, 2015, as that ordinance appears on the minute book of the City.

2. The Ordinance will be in full force and effect five days after publication in the City's official newspaper, which publication date is ___________, 2015.

3. A quorum of the members of the City Council was present throughout the meeting and a majority of the members voted in the proper manner for the passage of the Ordinance.

Dated: ____________, 2015.

CITY OF CAMAS, WASHINGTON

____
City Clerk

Lacamas Lake:
Nutrient Loading and In-lake Conditions

Clark County Public Works
Water Resources Section

April 2004

Prepared by
Jeff Schnabel and Bob Hutton

Funded by the
Clark County NPDES Clean Water Program

Table of Contents

Acknowledgements
We appreciate the assistance of Water Resources staff in the completion of this project. Ron Wierenga and Jason Wolf assisted with field data collection. Peer review was provided by Bob Hutton, Kelli Frost, and Rod Swanson.

Bob Hutton constructed report graphics and performed all statistical analyses. Thanks also to Jim Sweet, Aquatic Analysts Inc., for assistance with phytoplankton data interpretation.

Introduction

<u>Background</u>

Lacamas Lake and Round Lake are located in Clark County, Washington, on the northern boundary of the city of Camas. In a county with few lakes, Lacamas and Round Lakes are recognized as an important recreational resource. Fishermen, swimmers, boaters, and hikers utilize the lakes and their shores year-round.

Periodic water quality monitoring by the Southwest Washington Health District (SWHD) from 1974-1980 first raised concerns about water quality in Lacamas Lake and its tributary streams. In 1983, the Clark County Intergovernmental Resource Center (IRC) received a grant from the Washington Department of Ecology (Ecology) to fund a Phase I Diagnostic and Restoration Analysis (SRI, 1985).

Based on this investigation, Lacamas and Round Lake were categorized as "eutrophic". The terms oligotrophic, mesotrophic, and eutrophic are often used to characterize lakes according to a low, medium, or high level of algae production, respectively. Over time, lakes naturally move slowly along this continuum in a direction toward eutrophic conditions (high algal production). In some cases, however, this movement can be dramatically accelerated due to human activities in a lake or watershed.

It should be noted that trophic categories are not meant to convey value judgments. Oligotrophic conditions do not necessarily imply "good" water quality or a "healthy" lake. Conversely, eutrophic conditions do not always mean a lake is impaired or has "bad" water quality. Rather, trophic categories describe the amount of nutrient enrichment and biological productivity in a lake, whereas terms like "healthy" and "impaired" refer to the condition of a lake relative to its desired uses or natural condition (Snohomish County, 2003).

In the case of Lacamas Lake, accelerated eutrophication has dramatically altered the lake from its natural historical condition and resulted in conditions that may impair current desired uses such as fishing, swimming, and aesthetic enjoyment.

Water quality problems associated with Lacamas Lake eutrophication in 1984 included severe dissolved oxygen depletion, poor water clarity, high levels of algae growth, nuisance blue-green algae blooms, and dense beds of aquatic macrophytes. These conditions are typical of a highly eutrophic lake, and were attributed primarily to excessive inputs of the nutrient phosphorus due to human activities in the Lacamas watershed.

Subsequently, the Lacamas Lake Restoration Program (LLRP), supported in part by grants from the Centennial Clean Water Fund and Section 319 Fund, implemented a program of agricultural Best Management Practice (BMP) installation, water quality monitoring, and public education in the watershed between 1987 and 2001. Those efforts were aimed at reducing the amount of phosphorus in Lacamas Lake and are summarized in the Lacamas Lake Restoration Program Final Report (Hutton, 2002), Lacamas Lake Restoration Program: WY2000 and WY 2001 Water Quality Monitoring (Schnabel, 2002), and the Lacamas Lake Watershed Restoration Project Program Review (E&S, 1998). These reports and others relating to Lacamas Lake are available from Clark County Water Resources.

The LLRP was successful in reducing the number of agricultural sources of phosphorus to the lake, establishing a greater scientific understanding of its water quality and dynamics, and raising awareness among the citizens of Clark County. However, despite the fact that annual loading and in-lake concentrations of phosphorus declined, the lake continued to exhibit the signs of eutrophication observed in the early 1980s.

Since the expiration of the Lacamas grant in December 2001, Clark County Water Resources has continued ambient monitoring activities in Lacamas Creek and Lacamas Lake under its Clean Water Program. In the absence of a coordinated lake management and monitoring approach by other local and state jurisdictions, Water Resources continues ambient monitoring of this resource to enhance future lake management decisions and improve the evaluation of potential changes in lake health.

Purpose and Scope

This report updates water quality status and trend information for Lacamas Creek and Lacamas Lake. The report describes annual loading estimates, explores possible trends in key nutrient concentrations, presents recent lake monitoring results, and defines current lake trophic status. Although comparisons are made with historical data, the report does not include a comprehensive discussion of past Lacamas Lake monitoring results.

Report Components

The report describes two separate project components:

1) Lacamas Creek (inlet/outlet): the final summary for a five-year project to estimate total phosphorus and total suspended solids loading to and from Lacamas Lake.

Annual total phosphorus (TP) and total suspended solids (TSS) loads into and out of the lake are calculated, including an estimate of annual TP and TSS retention within the lake. Average annual TP concentrations in Lacamas Creek are compared with EPA criteria. The 1999-2003 Lacamas Creek data set is analyzed for trends in TP and TSS concentration, and current TP/TSS loading rates are compared with earlier estimates.

2) Lacamas Lake: an update of lake condition and trend information based on data collected during water year (WY) 2002 and WY2003, as well as the historical dataset.

Patterns of lake stratification, dissolved oxygen, and temperature are presented for WY2003. Box-plots of summertime epilimnetic TP and total Kjeldahl nitrogen (TKN) concentrations are constructed and the 1991-2003 lake data set is analyzed for trends in epilimnetic water transparency (Secchi disk), TP, and TKN. Median epilimnetic TP concentrations are compared to EPA criteria and nitrogen concentrations are compared to expected ranges for eutrophic water bodies.

WY2003 phytoplankton population density and biovolume are compared to results from 1984 and 1995, and current population composition is discussed. Recent Washington Department of Ecology (Ecology) aquatic plant survey results are also summarized. WY2003 lake trophic status is determined through the calculation of trophic state indices (TSI) for TP, Secchi disk, chlorophyll-*a*, and phytoplankton data. Box-plots of yearly summertime TSI values are presented for the 1984-2003 dataset.

Methods

Methods and QA procedures utilized in this project are described in the Lacamas Lake Watershed Water Quality Monitoring Program QAPP (1998), Lacamas Lake Monitoring Project QAPP (2004, draft), and, where noted, the report titled Lacamas Lake Restoration Program: WY2000 and WY2001 Monitoring (2002). For a complete description of laboratory procedures, see NCA's Quality Assurance Manual (2001).

Sample station locations

Figure 1 shows sample station locations for the Lacamas project. Station LACL11 (lake samples) is located over the deepest part of Lacamas Lake, and corresponds to the location of ambient water quality monitoring in previous Lacamas Lake studies. Station LACL00 (outlet samples) is located in the narrow channel connecting Lacamas and Round Lakes, immediately east of the State Route 500 bridge. Station LAC050 (inlet samples) is located on Lacamas Creek at the Goodwin Road bridge (County bridge #172), approximately ½ mile upstream from Lacamas Lake.

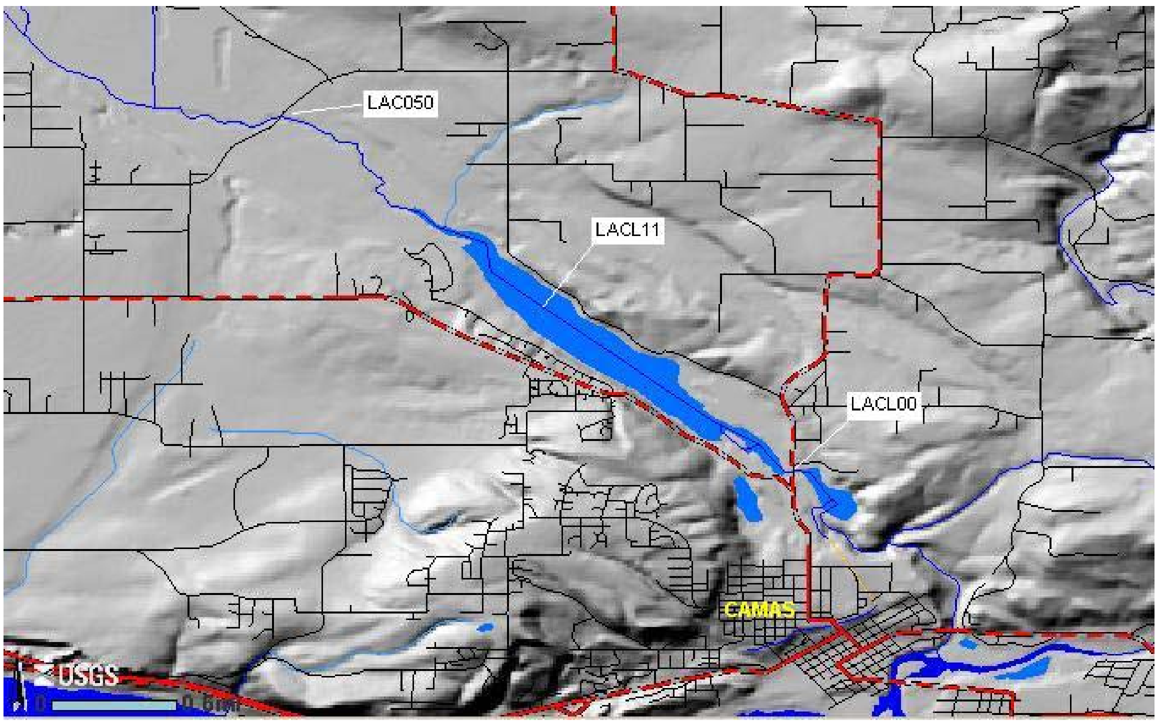


Figure 1. Location of Lacamas Lake Monitoring Program sample stations.

Sampling scheme and Parameters

The project consisted of two separate sampling components. The first component involved monitoring at the inlet and outlet of the lake to evaluate annual TP and TSS loading. The second consisted of monitoring in-lake conditions. Sampling schedules and parameters for each project component are shown in Table 1.

Field procedures

Lacamas Lake

Lake samples were collected at station LACL11. Field measurements for water temperature, dissolved oxygen, ph, and conductivity were collected at 1m intervals using a calibrated Hydrolab Datasonde 4 multi-probe and Surveyor 4 data-logger. Water samples for nutrient and suspended solids analyses were collected from the epilimnion, metalimnion, and hypolimnion using a vertical VanDorn-style sampling bottle.

Appropriate sample bottles were supplied by the analytical laboratory. Water samples were stored on ice in coolers until delivery to the lab. Secchi disk readings were taken on the shady side of the boat, with eye level just above the gunwale.

Chlorophyll *a* and phytoplankton samples were obtained by compositing three grab samples equally spaced through the photic zone. Photic zone depth was estimated as 2.5 times the measured Secchi depth. Grabs were collected using a VanDorn-style sampling bottle and composited in a nalgene carboy, from which sub-samples were drawn.

All field measurements were recorded on data sheets to provide a written backup of electronically stored data. Ancillary data pertaining to weather conditions, equipment function, and staff observations were also recorded on data sheets.

Project Component	Parameter	Schedule	Collection
Lacamas Creek:			
Inlet (LAC050)	stream flow	hourly	pressure transducer
	total phosphorus	weekly + storm events	automated grab
	total suspended solids	weekly + storm events	automated grab
Outlet (LACL00)	total phosphorus	weekly	manual grab
	total suspended solids	weekly	manual grab
Lacamas Lake:			
Lake (LACL11)	Secchi depth	monthly	visual measurement
	temperature	monthly	field meter, vertical profile
	dissolved oxygen	monthly	field meter, vertical profile
	conductivity	monthly	field meter, vertical profile
	pH	monthly	field meter, vertical profile
	total phosphorus	monthly	manual grab, 3 depths
	orthophosphorus	monthly	manual grab, 3 depths
	total suspended solids	monthly	manual grab, 3 depths
	total kjeldahl nitrogen	monthly	manual grab, 3 depths
	ammonia-nitrogen	monthly	manual grab, 3 depths
	nitrate + nitrite nitrogen	monthly	manual grab, 3 depths
	chlorophyll *a*	monthly (May-Oct 2003)	Composite, photic zone
	phytoplankton	monthly (May-Oct 2003)	Composite, photic zone

Table 1. Sampling schedule and collection methods.

Lacamas Creek (Inlet/Outlet)

Inlet samples were collected at station LAC050 using a Sigma 900MAX all-weather refrigerated sampler. In addition to providing automated sample collection, the Sigma equipment recorded hourly stream stage to calculate discharge. Water samples were collected approximately weekly and analyzed for total phosphorus and total suspended solids. In addition to this weekly base-flow sampling, selected storm events were sampled at a higher frequency to capture rapidly changing TP and TSS concentrations. A total of 125 samples were collected during WY2002 and 90 during WY2003.

Outlet samples were collected at station LACL00 using a vertical VanDorn-style sampling bottle or Sigma 900MAX portable sampler. Samples were collected from the SR500 bridge at approximately the midpoint of the channel and near the middle of the water column (approximately 2m below the water surface). Samples were collected approximately weekly and analyzed for total phosphorus and total suspended solids. A total of 53 samples were collected during WY2002 and 38 during WY 2003.

Laboratory procedures

Laboratory analyses for TP, TSS, TKN, ammonia nitrogen, nitrate + nitrite nitrogen, and chlorophyll *a* were conducted by North Creek Analytical, an Ecology-accredited facility in Beaverton, Oregon. Phytoplankton samples were analyzed by Aquatic Analysts in White Salmon, Washington. Table 2 contains analytical methods and reporting limits, in addition to precision, accuracy, and bias targets.

Characteristic	Method	Reference	Reporting Limit	Precision	Accuracy	Bias
		lab	conc/units	%RSD	units/% error	%REC
stream flow		na				
temperature	thermistor	na	0.01 C	10%	±0.15 C	na
dissolved oxygen	membrane electrode	na	0.01 mg/L	10%	±0.2 mg/L	na
conductivity	electrode	na	4 digits	10%	±0.5% of reading	na
pH	glass electrode	na	0.01 units	10%	±0.2 units	na
total phosphorus	colorimetric	EPA 365.1	0.02 mg/L	10%	25%	5%
orthophosphorus	colorimetric	EPA 365.2	0.01 mg/L	10%	25%	5%
total kjeldahl nitrogen	colorimetric	EPA 351.2	0.5 mg/L	10%	25%	5%
ammonia-nitrogen	colorimetric	EPA 350.1	0.05 mg/L	10%	25%	5%
nitrate+nitrite nitrogen	colorimetric	EPA 353.2	0.05 mg/L	10%	25%	5%
chlorophyll *a*	spectrophotometric	SM 10200H	0.2 ug/L	20%	45%	5%
phytoplankton	slide transect	na	na	na	na	na

Table 2. Analytical methods and measurement quality objectives.

QA/QC

Field QA

The Quality Assurance program for field sampling consisted of several components: 1) sample collection according to standard procedures as described in the previous section and in Standard Procedures for Monitoring Activities, Clark County Water Resources Section (June 2002), 2) field staff training, 3) documented instrument calibration, and 4) the collection of field Quality Control (QC) samples.

Four types of field QC samples or measurements were collected.

- Duplicate field samples and duplicate field measurements- these consisted of an additional sample collection or measurement made a few minutes after the initial sample or measurement. These samples are also referred to as "sequential" duplicates and represent the variability due to short-term in-stream or in-lake processes, sample collection and processing, and laboratory analysis.
- Split field samples- these consisted of a single composite sample split into two containers that were processed as individual samples. This eliminated the in-lake variability and isolated the variability to that due to field processing and analysis.
- Transfer blanks- these consisted of the submission and analysis of de-ionized water samples exposed to sampling equipment and procedures in the field.
- Transport blanks- these consisted of the submission and analysis of de-ionized water samples prepared in the office and carried through the field trip.

QC collection targets were modified during late 2002 as part of a Water Resources QA review and update. QC sample schedules below reflect the updated targets used during WY 2003. At the lake station (LACL11), duplicate field samples and duplicate field measurements were collected every other month for all characteristics except chlorophyll-*a*. One split field sample was collected for chlorophyll-*a* analysis. Transfer blanks were collected during lake trips semi-annually and a transport blank was collected annually. QC samples were submitted semi-blind to the laboratory. They were identified as QC samples from a particular station, but sample type (duplicate, transfer blank, or transport blank) was not identified.

Field meters were calibrated and maintained in accordance with manufacturer's instructions. Conductivity check standards and a NIST-certified thermometer were used to verify field meter accuracy. Calibration logs were completed during each calibration and are archived in Water Resources Section files. Calibration drift in pH meters was checked against pH buffer solutions, and dissolved oxygen measurements were verified using a modified Winkler titration.

Duplicate field samples from the inlet/outlet stations (LAC050 and LACL00) were collected every other month beginning in late WY2002. Stage measurements recorded with the Sigma 900MAX at station LAC050 were checked for consistency against staff gage readings and a backup stage recorder at the same location. The accuracy of the stage-discharge relationship used for calculating stream discharge was verified through comparison with instantaneous discharge measurements collected during WY2003.

Laboratory QA

Laboratory check standards, matrix spikes, analytical duplicates, and blanks were analyzed in accordance with the NCA Quality Assurance Manual (2001). QC results were reported to Water Resources along with sample data. Laboratory data reduction, review, assessment, and reporting were performed according to the NCA Quality Assurance Manual.

Data Analysis Procedures

Data analysis included the calculation of annual loading estimates, construction of box-and-whisker plots, trend analysis, trend power and the calculation of trophic state index values. Analyses were performed using Microsoft Excel, Minitab, and WQStat Plus software. Data analysis procedures are included in the Appendix.

Results and Discussion

Quality Assurance
QA/QC results and discussion are included in the Appendix.

Lacamas Creek (inlet/outlet)
TP and TSS loading
Table 3 and Figure 2 summarize available TP loading, TSS loading, and streamflow estimates for Lacamas Creek since 1984.

During WY 2003, TP loading was estimated at 5000 kg (~5.5 tons) and TP export from the lake was ~4400 kg. This amounts to a net annual TP retention of 600 kg (12%) within the lake. Between WY1999 and WY2003, mean annual TP loading was 6000 kg, which compares favorably to the estimate of 14,000 kg in 1984. However, differences in annual stream discharge can greatly affect annual loads. To compensate for these differences, loading was also calculated per unit of stream discharge (kilograms/acre-ft). Since 1999, estimated TP loading has remained consistently between 0.06 and 0.07 kilograms per acre-foot of stream discharge. Again, this compares favorably to the earlier estimate of 0.11 kg/acre-ft in 1984 (Figure 2).

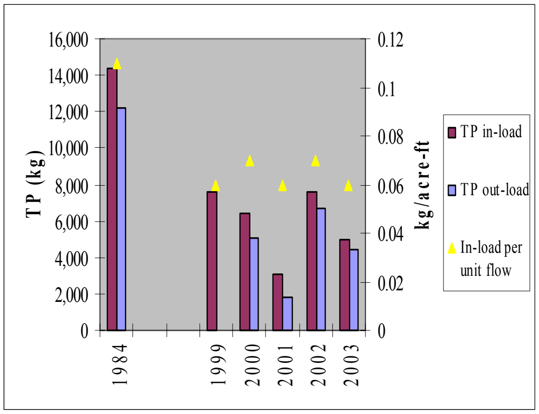
	~WY 1984	WY 1999	WY 2000	WY 2001	WY 2002	WY 2003
Total Stream Discharge (ac-ft/yr):	128,237	127,098	96,265	48,778	102,471	81,151
Mean Discharge (cfs)	178	176	133	67	141	112
TP In-load (kg):	14,387	7,560	6,414	3,061	7,632	5,001
TP load per discharge (kg/ac-ft):	0.11	0.06	0.07	0.06	0.07	0.06
TP Out-load (kg):	12,161	n/a	5,065	1,785	6,650	4,390
% Retained in lake:	15	n/a	21	42	13	12
TSS In-load (kg):	1,820,000	812,094	1,238,691	719,246	615,291	523,891
TSS load per discharge (kg/ac-ft):	14.2	6.4	12.9	14.8	6.0	6.5
TSS Out-load (kg):	n/a	n/a	543,242	464,888	417,687	204,967
% Retained in lake:	n/a	n/a	56	35	32	61

Table 3. Streamflow and loading estimates since 1984.

There has been a net retention of TP in the lake each year that loading estimates have been calculated. The retention rate has ranged from 12% to 42% of the estimated in-load, with the highest annual retention rate corresponding to a water year with exceptionally low annual discharge (WY2001).

TSS loading for WY 2003 was estimated at slightly more than 500,000 kg (~550 tons, or about 55 dump-truck loads). TSS export was estimated at ~200,000 kg, leaving a net annual TSS retention of ~300,000 kg (61%) during WY 2003. The mean annual TSS load between WY1999 and WY2003 was just under 800,000 kg, compared to 1,820,000 kg in 1984. However, TSS loading per unit of stream discharge has ranged from 6 to 15 kg/ac-ft over the past five years, compared to 14 kg/ac-ft in 1984 (Figure 2).

As with TP, there has been a net retention of TSS in the lake during each year monitored. Retention rate estimates have ranged from 32% to 61% of the estimated in-load, indicating consistent deposition of sediment within Lacamas Lake.



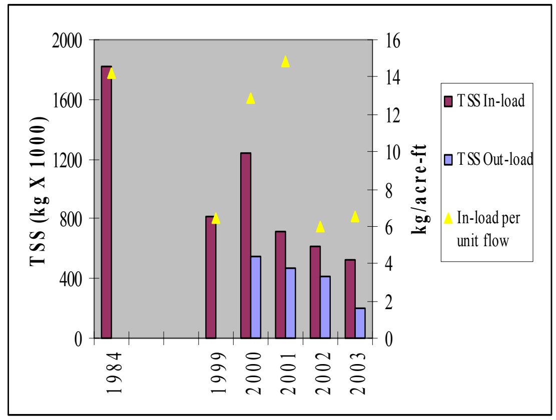


Figure 2. Annual TP and TSS in-load, out-load, and in-load per unit flow.

TP and TSS concentrations

Table 4 shows the time-weighted mean TP and TSS concentrations at the inlet and outlet of Lacamas Lake. Time-weighted means were calculated by taking the mean of the entire hourly dataset, so that individual measurements were weighted according to the length of time they were used to represent stream concentration. The time-weighted mean is an estimate, but should be a more accurate representation of annual stream conditions than the mean of the individual samples because it compensates for the effect of high concentrations in storm samples which only persist for a short time.

	~WY 1984	WY 1999	WY 2000	WY 2001	WY 2002	WY 2003
Mean In-flow TP (mg/L):*	0.089	0.050	0.061	0.046	0.052	0.038
Mean Out-flow TP (mg/L):*	n/a	n/a	0.039	0.034	0.034	0.030
Mean In-flow TSS (mg/L):*	11.5	6.3	12.5	9.6	5.3	4.1
Mean Out-flow TSS (mg/L):*	n/a	n/a	6.2	8.4	3.0	2.0
*Time-weighted						

Table 4. Time-weighted mean TP and TSS concentrations at Lacamas Lake inlet and outlet.

The usual EPA criterion for TP in streams is 0.100 mg/L. However, EPA established a more stringent criterion of 0.050 mg/L for streams that enter lakes. The EPA in-lake criterion for avoiding eutrophication is 0.025 mg/L. Since 1999, the mean inflow TP has remained near the 0.050 mg/L criterion, with the lowest concentration occurring during WY 2003. This represents a considerable decrease when compared to the annual mean of 0.089 mg/L TP in 1984. Mean outflow TP slightly exceeded the in-lake criteria of 0.025 mg/L, but has remained well below stream criteria as it enters Round Lake and, presumably, Lacamas Creek downstream of the lakes.

Figure 3 shows the results of a Seasonal Kendall test for trend on flow-adjusted monthly TP data collected at station LAC050 for WY1999-2003. For months with multiple samples, the sample collected closest to the middle of each month was used in the analysis. See the trend analysis section in the Appendix for a complete explanation of the data set and procedures used for trend analysis.

The trend analysis indicates a slight downward slope in concentration. However, the trend is not statistically significant at the 80%, 90%, or 95% confidence levels.

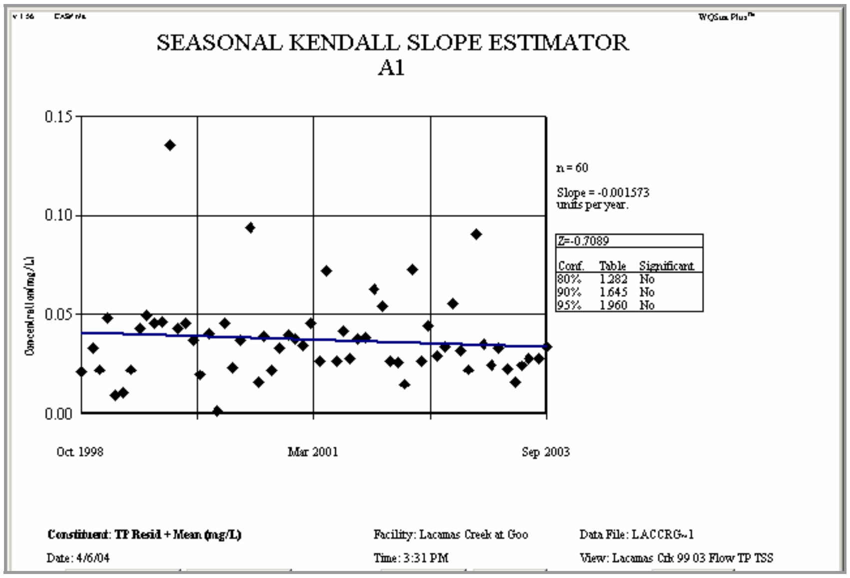


Figure 3. Seasonal Kendall test for trend in flow-adjusted total phosphorus concentrations, Lacamas Creek station LAC050, WY1999-2003.

Time-weighted mean TSS concentrations at station LAC050 from 1999-2003 ranged from 4.1 to 12.5 mg/L. Numeric criteria for TSS in streams have not been established.

Figure 4 shows the results of a Seasonal Kendall test for trend on monthly TSS data collected at station LAC050 for WY1999-2003. Again, for months with multiple samples the sample collected closest to the middle of each month was used in the analysis. TSS values were not flow-adjusted because a large number of censored data points (below laboratory reporting limits) precluded the use of the flow-adjustment procedure. The test indicates a decreasing trend in TSS concentration between 1999 and 2003. The trend is statistically significant at the 95% confidence level. However, a reliable estimate of the *slope* of the trend cannot be calculated due to the large proportion of censored data.

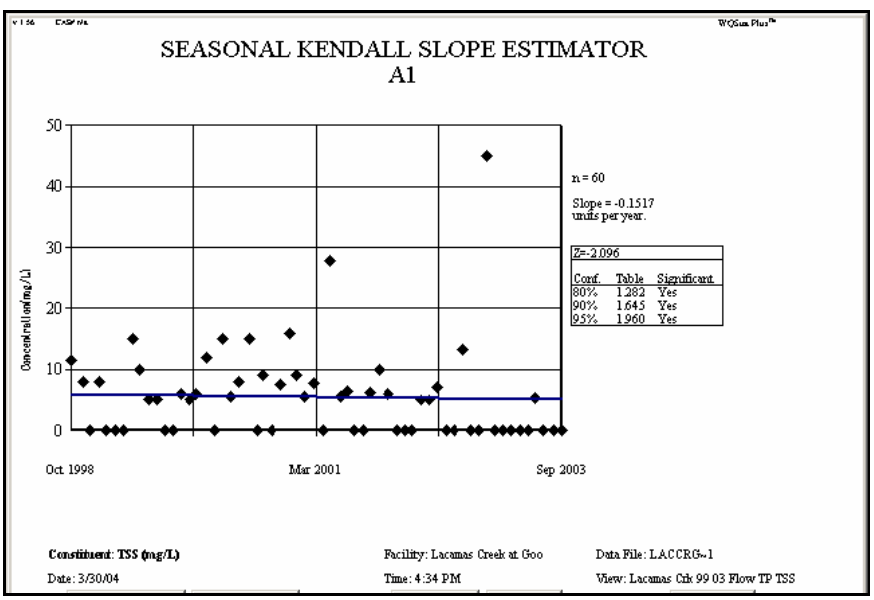


Figure 4. Seasonal Kendall test for trend in total suspended solids concentrations, Lacamas Creek station LAC050, WY1999-2003.

Lacamas Lake

Thermal stratification

In lake ecology, thermal stratification refers to the separation of the water column into distinct, non-mixing layers. Stratification occurs when solar energy warms the surface water, or epilimnion. The deeper water (hypolimnion) tends to remain colder because the sun's rays only penetrate a short distance. In a sense, the warm upper water "floats" on the cold deeper water, separated by a layer of rapidly decreasing temperature called the thermocline.

This temperature gradient is often strong enough to confine water, nutrients, dissolved oxygen, and suspended materials to a discrete layer, playing a key role in the movement of materials within lakes. Stratification generally occurs during summer, with fully-mixed periods occurring during fall through spring when solar warming is less pronounced. During mixed periods, the temperature gradient is weak or non-existent, allowing water and materials to circulate throughout the water column.

Lacamas Lake typically displays strong thermal stratification from approximately May through October. The progression of thermal stratification during WY 2003 (Figure 5) followed a similar pattern to previous years. Note the fully mixed conditions during January through March, followed by increasing stratification through spring and a strong thermocline developing between three and six meters during June through September.

Temperature

Water temperature is a key element controlling biological processes in lakes, and has a direct impact on the health of aquatic organisms. Washington State water quality criteria require that "all lakes and all feeder streams to lakes (reservoirs with a mean detention time greater than fifteen days are to be treated as a lake for use designation) … be protected for the designated uses of salmon and trout spawning, core rearing, and migration; and extraordinary primary contact recreation" (Washington Administrative Code 173-201A-600). The mean detention time calculated for Lacamas Lake (1984) is approximately 22 days. This criterion specifies that lake water temperature should not exceed 16° C (60.8° F).

Lacamas Lake temperature data from WY 2003 is summarized in Figure 5. Epilimnetic water temperatures exceeded the state criterion from June through September during both WY2002 and WY2003, reaching a maximum of approximately 23° C and 25° C during July of each year, respectively. Temperatures in this range are sufficient to promote algal growth throughout the summer, and are considerably above the acceptable temperature range for cold-water fish species such as trout. Water temperatures below 16° C were present throughout the summer at depths greater than 4-6 meters. However, as shown in the next section, these cold-water areas were often uninhabitable by fish due to extremely low dissolved oxygen concentrations.

Dissolved Oxygen

The state criterion for dissolved oxygen in lakes is 9.5 mg/L (WAC 173-201A-200). Figure 5 shows Lacamas Lake dissolved oxygen concentrations during WY2003. Dissolved oxygen concentrations have followed a similar pattern since at least 1984, decreasing dramatically with increasing depth during the summer months.

There is generally insufficient oxygen for most aquatic life uses (<5 mg/L) at depths greater than 4-5 meters from June through October, with essentially no oxygen at all below 6 meters from July through September (see lighter shades in lower section of Figure 5). Only from January through March does the entire water column meet the state criterion.

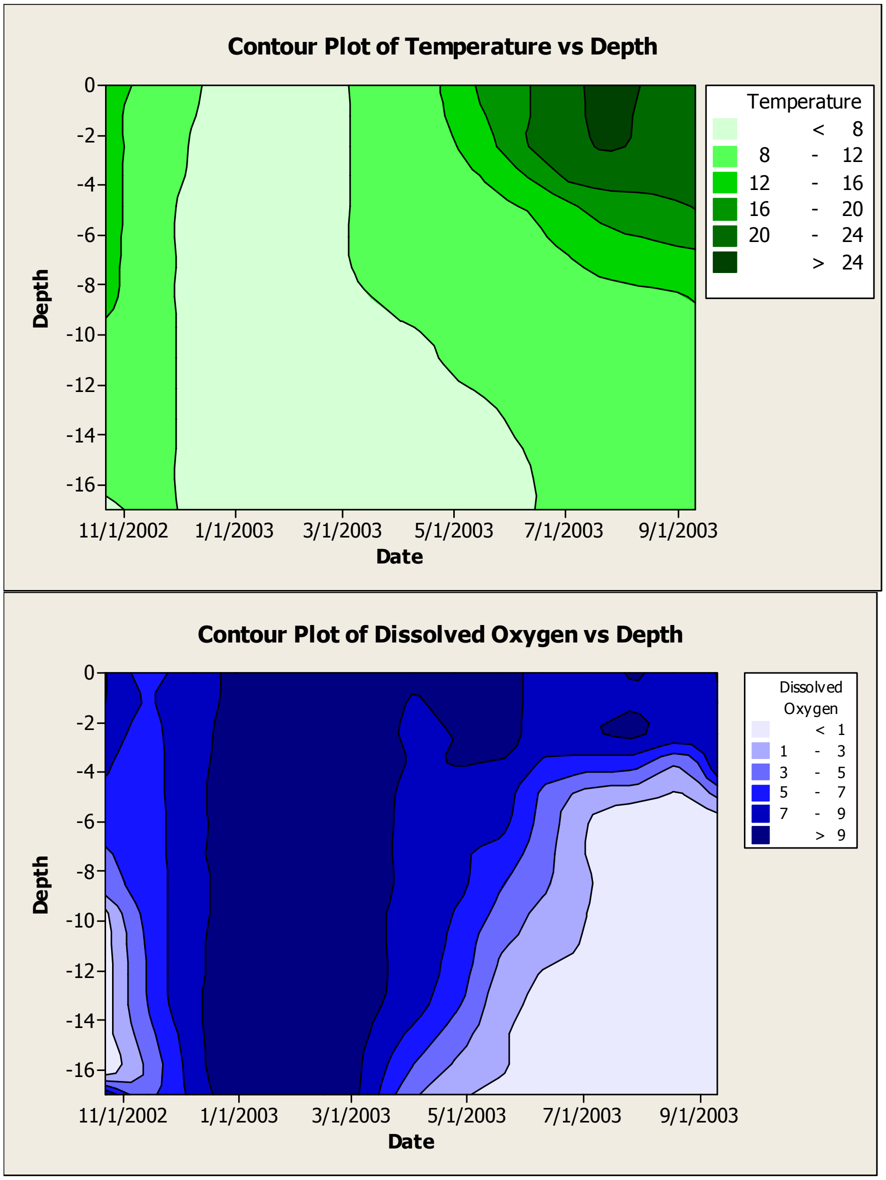


Figure 5. Water temperature and dissolved oxygen contours in Lacamas Lake, WY 2003.

Oxygen in the deeper waters is consumed as microorganisms decompose settled algae and larger plant material. Thermal stratification does not allow fresh oxygen from the atmosphere to reach the deeper layers and the hypolimnion eventually becomes anoxic. The oxygen is only replenished when the thermocline breaks down and vertical mixing of the water column occurs during fall.

During May to October of most years, the combination of hypolimnetic dissolved oxygen depletion and elevated epilimnetic temperatures in Lacamas Lake forces fish and other aquatic life to survive in a very restricted, and sometimes non-existent, band of suitable habitat.

Water transparency

Transparency represents light penetration in a lake. It is measured with a standard Secchi disk, a 20-cm white and black disk that is lowered into the water to the point it is no longer visible. Transparency can be affected by suspended sediment as well as algal growth and other organic material in the water. The Secchi disk is widely used as a general indicator of lake condition. Measurements <2.0 m often coincide with eutrophic conditions.

During WY2003, summer season (May-October) transparency in Lacamas Lake ranged from 1.2 m to 2.8 m, with a median of 1.6 m. Between 1984 and 2003, for years having at least three summer season readings, median Secchi depth has ranged from 1.2 m to 1.9 m. Figure 6 shows the results of a Seasonal Kendall test for trend on the 1991-2003 monthly Secchi disk dataset. Measurements ranged from approximately 0.5 m to 3.0 m during this time period, reflecting seasonal changes in weather, turbidity, and biological growth. The results do not indicate a statistically significant trend in water transparency since 1991.

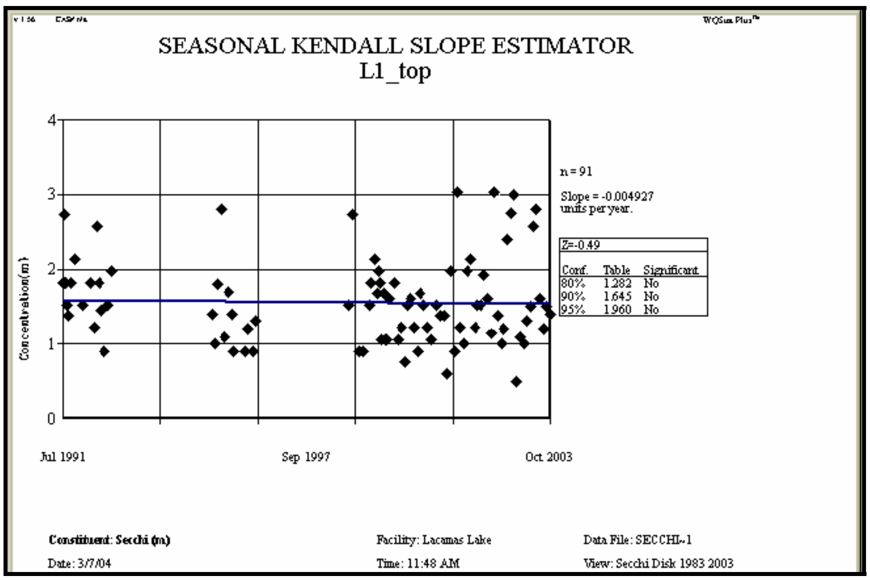


Figure 6. Seasonal Kendall test for trend in water transparency (Secchi disk), Lacamas Lake 1991-2003.

Total Phosphorus

High levels of phosphorus in Lacamas Lake were well-documented in 1984 (Beak and SRI, 1985). Phosphorus is an essential nutrient for the metabolism of all living organisms. Plant and algal growth are normally limited by phosphorus availability. Consequently, a scarcity of phosphorus will limit algal growth, while the addition of more phosphorus may produce excessive algae. Decreased dissolved oxygen concentrations often follow when the dead plant matter is broken down by oxygen-consuming bacteria. Based on the results of 1984 sampling, phosphorus reduction became the central goal of the Lacamas Lake Restoration Program.

The EPA has established TP criteria for lakes at a level of 0.025 mg/L to minimize eutrophication. Additionally, the State of Washington uses nutrient criteria to assess lakes and determine whether action needs to be taken to reduce nutrient loading (Section 173-201A-230 WAC). Washington State TP criteria are assigned by ecoregion but have not been determined for the Willamette Valley Foothills Ecoregion, where Lacamas Lake is located. However, an "action level" from the near-by Coast Range, Puget Lowlands, and Northern Rockies Ecoregions has been set at 20 μg/L (WAC Section 173-201A-230).

Based on total phosphorus samples collected by Water Resources during WY1999-WY2001, Ecology has listed Lacamas Lake as impaired in the draft 2002/2004 303(d) list, requiring that a TMDL (Total Maximum Daily Load) be developed to further reduce phosphorus loading to the lake.

Figure 7 contains annual box plots of epilimnetic (surface) TP concentrations during the summer growing season (May-October). A visual inspection of the plots suggests significant differences in the following cases where confidence intervals (darker internal boxes) do not overlap: 1984 vs. 1994, 1984 vs. 2002, 1984 vs. 2003, and 1994 vs. 1995. Overall, data from the more recent years indicates a significant decrease from the concentrations observed in 1984.

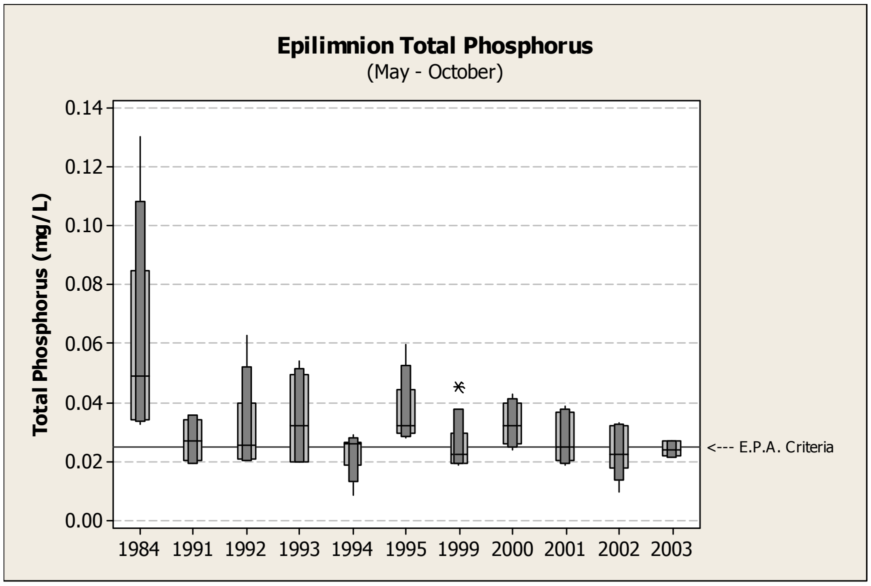


Figure 7. Median and interquartile range of May-October epilimnetic total phosphorus concentrations, Lacamas Lake, 1984-2003.

Despite this improvement, median summertime concentrations (indicated by horizontal line in each box) since 1984 have generally remained above the EPA lake criterion, indicating sufficient TP to facilitate eutrophic conditions. Small variations between years are likely due to fluctuating weather patterns and biological activity.

The Seasonal Kendall test for trend does not indicate a statistically significant trend in epilimnetic TP between 1991 and 2003 (Figure 8).

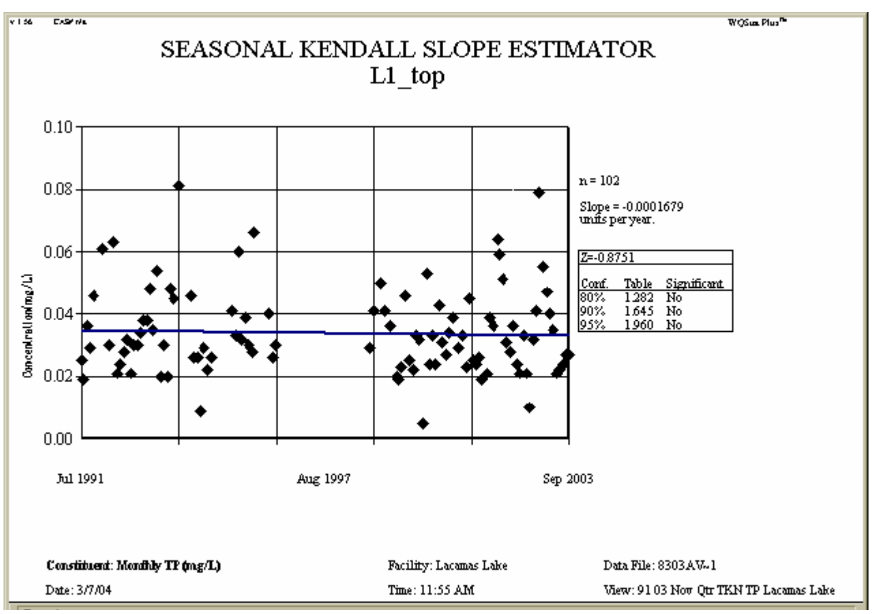


Figure 8. Seasonal Kendall trend test, Lacamas Lake epilimnion total phosphorus, 1991-2003.

Nitrogen
Nitrogen is the second major plant nutrient of interest in lakes. In the presence of sufficient phosphorus, elevated nitrogen levels may also cause excess algal and plant growth. Inorganic nitrogen forms are the most readily available for uptake by algae and plants, while total Kjeldahl nitrogen primarily reflects nitrogen already captured in organic material. Total Kjeldahl Nitrogen is the sum of organic + ammonia nitrogen, while inorganic nitrogen consists of nitrite + nitrate-N and ammonia.

Inorganic-N concentrations are highly variable seasonally. In general, springtime inorganic-N concentrations >0.3 mg/L are sufficient to facilitate summer algal blooms, and average concentrations 0.5 to 1.5 mg/L are often associated with eutrophic conditions (Wetzel, 1983). Springtime inorganic-N concentrations in Lacamas Lake routinely range from 0.5 – 1.2 mg/L, and annual average concentrations in WY2002 and WY2003 were 0.65 mg/L and 0.56 mg/L, respectively.

Wetzel (1983) suggests that average epilimnetic organic nitrogen concentrations of 0.4 to 0.7 mg/L generally correspond to meso-eutrophic conditions while average concentrations >0.7 mg/L correspond to eutrophic conditions. Annual average concentrations in WY2002 and WY2003 were 0.72 mg/L and 0.55 mg/L, respectively, placing Lacamas Lake in the meso-eutrophic to eutrophic categories. Additionally, Figure 9 contains annual box plots of epilimnetic TKN during the growing season (May-October). The plots suggest significant differences in the following cases where confidence intervals do not overlap: 1991 vs. 2000, 1991 vs. 2001, 1991 vs. 2002, and 1993 vs. 2000.

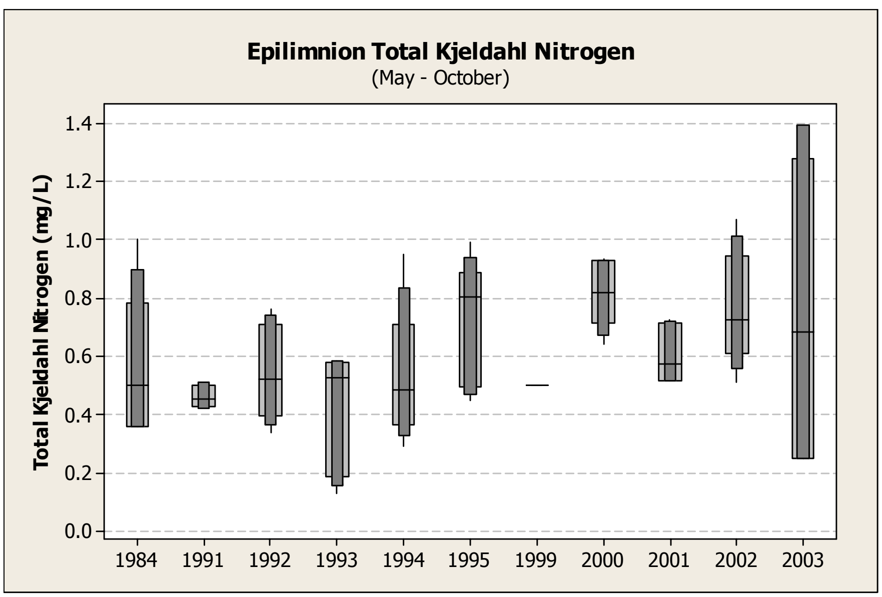


Figure 9. Median and interquartile range of epilimnetic total Kjeldahl nitrogen concentrations, Lacamas Lake, 1984-2003.

Figure 10 shows the results of the seasonal Kendall test for trend in epilimnetic TKN from 1991-2003. The test indicates an increasing trend in TKN concentrations of approximately 0.020 mg/L per year and is significant at the 95% confidence level. The trend suggests an overall increase in the amount of nitrogen being captured in organic material in Lacamas Lake.

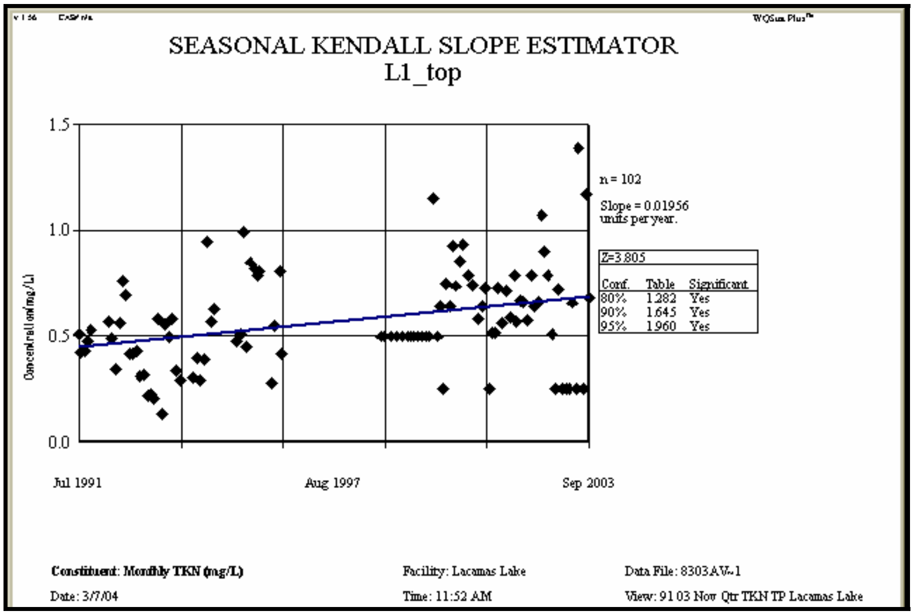


Figure 10. Seasonal Kendall test for trend, Lacamas Lake epilimnetic total Kjeldahl nitrogen, 1991-2003.

TIN:TP ratio

The ratio of Total Inorganic Nitrogen (TIN) to TP provides an indication of lake nutrient dynamics and the likelihood of blue-green algae blooms. TIN includes nitrate-nitrite N and ammonia-N. As noted above, phosphorus is often the limiting factor for algal growth in lakes.

However, in some lakes with plentiful phosphorus, nitrogen may become the limiting factor during certain periods, especially summer and fall. In a nitrogen-limited system, blue-green algae species have a competitive advantage due to their ability to utilize atmospheric nitrogen. Under these circumstances, large blooms of blue-green species may occur.

Monitoring during 1995 by E&S Environmental Chemistry, Inc. suggested that Lacamas Lake may be nitrogen limited during parts of the summer and fall. A TIN:TP ratio >20 suggests phosphorus limitation, while a ratio <15 often indicates limitation by nitrogen. Figure 11 shows the monthly TIN:TP ratios for Lacamas Lake during WY2003, following the same procedure used in 1995. Although P was limiting during much of the winter, spring, and early summer, the lake was N-limited from mid- summer through fall. The switch from P to N limitation during July coincides with the onset of dominance by blue-green algal species.

On a practical level, the N-limitation during summer and fall indicates that the P concentration would need to be further reduced in order for phosphorus to be limiting during this time period. Consistent limitation by phosphorus could be a positive change in the lake, possibly leading to lower overall algal biomass and a decreased competitive advantage for blue-greens.

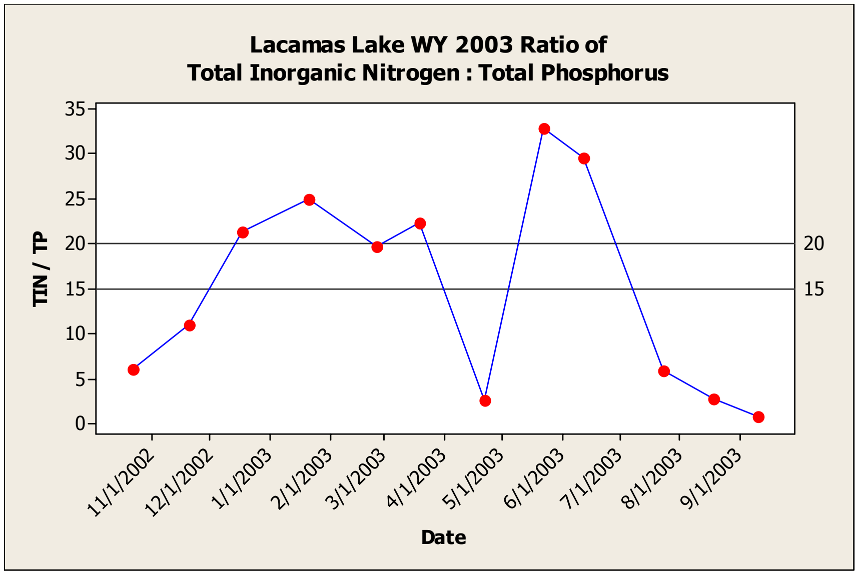


Figure 11. TIN:TP ratio in the eplimnion of Lacamas Lake, WY2003.

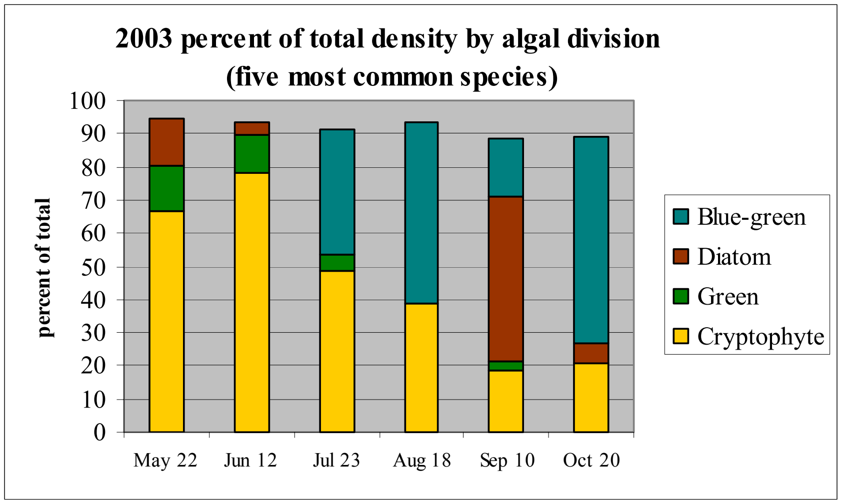
Phytoplankton
Phytoplankton, or algae, are microscopic plant-like organisms that capture solar energy through photosynthesis. They are the source of primary production that forms the base of the aquatic food web. The type and amount of algae affects water chemistry, transparency, food availability, and the composition of the higher food web.

Cell density was enumerated and biovolume calculated for each algal species in each sample. Density is simply the number of algal units/mL of sample, while biovolume is a measure of the total volume of the algal cells. Because algal cells of different species vary widely in size, biovolume provides a convenient way to measure the total amount, or volume, of algal production. Diatom species are often the most desirable food for grazers (zooplankton), though green algae and cryptophytes are also grazed. Blue-green species are considered a poor food source.

Figure 12 shows the percentage of total 2003 density and biovolume by algal division. The figures are based on the five most dominant species in each sample (either by density or biovolume), which in most cases accounted for over 90% of the total.

The small, flagellated cryptophytes *Rhodomonas minuta* and *Cryptomonas erosa* comprised the majority of the algal density from May through July and were present in significant numbers throughout the sampling period. Rhodomonas is among the most common planktonic algae nationwide and is common in all types of lakes, whereas Cryptomonas tends to be more abundant in mesotrophic to eutrophic conditions. Rhodomonas was generally more common than Cryptomonas until late summer. Due to their small size, the cryptophytes comprised only a small percentage of the total biovolume.

During May, June, and September, diatom blooms consisting primarily of *Fragilaria crotonensis* dominated the biovolume. Fragilaria is a large, colonial, planktonic species and usually indicates eutrophic conditions. It rarely occurs in oligotrophic lakes. Although it can thrive in cool water and low-light conditions, Fragilaria is more typical of warmer surface waters.



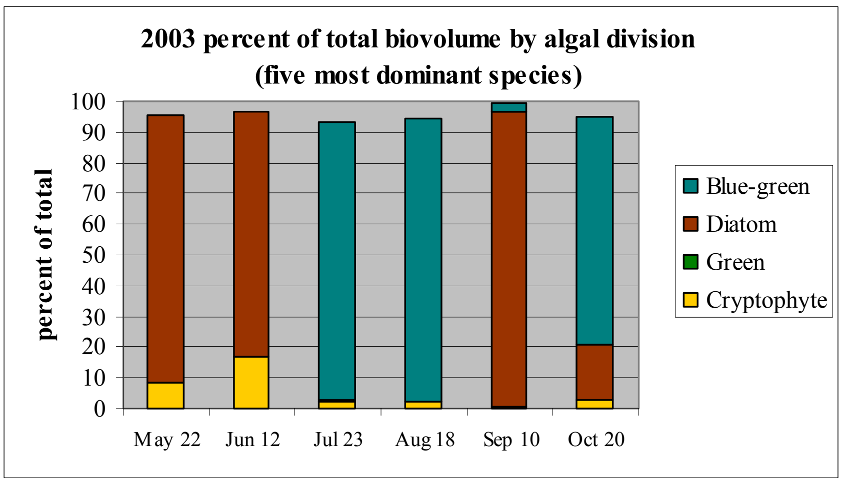


Figure 12. 2003 summer Lacamas Lake algal density and biovolume, by algal division.

During July, August, and October, algal biovolume was dominated by blooms of blue-green algae species. During July and August, both density and biovolume were dominated by *Anabaena planctonica*. In September, *Anabaena planctonica* declined sharply while *Aphanizomenon flos-aquae* increased. By October, *Aphanizomenon flos-aquae* dominated in terms of density while the larger *Anabaena planctonica* had a smaller population but represented most of the biovolume.

Anabaena species tend toward eutrophic lakes and often form blooms that may be unaesthetic, smell badly, and deplete hypolimnetic oxygen after decomposing. *Aphanizomenon flos-aquae* is a very good indicator of eutrophic and hyper-eutrophic lakes. An increase in either of these two species over time is a good indicator of advancing eutrophication (Jim Sweet, personal comm.).

The dominance of blue-green species can be problematic in several ways. Blue-green algae are highly specialized and often have a competitive advantage over more desirable algae species. In addition to being a poor food source for zooplankton, some species produce toxins that may be harmful to aquatic biota, terrestrial animals, or humans in significant amounts.

All Anabaena species are potentially toxin-producing, although *Anabaena flos-aquae* is usually more related to harmful toxin levels than is *Anabaena planctonica*. *Anabaena flos-aquae* was present in very low numbers in Lacamas Lake during 2003. *Microcystis aeruginosa*, a highly toxic species, was also present in low numbers in 2003. *Aphanizomenon flos-aquae* is generally not particularly toxic, but it too has the potential to produce toxins under certain conditions.

Lacamas Lake phytoplankton were sampled in 1984 and 1995 in addition to 2003. This phytoplankton dataset is not sufficient to perform statistical comparisons between sampling periods, and extensive comparative analysis of algal populations is beyond the scope of this report. However, a limited examination of growing season (May-October) algal density and biovolume during these years reveals several notable differences.

Overall, the relative densities of dominant species for May-October of 1984, 1995, and 2003 were:

1984		**1995**		**2003**	
Fragilaria crotonensis	44.0 %	Fragilaria crotonensis	19.6%	Rhodomonas minuta	25.8%
Rhodomonas minuta	9.8	Anabaena planctonica	19.0	Cryptomonas erosa	19.4
Schroederia judayi	7.4	Rhodomonas minuta	17.6	Anabaena planctonica	17.6
Ochromonas sp.	3.2	Cryptomonas erosa	14.1	Fragilaria crotonensis	11.6
Chrysophyte sp.	3.2	Asterionella Formosa	7.6	Aphanizomenon f.-aquae	10.4

Among individual species, several possible shifts are apparent. The dominance of *Fragilaria crotonensis* in 1984 was reduced in 1995, and by 2003 Fragilaria comprised only 12% of the population density. As noted above, Fragilaria remains a dominant species in terms of biovolume due to its large colonial structure. It is also noteworthy that the most common 5 species in 1984 composed 67% of the total phytoplankton population. By 1995, this percentage increased to 78%, and by 2003 the most common 5 species comprised 85% of the total algal density.

The most notable shift may be the advance of *Aphanizomenon flos-aquae.* As noted above, an increase in this species over time is a good indication of advancing eutrophication. In 2003, *Aphanizomenon flos-aquae* comprised 10% of the algal density during the May-October period. During the same period in 1995 it represented 1%, and in 1984 only 0.1%. Also, the highly toxic blue-green alga *Microcystis aeruginosa*, though still not common, increased from 0.1% in 1995 to 0.6% in 2003. This species was not found in 1984.

Although toxic algal blooms have not been a historical problem in Lacamas Lake, the dominance of blue-green species during mid-late summer, and particularly the increasing presence of *Microcystis aeruginosa*, is a potential area of concern for future recreational use.

Mean summer biovolume was similar in May-October of 1984, 1995, and 2003. Figure 13 shows the average monthly biovolume by algal division in the summer of 1984. A somewhat similar pattern of biovolume dominance among algal divisions is apparent when compared with the 2003 results shown in Figure 12, although the dominance by diatoms and blue-green algae evident in 2003 was not as pronounced in 1984. In particular, during 1984 the cryptophytes represented a much greater percentage of early summer biovolume, and green algae were present in measurable amounts throughout much of the summer.

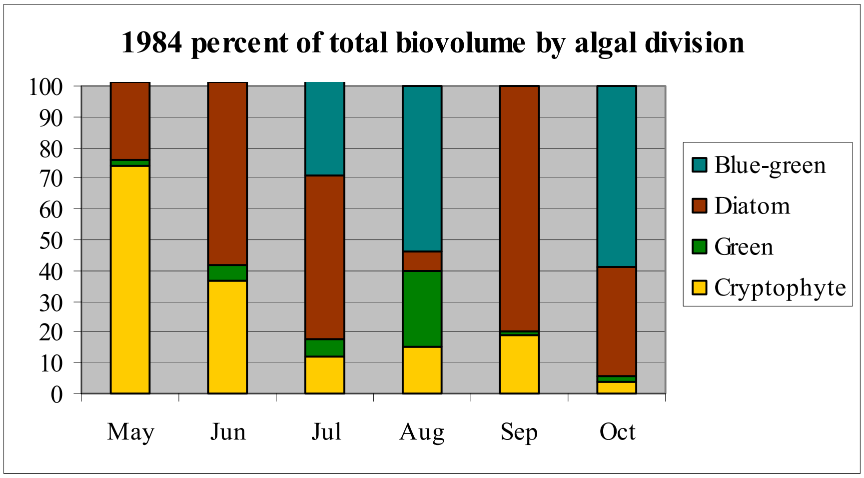


Figure 13. 1984 summer Lacamas Lake algal biovolume, by division.

Aquatic plants
Lacamas Lake is characterized by extensive aquatic plant (macrophyte) growth. Based on surface and scuba surveys, as well as Secchi disk readings and lake bathymetry, scientists in 1984 concluded that at least 97% of the potential colonizable area in Lacamas Lake was already being used by macrophytes.

An aggressive exotic species called *Egeria densa* (Brazilian elodea) was common in Lacamas Lake by 1984, although it was generally found on the outer (deeper) edges of plant beds and was interspersed with several other species. The native *Elodea canadensis* (Common elodea) dominated shallower depths. In Round Lake, *Egeria densa* was already dominant by 1984, to the almost complete exclusion of other submersed macrophytes (Beak and SRI, 1985).

The most recent Ecology aquatic plant survey performed in Lacamas Lake took place in June, 1999. Plant species and distribution data are summarized in Table 5. Of particular interest is the continued expansion of *Egeria densa*. In many areas, *Egeria densa* has displaced more desirable species such as the native *Elodea canadensis* and some pondweed species.

Trophic state index
Monthly TSI values for Lacamas Lake during May-October 2003 are shown in Figure 14. Values are generally in the mid to upper mesotrophic range (45-50) during late May and June, increasing to the eutrophic range (50-70) from July-October.

The seasonal pattern of results is generally consistent between parameters, although some variability is normal. 2003 phytoplankton results consistently indicate a higher trophic status than the other variables, while chlorophyll-*a*, Secchi disk, and total phosphorus results generally agree more closely.

In some cases, variability between parameters may be caused by non-random variability such as errors in sample collection or analysis. The exceptionally low TSI value for chlorophyll-a during August 2003 is probably an example of this type of error. It is likely that the low value (40, or oligo-mesotrophic) is erroneous when compared to the results from the other three parameters (52-63, or eutrophic). See the QA discussion in the Appendix for a description of chlorophyll-*a* analysis issues.

Date 17-Jun-99

Scientific name	Common name	Distribution Value	Comments
Callitriche stagnalis	pond water-starwort	1	only in north end of lake near river
Ceratophyllum demersum	Coontail; hornwort	2	
Egeria densa	Brazilian elodea	4	dominant or co-dominant throughout most of shoreline
Elodea canadensis	common elodea	2	some dense areas in north end
Lemna minor	duckweed	1	only in north end of lake near river
Nitella sp.	stonewort	1	
Nuphar polysepala	spatter-dock, yellow water-lily	2	most in north end
Phalaris arundinacia	reed canarygrass	3	dense in north end
Potamogeton amplifolius	large-leaf pondweed	3	co-dominant with Egeria
Potamogeton epihydrus	ribbonleaf pondweed	1	only in north end of lake near river
Potamogeton illinoensis	Illinois pondweed	2	
Potamogeton robbinsii	fern leaf pondweed	2	
Scirpus sp.	bulrush	1	one patch seen on E shore
Sparganium sp.	bur-reed	1	only in north end of lake near river
Typha sp.	cat-tail	1	

Comments: Overcast, cool. Egeria very dense in many areas, at the surface and blooming. Grows densely to 3 m deep. More diverse in the river north of the lake. Lots of water skiers. Made a map with plant locations.

Distribution Value Definitions:

- 0 the value was not recorded (plant may not be submersed)
- 1 few plants in only 1 or a few locations
- 2 few plants, but with a wide patchy distribution
- 3 plants growing in large patches, co-dominant with other plants
- 4 plants in nearly mono-specific patches, dominant
- 5 thick growth covering the substrate at the exclusion of other species

Table 5. 1999 Lacamas Lake aquatic plant summary (Washington State Dept of Ecology).

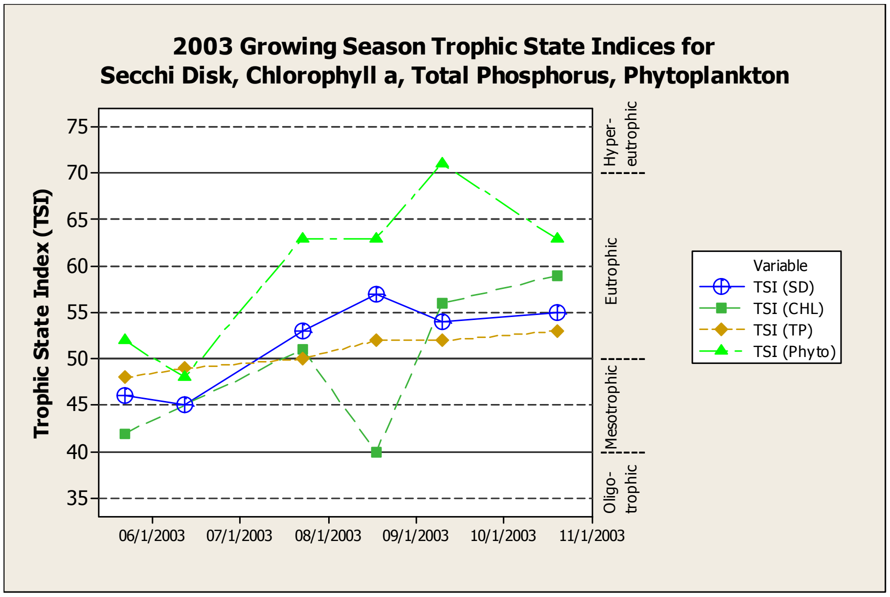


Figure 14. Monthly TSI values for Lacamas Lake, May-October 2003.

Annual box plots of May-October TSI values, based on the historical Lacamas Lake dataset (1984-2003), are shown in Figures 15, 16, 17, and 18. Note that phytoplankton and chlorophyll-*a* data are somewhat limited for the period of record.

Despite some variation in median TSI values for each parameter, most of the annual confidence intervals overlap indicating that statistically significant differences in medians between years are unlikely.

Median TSI values for Secchi depth and total phosphorus tend to be in the low to mid-eutrophic range (50-60), occasionally dropping into the upper mesotrophic category (45-50) for TP. No significant differences are indicated for Secchi depth TSI. However, a significant difference is indicated between the total phosphorus median values in 1984 versus 1994, 2002, and 2003. In 1984, median total phosphorus TSI was in the mid-eutrophic range (60), with values ranging upwards into the hyper-eutrophic range (>70). Since that time, medians have not exceeded 55 and individual values have generally remained below 60.

Most of the available chlorophyll-*a* and phytoplankton data consistently indicate eutrophic status, with median values tending to fall in the mid to upper-eutrophic range. The exception is the median of the 2003 chlorophyll-a data. However, as discussed in the QA section in the Appendix, the low chlorophyll-*a* TSI values for 2003 may be due to problems with the laboratory analysis. Despite the questionable low values, the median value for 2003 still falls in the lower eutrophic range.

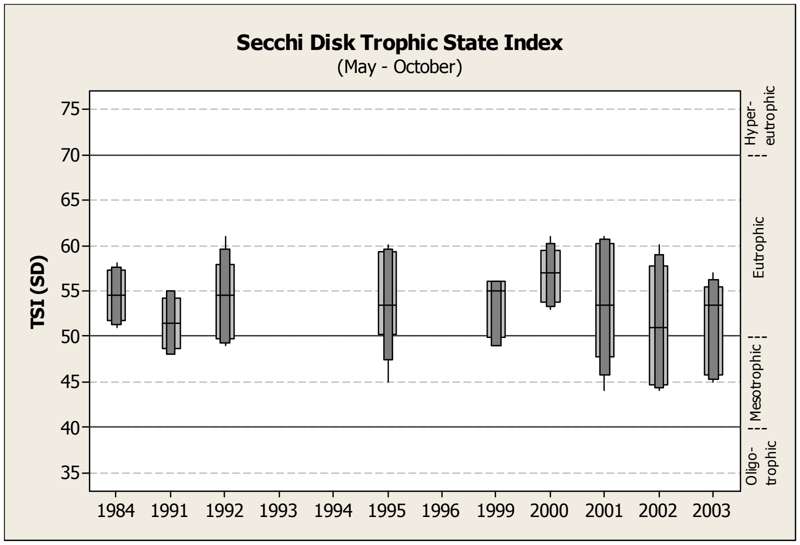


Figure 15. Median and interquartile range for May-October Secchi depth TSI, `
Lacamas Lake 1984-2003.

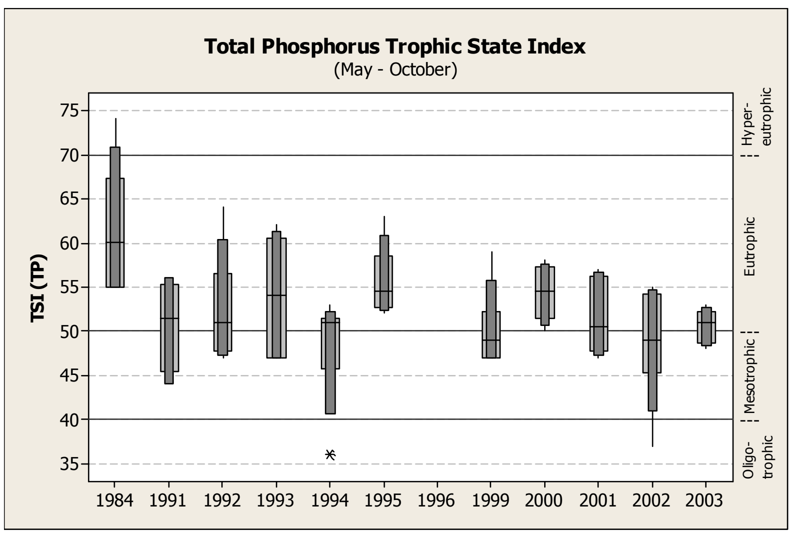


Figure 16. Median and interquartile range of May-October total phosphorus TSI, Lacamas Lake 1984-2003.

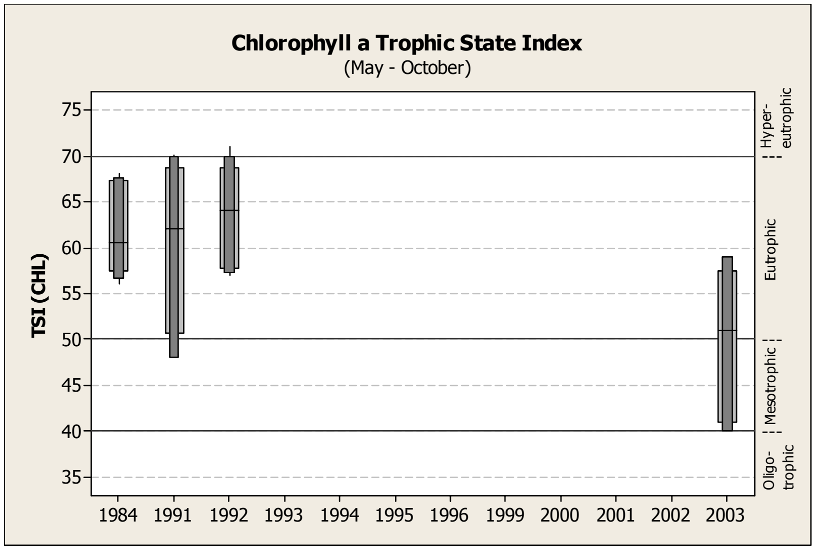


Figure 17. Median and interquartile range of May-October chlorophyll-*a* TSI, Lacamas Lake 1984-2003.

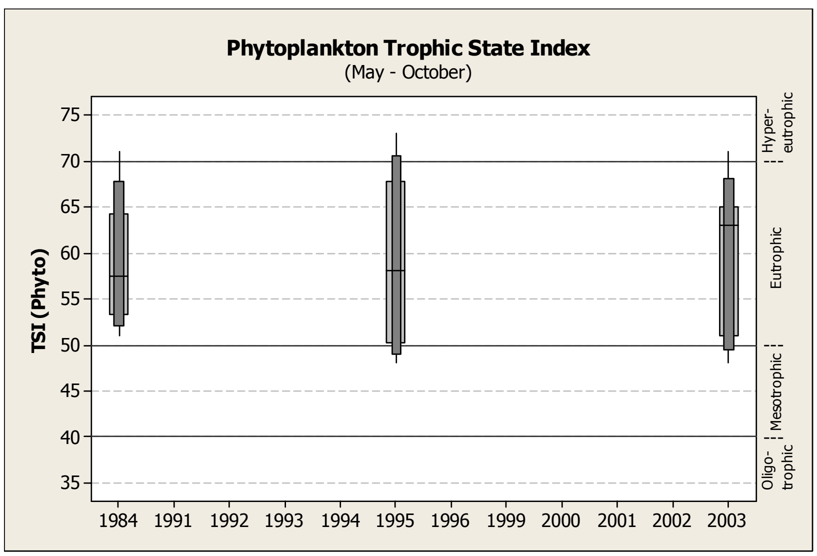


Figure 18. Median and interquartile range of May-October phytoplankton TSI, Lacamas Lake 1984-2003

<u>Trend Power</u>

The trend power analysis and results are described in more detail in the Appendix. The power of a trend test is the probability that the test will actually detect a trend when one is present. Therefore, an evaluation of the trend power provides insights into the limitations of conclusions reached using statistical tests. A failure to *detect* a trend is often used to improperly conclude that there *was no trend*, when in reality there may have simply been insufficient data or too much variance in the data to allow trend detection at the specified level of confidence (Hallock, 2003).

Predicted minimum detectable trends (as a percentage change in the mean) for the Lacamas Creek data were 37% and 93% for TP and TSS data, respectively. In effect, this means we would only expect to be able to detect trends in excess of these magnitudes. For example, the calculated change in the mean for Lacamas Creek TP over the 5-year monitoring period was 21%, and no significant trend was detected. A trend was detected in TSS data, even though the calculated change in mean was only 13%. This significant trend was probably influenced by the presence of a large number of censored data points in the TSS data set. Although a significant TSS trend does exist, it was not possible to reliably assign a magnitude to that trend.

Predicted minimum detectable trends (as a percentage change in the mean) for the Lacamas Lake data were 20%, 29%, and 20% for TKN, TP, and Secchi disk data, respectively. Therefore, we would only expect to be able to detect trends in excess of these magnitudes. The calculated changes in the means were 34% for TKN, 5% for TP, and 3% for Secchi disk. TKN was the only parameter having a calculated trend larger than the predicted minimum detectable trend, and was also the only parameter where a significant trend was detected.

Summary

The information summarized below is addressed in greater detail in the Results and Discussion section. For additional information from historical monitoring in Lacamas Creek and Lacamas Lake, see the documents listed in the Background section of this report.

Creek

Loading:

In 2003, annual loading was estimated at 5000 kg of total phosphorus (TP) and 500,000 kg of total suspended solids (TSS). Since 1999, annual TP loading has averaged 6000 kg and TSS has averaged 800,000 kg. During this time, the in-lake retention rate for TP ranged from 12-42% of the annual load. TSS retention in the lake ranged from 32-61%. This indicates a considerable annual accumulation of nutrients and settled material in Lacamas Lake.

Current loading rates compare favorably with annual estimates from 1984, when TP load was estimated at 14,000 kg and TSS load was estimated at 1,800,000 kg. On the basis of kilograms/acre-ft of annual discharge, TP loading since 1999 has remained consistently between 0.06 and 0.07 kg/acre-ft, compared to 0.11 kg/acre-ft in 1984. TSS has not followed a similar pattern: loading since 1999 has ranged from 6-15 kg/acre-ft, compared to 14 kg/acre-ft in 1984.

Total phosphorus concentration:

The EPA criterion for TP in streams that enter lakes is a maximum of 0.050 mg/L. For the five-year period beginning in 1999, the annual mean TP concentration in Lacamas Creek has ranged from 0.038 to 0.061 mg/L, meeting the EPA criterion in 3 years and narrowly exceeding the criterion (0.052 mg/L) in another year. These values compare favorably to an annual mean of 0.089 mg/L estimated in 1984. Despite the apparent reduction compared to 1984 estimates, no trend is apparent in recent Lacamas Creek TP concentration (1999-2003). Outflow TP concentration ranged from 0.030 to 0.039 mg/L during 1999-2003. If concentrations remain fairly constant as the water travels through Round Lake, then water discharged to Lacamas Creek downstream of the lakes is well within the EPA criterion of 0.1 mg/L for streams not flowing into lakes.

Total suspended solids concentration:

For the five-year period beginning in 1999, the annual mean TSS concentration in Lacamas Creek has ranged from 4.1 to 12.5 mg/L. An annual mean of 11.5 mg/L was calculated in 1984. Since 1999, trend analysis indicates a decrease in TSS concentration in Lacamas Creek at the 95% confidence level. However, due to limitations in the dataset, it is not possible to reliably calculate the slope, or magnitude, of the apparent trend. Overall, baseflow TSS concentrations in Lacamas Creek tended to remain quite low, with somewhat higher concentrations occurring during storm events.

Lake

Secchi transparency:
Secchi measurements <2.0 m are often associated with eutrophic conditions. Median secchi depth during 1984 and 1991-2003 ranged from 1.2-1.9 m. No trend is apparent in the 1991-2003 dataset.

Temperature:
The Washington State temperature criterion for lakes is <16 degrees C. In 2002 and 2003, Lacamas Lake failed to meet the criterion from June-September. Annual maximums were 22 C and 25 C, respectively. The dataset since 1984 indicates that summer cold-water habitat beneficial uses are consistently impaired.

Dissolved Oxygen(DO):
The Washington State dissolved oxygen criterion for lakes is >9.5 mg/L. In 2002 and 2003, Lacamas Lake had severe DO depletion below 4m depth from June-October. Severe summertime DO depletion below 4-5 meters depth has been a consistent issue since 1984. Habitat for aquatic biota is severely limited during summer due to a combination of elevated water temperatures in the epilimnion and dissolved oxygen depletion in the hypolimnion.

Total Phosphorus(TP):
The EPA criteria for TP in lakes is <0.025 mg/L. The State of Washington has set an "action level" of TP in nearby ecoregions at <0.020 mg/L. In 2002 and 2003, median TP concentrations met the EPA lake criterion, but still exceeded the state action level for nearby ecoregions. Summer TP concentrations are significantly lower today than in 1984, but since 1991 have continued to exceed state action levels and EPA criteria on a regular basis. No statistically significant trend in TP is apparent in the 1991 to 2003 dataset. Based on data collected by Water Resources between 1999 and 2001, Ecology has listed Lacamas Lake as impaired in the draft 2002/2004 303(d) list, requiring that a TMDL (Total Maximum Daily Load) be developed under the Clean Water Act to further reduce phosphorus loading to the lake.

Nitrogen
Inorganic nitrogen, consisting of nitrite + nitrate-N and ammonia-N, occurs in the forms most readily available for uptake by algae and plants. Springtime inorganic-N concentrations in Lacamas Lake typically range from 0.5 – 1.2 mg/L, and annual average concentrations in 2002 and 2003 were 0.65 mg/L and 0.56 mg/L. Springtime concentrations >0.3 mg/L and annual average concentrations 0.5 to 1.5 mg/L are often associated with eutrophic conditions and summer algal blooms.

Total Kjeldahl nitrogen (organic N + ammonia) is composed primarily of nitrogen that has been incorporated into biomass. In general, recent annual average TKN concentrations correspond to concentrations typically found in meso-eutrophic to eutrophic lakes. An increasing trend in TKN of ~0.020 mg/L per year is apparent in the 1991-2003 dataset. This trend is significant at the 95% confidence level (i.e. there is a 95% chance that the perceived trend actually exists). The trend suggests an overall increase in the amount of nitrogen being captured in organic material in Lacamas Lake.

TIN:TP ratio
The ratio of total inorganic nitrogen to total phosphorus gives an indication of which primary nutrient (N or P) is the limiting factor for algal growth in lakes. A ratio >20 suggests P limitation and <15 suggests N limitation. In 2003, similar to 1995 and 1984, Lacamas Lake was nitrogen limited during mid-summer through fall, probably contributing to the dominance of blue-green algae which, unlike other algae species, are able to obtain nitrogen directly from the atmosphere.

Phytoplankton (algae):
In summer 2003, the phytoplankton community biovolume was dominated by species commonly associated with eutrophic conditions. The average biovolume and a general pattern of dominance by the diatom *Fragilaria crotonensis* and blue-green algal species were consistent with results from 1984 and 1995. However, a significant increase in the blue-green algae *Aphanizomenon flos-aquae* since 1984 is a likely indication of advancing eutrophication.

Macrophytes (aquatic plants):
Results of a WA Dept of Ecology survey in 1999 indicate increasing dominance of the macrophyte community by *Egeria densa*, an aggressive exotic species. Since 1984, *Egeria densa* has largely displaced more desirable native species in the shallow-water areas.

Trophic state:
A Trophic State Index (TSI) is used to describe the level of algae production of a lake. The index uses a numbered scale to compare variables with one another, or with a reference number. Thus indices provide a "common currency" with which to describe lake conditions. A TSI value <40 = oligotrophic, 40-50 = mesotrophic, 50-70 = eutrophic, and >70 = hypereutrophic.

Median monthly TSI values (May-October 2003) for secchi transparency (53), total phosphorus (51), chlorophyll-*a* (51), and phytoplankton (63) all indicate that Lacamas Lake is eutrophic. Total phosphorus is the only TSI indicator that suggests a possible decrease in trophic status since 1984. There has been no significant change in the median value for other TSI indicators, though individual TSI values for Secchi disk and TP periodically dip into the upper-mesotrophic range.

Conclusions

All of the measurements and indicators utilized in this report suggest that Lacamas Lake remains eutrophic. A few indicators suggest that eutrophication may in fact be increasing.

Total phosphorus concentrations in the creek and lake are much lower today than when first measured in the 1970s and 1980s. Despite this improvement, Trophic State Index values for secchi disk, total phosphorus, chlorophyll-a, and phytoplankton have remained relatively constant since 1984, with annual median values falling consistently within the eutrophic range. The available data do not suggest an impending shift to a lower trophic state.

An increasing trend in total Kjeldahl nitrogen since 1991 may be an indication of continuing or accelerating eutrophication despite past reductions in phosphorus. Additionally, continued high levels of algal production and an apparent increase in the blue-green species *Aphanizomenon flos-aquae* suggest that the level of eutrophication is stable at best and possibly increasing.

The water quality issues first noted in the 1970s and 1980s continue to threaten the beneficial uses of Lacamas Lake. In particular, the combination of severe hypolimnetic dissolved oxygen depletion and high surface water temperatures during the summer, high algal productivity dominated by blue-green species during mid-late summer, and the continued expansion of the exotic macrophyte *Elodea densa* pose significant challenges to the primary beneficial uses of fishing, swimming, and boating.

In assessing the long-term information available for Lacamas Lake, it appears that early efforts in the watershed successfully decreased phosphorus inputs. Although these reductions were not sufficient to bring about an improvement in overall lake conditions, they appear to have slowed or even temporarily halted the rapid advance of eutrophication. The long-term dataset suggests that lake conditions, though still eutrophic, have remained relatively stable since the early 1990s. However, some current data raises concerns that Lacamas Lake may be sliding toward further eutrophication and increased water quality problems.

Given the already significant extent of eutrophication, further nutrient enrichment and the associated water quality degradation it causes has the potential to seriously impact future beneficial uses of Lacamas Lake.

Current monitoring results and trend analyses support the premise put forth by E&S Environmental Chemistry, Inc (1998) and Clark County Water Resources (Schnabel 2002), that future Lacamas Lake management efforts should focus not on returning the lake to a pristine state but rather on protecting and enhancing current beneficial uses and minimizing further degradation.

The Lacamas watershed has been and will continue to be impacted by human activities. Despite past progress in controlling phosphorus pollution, historical and ongoing land use changes have permanently altered the lake and watershed in ways that render a return to pristine, pre-settlement conditions infeasible. In all likelihood, Lacamas Lake and its watershed will require diligent, ongoing management simply to maintain current beneficial uses such as fishing, boating, and aesthetic enjoyment, especially given increasing impacts from a growing population.

A renewed commitment by the public and local agencies, along with prudent lake and watershed management choices, is needed if Lacamas Lake and its watershed are to remain valuable community assets for future generations.

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Appendix

Data Analysis Procedures

Loading estimates

Annual loading estimates for TP and TSS in WY2002 and WY2003 were calculated according to the method described in Lacamas Lake Restoration Program: WY2000 and WY2001 Monitoring (Schnabel, 2002). Individual TP and TSS grab sample concentrations were combined with the hourly discharge dataset. Each grab sample result was assumed to represent the constituent concentration in the stream until the time of the next sample collection. Using hourly discharge totals and the concurrent TP or TSS concentration, individual loads (in kg) were calculated for each 1-hr period and summed to provide an estimate of annual load.

Discharge data was not available at the outlet of Lacamas Lake (station LACL00). As a result, out-load calculations were based on the discharge dataset from the lake inlet (station LAC050). However, dam operations, fluctuating lake storage, and the effect of Dwyer Creek inflow below station LAC050 all result in differences in the instantaneous discharge at the two stations. Over the course of a year the effect of these fluctuations is assumed to be negligible, but outload estimates should be interpreted with caution as the true instantaneous discharge is unknown.

Box-and-whisker plots

Box-and-whisker plots, or box-plots, allow convenient comparison of central tendency and distribution characteristics such as medians, ranges or dispersion, symmetry, and extreme values. The horizontal line within each box depicts the median value of the data set. The upper and lower edges of the outer (light gray) box depict the 75th and 25th percentiles while the distance between them is the interquartile range (IQR) or the middle 50% of values. The inner (dark gray) box that extends within and often beyond the ends of the IQR represents the 95% confidence interval around the median (e.g. there is a 95% probability that the true median lies somewhere within this range). Vertical lines or whiskers extending from the ends of the inner box include all values that are less than 1.5 times the IQR. Finally, asterisks appear for extreme values or outliers that are more than 1.5 times the IQR from the box.

Differences between medians are statistically significant at the 95% confidence level only if the inner (dark gray) boxes do not overlap. If the data are symmetrically distributed the median will lie near the center of the box-plot and the whiskers will be of similar length. High variability in the data is reflected by a large IQR. The statistical software package MINITAB (MINITAB, 2003 [Release 14]) was used to construct the box-plots.

Annual box-plots of growing season data (May-October) were constructed to highlight both inter-annual changes and potential patterns in nutrients and trophic state index values.

Trends

Both Lacamas Lake and Lacamas Creek water quality were evaluated for trends over time. Initially, exploratory data analysis was conducted using descriptive statistics, time series plots, and scatterplots to examine distributions, patterns in the data, and relationships between water quality parameters. The effects of seasonality and flow for Lacamas Creek data were addressed with the overall goal of reducing background variability and improving trend detection.

Lacamas Lake secchi disk depth, total phosphorus, and total Kjeldahl nitrogen values and Lacamas Creek total phosphorus and total suspended solids were analyzed for monotonic trends using the nonparametric Seasonal Kendall test. Statistical considerations (Helsel and Hirsch, 1993) supported the use of monotonic trend analysis (for trends are generally expected to indicate gradual and continuous changes over time). Step-trend analysis was not supported due to the relative continuity of the data and the absence of any definable event that may have dramatically changed overall water quality.

The analysis was limited to the periods of July 1991 through September 2003 for the lake data and October 1998 through September 2003 for the creek data due to the limited amount of earlier data and substantial gaps in the historical dataset.

Data transformation was not required because the nonparametric Seasonal Kendall test (used for both lake and creek trend analyses) has less restrictive distribution assumptions than comparable parametric approaches, the variability of the tested parameters was relatively constant over time, and the ratio of the smallest to largest data values was less than twenty (Gilbert, 1987).

Prior to trend analysis, censored data (values below reporting limits) were substituted with other values. Data sets containing less than 5% censored data and a single reporting limit had their censored data recoded as one-half of the reporting limit (Schertz, et al., 1991). For data sets with more than 5% censored data and multiple reporting limits, values reported as less than the most common reporting limit were entered as zero, while three censored values greater than the most common reporting limit were discarded.

Additional statistical techniques were needed to analyze Lacamas Creek data (station LAC050) for trends in TP and TSS concentrations. Natural, random fluctuations in an associated variable (X) such as flow often increase the variability of constituent concentrations due to the effects of dilution and surface wash-off or overland flow (Helsel and Hirsch, 1993). Statistical models such as regression or smoothing can help explain or account for the effects of flow, increasing the ability or power of the trend test to discern changes over time. As with the lake data, seasonal variation must also be compensated for in order to better discern trends.

Prior to testing for trends, applicable Lacamas Creek data were flow-adjusted by utilizing the smoothing technique LOWESS (Locally Weighted Scatter-plot Smoothing) to describe the relationship between Y (concentration) and X (flow). An f (fraction) value of 0.5 and two iterations for smoothing were utilized. This approach does not assume linearity or normality of residuals. Residuals, which express the differences between the fitted model $Y^{\wedge}$ and the actual Y values (concentrations), describe the variation in concentrations over and above that due to changes in X (flow). The assumption was made that there was no substantial trend or drift in flow over the monitoring period.

Both the Lacamas Lake and Creek data sets were reduced in order to maintain representativeness and minimize bias. In the few cases where multiple Lacamas Lake values existed for any particular month, the values were averaged to obtain a single monthly value. Because Lacamas Creek was often sampled more frequently during data gathering primarily for loading estimates, its data set was reduced by selecting the data point closest to the middle of each month over the five year monitoring period (Schertz, et al., 1991).

After the data were reduced, the Seasonal Kendall trend test was applied. The statistical test was applied directly to the monthly Lacamas Lake values. However, prior to performing the trend test, the applicable flow-adjusted Lacamas Creek values [residuals of the LOWESS model of Y (concentration) versus X (flow)] were transformed by adding the mean of the reduced data set to each flow adjusted value. Statistical significance is reported for tests at the 80, 90, and 95% confidence levels while the yearly rate of change in median values is expressed as a slope (WQSTAT PLUS, 1998).

Data sets were analyzed and results graphed utilizing the spreadsheet software EXCEL (Microsoft EXCEL 2002, 2002), statistical software (MINITAB release 14 for Windows, 2003), and the water quality statistical software WQSTAT PLUS (WQSTAT PLUS, 1998).

Trend power

The power of a trend test is the probability that the test will actually detect a trend where one is present. Therefore, an evaluation of the trend power provides insights into the limitations of conclusions reached using statistical tests. A failure to *detect* a trend is often used to improperly conclude that there *was no trend*, when in reality there may have simply been insufficient data or too much variance in the data to allow trend detection at the specified level of confidence (Hallock, 2003). An understanding of the smallest practical difference (versus actual statistical difference) in the means over time is also needed (Kleinbaum, et al., 1988).

Estimates of minimum detectable trends for each parameter over the monitoring period were derived from chosen levels of acceptable errors and other calculations. First, acceptable probabilities for alpha (Type I error) and Beta (Type II error) were set at 10%. Estimates were then made of the central tendencies of the original data (mean and median). The standard deviation was calculated after de-seasonalizing (subtracting seasonal means from individual data points then adding back the overall mean) and de-trending the data (Sen's Slope estimator in WQStat Plus). A minimum *relative* detectable trend (delta value) was looked up (Hallock and Ehinger, 2003) for a given number of monthly values (sample size).

The *predicted* minimum detectable trend was then calculated from the above information and expressed as a percent of the change in the mean over the monitoring period. A correction factor (Hallock, 2003) was incorporated to address the non-normality typically found in water quality data. Finally, statistically calculated changes in the mean over the monitoring period were compared to the predicted minimum detectable trend to evaluate the reliability of the statistical test. If the absolute value of the calculated statistical trend is smaller than the predicted minimum detectable trends, the results of statistical tests may be suspect.

Trend power calculations for Lacamas Creek and Lacamas Lake are shown in the following table:

Methodology for Water Resources Trend Power Calculations

Adapted from Washington Department of Ecology's:

River and Stream Ambient Monitoring Report for Water Year 2002, Publication No. 03-03-032, June 2003,
Stream Ambient Water Quality Monitoring Quality Assurance Monitoring Plan (Draft), January 2003.

Assumptions:

Type 1 Error (alpha or significance level) = 0.1 (i.e., 10% probability of incorrectly deciding trend exists when in fact one does not.)
Type 2 Error (beta) = 0.1 (i.e., 10% probability of incorrectly deciding trend does not exists when one in fact does exist.)
Minimum Relative Detectable Trend (delta) for monthly data:

For n = 60 months or 5 years, delta = 1.33 | For n = 120 months or 10 years, delta = 0.93
For n = 180 months or 15 years, delta = 0.76 | For n = 240 months or 20 years, delta = 0.66

Usually preferable to use flow adjusted values for applicable data sets (if for example, less than 5% of the original data is censored).

Formulas:

Minimum change in the mean over some time period for normally distributed data:
Minimum change in the mean = total standard deviation of deseasonalized & detrended data * minimum relative detectable trend

Correction Factor (used by Washington State Department of Ecology):
CF=(1+(mean-median)/mean)**-6

Predicted Minimum Detectable Trends (MDT) for nonnormally distributed data (combination of above two formulas):
Predicted MDT expressed as a percent of change in the mean over some time period at given Type I and II Error rates.
PredMDT=(100/mean)*(Std Dev of Deseasonalized Detrended Data*Minimum Relative Detectable Trend)*(1+(mean-median)/mean)**-6

Lacamas Watershed Trend Power Calculations (Typical of Nonnormally Distributed Data):

Using **Lacamas Creek** at Goodwin Road monthly data for WY 1999 - 2003 (assuming Type 1 and 2 errors of 10%):

Parameter	Mean	Median	Standard Deviation of Deseasonalized & Detrended Data	Minimum Relative Detectable Trend (delta for 60 months)	Predicted Minimum Detectable Trend (% of change in mean over monitoring period)
Flow (cfs)	139.8	76.7	99.15	1.33	10.1
Flow Adjusted TP (mg/L)	0.038	0.034	0.019	1.33	36.5
Non-Flow-Adjusted TSS (mg/L)	5.542	5	6.78	1.33	93.0

Compared to Seasonal Kendall test and Slope Estimator for Trend calculated in WQSTAT PLUS for above parameters:

Parameter	Significant Trend (alpha=0.1)	Number Of Months (n)	Annual Trend Slope (units per year)	5 Year Change (units per 5 years)	Calculated Change in Mean Over 5 Years*
Flow (cfs)	Yes	60	-7.875	-39.375	-28.2%
Flow Adjusted TP (mg/L)	No	60	-0.0016	-0.008	-21.1%
Non-Flow-Adjusted TSS (mg/L)	Yes *	60	-0.1517	-0.7585	-13.7%

* Note:
Calculated trend for non-flow-adjusted TSS was statistically significant but was less than the predicted minimum detectable trend.
The magnitude of this trend is not reliable possibly due to highly censored and variable data and / or too short a monitoring period.

Using **Lacamas Lake** monthly data for WY 1991 - 2003 (assuming Type 1 and 2 errors of 10%):

Parameter	Mean	Median	Standard Deviation of Deseasonalized & Detrended Data	Minimum Relative Detectable Trend (delta for 120 months)	Predicted Minimum Detectable Trend (% of change in mean over monitoring period)
TKN (mg/L)	0.5694	0.5240	0.1947	0.93	20.1
TP (mg/L)	0.0367	0.0310	0.02729	0.93	29.0
Secchi (m)	1.5509	1.4440	0.5012	0.93	20.1

Compared to Seasonal Kendall test and Slope Estimator for Trend calculated in WQSTAT PLUS for above parameters:

Parameter	Significant Trend (alpha=0.1)	Number Of Months (n)	Annual Trend Slope (units per year)	Approximate 10 Year Change (units per 10 years)	Approximate Calculated Change in Mean Over 10 Years
TKN (mg/L)	Yes	102	0.0196	0.1956	34.4%
TP (mg/L)	No	102	-0.0002	-0.0017	-4.6%
Secchi (m)	No	91	-0.0049	-0.0493	-3.2%

Trophic state index
A Trophic State Index (TSI) is used to describe the level of production of a lake, or the amount of algal matter produced by photosynthesis in a lake (Carlson, 1981, Wetzel, 1983). The amount of algal matter has proven to be a reliable measure of the problems that typically plague lakes. An index generally uses a numbered scale to compare variables with one another, or with a reference number. Thus indices provide a "common currency" with which to describe lake conditions.

The terms oligotrophic, mesotrophic, and eutrophic are used to characterize lakes by a low, medium, and high amount of algae production, respectively. The TSI interprets measured indicators of algal biomass, and expresses the result on a numbered scale that is easy to understand, approximately from zero to one hundred. A single measurement of TSI does not imply whether a lake's health is deteriorating, nor does it imply where a lake *should be* in terms of the current health.

The following equations, taken from Carlson and Simpson, 1996, were used to calculate the TSI from chlorophyll-a , Secchi depth, and total phosphorus data. The equation calculating TSI from algal biovolume was provided by the consultant performing the algal counts (Jim Sweet, personal communication, December 2003):

- TSI(SD) = 60 - 14.41 ln(SD), where SD is Secchi depth in meters;
- TSI(CHL) = 9.81 ln(CHL) + 30.6, where CHL is chlorophyll-a in µg/L;
- TSI(TP) = 14.42 ln(TP) + 4.15, where TP is total phosphorus in µg/L;
- TSI (BV) = (Log-base 2 (B+1))*5, where B is the phytoplankton biovolume in cubic micrometers per milliliter, divided by 1000.

<u>Quality Assurance/Quality Control Results</u>
During WY2002 and WY2003, all of the scheduled lake nutrient samples, vertical lake profiles, and composite samples were collected. Inlet/outlet samples were collected at nearly the intended rates, with sampling intervals sometimes exceeding one week. A total of 215 inlet and 91 outlet samples were collected during the monitoring period, but fewer outlet samples were collected in WY2003 (38) than were anticipated (52).

Quality Control sample collection for WY2002 and WY2003 is shown in Table X. Note that QC collection targets were modified during late 2002 as part of a Water Resources QA review and update. WY2002 QC collection met targets for that time period, except for duplicate field samples at the inlet/outlet stations. During WY2003, duplicate field sample collection at the inlet/outlet stations again fell slightly short of targets, but all other QC sample collection met or exceeded targets.

Precision results for duplicate samples, duplicate measurements, and split samples are reported as pooled percent relative standard deviation (%RSD) in Table X. Target precision for each characteristic was 10% RSD, except for chlorophyll-*a* which had a target of 20% RSD.

Percent RSD calculations for chlorophyll-*a* included data from Battleground Lake and Vancouver Lake because only one duplicate pair was collected in Lacamas Lake. All other percent RSD values include only LLMP project duplicates.

Field QC sample type	WY2002 Collected	WY2003 Collected	WY2003 Target	Comment
Transfer blank	1	3	4	expanded in WY2003
Transport blank	0	1	1	added in WY2003
Duplicate field sample (lake)	12	7	6	reduced in WY2003
Duplicate field sample (inlet/outlet)	2	4	6	expanded in WY2003
Duplicate field measurement (lake)	2	6	6	expanded in WY2003
Field split sample (chlorophyll-*a*)	0	1	1	not applicable in WY2002

Table X. Field QC sample collection completeness.

Characteristic	Pooled %RSD	Characteristic	Pooled %RSD
Total Phosphorus (lake)	± 18%	Total Suspended Solids (lake)	± 8%
Total Phosphorus (inlet/outlet)	± 10%	Total Suspended Solids (inlet/outlet)	± 17%
Ortho-phosphorus	± 6%	Temperature	± 0.8%
Total Kjeldahl Nitrogen	± 21%	Dissolved Oxygen	± 12%
Nitrate/Nitrite-Nitrogen	± 8%	pH	± 5%
Ammonia-Nitrogen	± 13%	Conductivity	± 0.7%
Chlorophyll-a	± 38%		

Table X. Precision as pooled % relative standard deviation.

Six constituent categories failed to meet target criteria. However, in-lake or in-stream variability is included in the duplicate field samples and duplicate field measurements, so their variability is not solely a measure of sampling error plus analytical error. Allowing for expected natural variability, %RSD results were acceptable for all characteristics except chlorophyll-*a*.

The split field samples collected for chlorophyll-*a* measure variability from sampling error plus analytical error, and do not include in-lake variability. The 38% RSD for chlorophyll-*a* was nearly twice the target level and is addressed in the issues section below.

The expected results of the analyses of blank samples were "below reporting limit" for all measured characteristics. With one exception, all results for blank samples met expectations. The total phosphorus transport blank was reported at 0.241 mg/L and is discussed below.

Review of stage measurement comparisons and the stage-discharge relationship versus manual measurements indicated good agreement.

Laboratory staff assessed the laboratory QA program through review of laboratory quality control results including check standards, matrix spikes, and laboratory blanks. Results were within acceptable ranges as defined in NCA's quality assurance manual or were coded as necessary on laboratory reports.

Quality Assurance Issues

1) 117 of 432 lake nutrient results (27%) were below laboratory reporting limits, primarily ammonia (35 results), total suspended solids (27 results), and ortho-phosphorus (24 results).

Large numbers of results reported as non-detects can complicate data analysis and may limit the usefulness of a monitored characteristic. Ortho-phosphorus non-detects will not be addressed because results are expected to fall below reporting limits during summer. Ammonia concentrations are also expected to remain relatively low, but in response to the high rate of non-detects the laboratory reporting procedure has been modified. Ammonia results below the reporting limit but above the method detection limit (MDL) will be reported and flagged as an estimated value (J) rather than ND. Total suspended solids analysis will be replaced by turbidity measurements in future Lacamas Lake sampling. Turbidity data provide a useful measure of water clarity and will reflect the presence of suspended colloidal material (very fine sediment) more effectively than TSS.

2) Chlorophyll-a results from WY2003 did not meet measurement quality objectives for precision. Comparison with pheophytin concentrations and other results indicate that samples may have been unintentionally degraded during storage, preparation, or analysis. One clearly suspect chl-a value from 6/12/03 has been excluded from the dataset. The remaining five values from WY2003 are utilized in this report, but the reader should note the poor data precision and the probability that reported chl-a values are lower than the true value. Based on WY2003 results, Water Resources may utilize a different laboratory for future chlorophyll-*a* analyses.

3) The high transport blank TP result suggests that sample contamination occurred during field processing or during laboratory analysis. A specific cause was not apparent. Possible sources of this error could include contamination during bottle prep (e.g. phosphorus soap), sample switching at the laboratory, contamination during the analytical procedures, or data entry error at the laboratory. The abnormal result was brought to the attention of the contracted laboratory.

Monitoring Report
Lacamas Lake Annual Data Summary for 2007

Background

Since the original settlement of Clark County, land use changes have dramatically altered Lacamas Lake and resulted in conditions that reduce the lake's suitability for fishing, swimming, and aesthetic enjoyment. High nutrient inputs (primarily phosphorus but also nitrogen) from the watershed have been identified as a major contributing factor.

Ongoing problems include summertime dissolved oxygen depletion, poor water clarity, high levels of algae growth, nuisance blue-green algae blooms, and dense beds of aquatic plants.

Grant-funded activities implemented by Clark County and other agencies between 1987 and 2001 reduced agricultural phosphorus sources and increased public awareness of lake issues. Water quality monitoring indicated that phosphorus concentrations in the lake and its major tributary, Lacamas Creek, were substantially reduced during this period. Despite these improvements, however, water quality problems persist in Lacamas Lake.

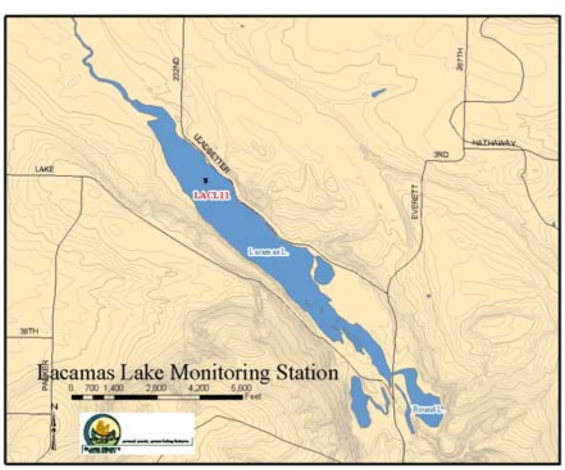
Since the conclusion of grant-funded work in 2001, Clark County's Clean Water Program has continued routine monitoring of this resource to provide information for future lake management decisions.

This report summarizes monitoring activities and data collected from May through October 2007. Historical lake data and nutrient loading were most recently summarized following data collection in 2003. The April 2004 report Lacamas Lake Nutrient Loading and In-Lake Conditions may be viewed at http://www.clark.wa.gov/water-resources/documents.html. Summaries of grant-funded activities from 1987 through 1998 are also available.

Lake Description

Location

Lacamas Lake and Round Lake are located in Clark County, Washington, on the northern boundary of the city of Camas. Though named separately, Round Lake is part of Lacamas Lake connected by a small channel flowing under SE Everett Road. In a county with few lakes, Lacamas Lake is recognized as an important community resource. Fishermen, swimmers, boaters, and hikers utilize the lake and its shores year-round.



Size and morphology

Lacamas Lake is 2.4 miles long and has a maximum width of one quarter mile.

The lake is relatively deep, about 60 feet at its deepest, and covers approximately 330 acres. Water level is controlled by a dam originally constructed in the late 1800s to provide industrial water supply and a means to float logs to the mill in Camas.

Watershed
The Lacamas Creek watershed includes 67 square miles of forest, farm, residential, commercial, and industrial land. The Lacamas watershed extends from Hockinson in the north to Camas in the south. Its western border is approximately 162nd Avenue, and the eastern border is formed by Elkhorn and Livingston mountains (Clark County, 2004).

Lacamas Creek has five major tributaries: Matney Creek, Shanghai Creek, Fifth Plain Creek, China Ditch, and Dwyer Creek. There are also many smaller streams. Lacamas Creek flows about 12.5 miles, from relatively undisturbed forest headwaters through rural, agricultural, and residential areas, into Lacamas and Round Lakes. Below the lakes, Lacamas Creek drops through a series of waterfalls, and finally into the Washougal River (Clark County, 2004).

Monitoring activity summary

Methods
The details of the Lacamas Lake monitoring project are described in the project's quality assurance project plan (QAPP). Staff and volunteer monitors use standardized procedures for performing environmental measurements (Clark County, June 2002).

Monitoring is conducted on a monthly basis from May through October each year. Samples are collected at a single location over the deepest portion of the lake. This station has been utilized for monitoring since the early 1980s and provides a consistent location for long-term data collection.

Field measurements include vertical profiles for water temperature, dissolved oxygen, pH, and conductivity, as well as a single measurement of turbidity and Secchi depth. Water samples collected from the epilimnion (near the surface) and hypolimnion (near the bottom) are analyzed for total phosphorus, total Kjeldahl nitrogen, and nitrate + nitrite nitrogen. Chlorophyll *a* samples are obtained by compositing three grab samples equally spaced through the photic zone. The photic zone is the depth to which light penetrates, and is estimated as 2 times the measured Secchi depth.

The 2007 sampling was performed with the assistance of volunteers, as the project continues a transition to a volunteer project administered under Clark County's Clean Water Program.

Data management and analysis
Field observations and measurements are recorded with electronic field meters and backed up with hard copy forms. Field and analytical data are reviewed to ensure the data are complete and meet the quality control objectives for the project. Data are stored in hard-copy form in three-ring binders until the completion of each sampling season, after which they are entered into the county's water quality database.

The level of data analysis and reporting varies according to a five-year schedule. Brief data summaries such as this one are produced following each sampling year. A technical report is completed following year five sampling, focusing on long-term trends in lake condition. The next technical report is scheduled for completion following 2008 monitoring.

Data analysis focuses on the assessment of lake conditions, specifically on the level of algal growth and related parameters. Basic summary statistics showing central tendency and variability of the data are calculated on seasonal datasets and summarized in tables. Data are also displayed using simple graphical techniques, such as time series and possibly box-and-whisker plots.

A Trophic State Index (TSI) is used to describe the level of productivity of a lake, or the amount of algal matter produced by photosynthesis. Indices are used to integrate complex datasets, provide a common reference point to describe lake conditions, and help track changes over time. A single measurement of TSI does not indicate whether a lake's health is deteriorating, nor does it imply where a lake *should be* in terms of the current health.

Lake conditions

Based on a series of investigations dating back to the early 1980s, Lacamas and Round Lakes are categorized as "eutrophic" (see Table 1 at the conclusion of this report for summary water quality values). The terms oligotrophic, mesotrophic, and eutrophic are often used to characterize lakes according to a low, medium, or high level of algal production, respectively. Over time, lakes naturally move slowly along this continuum in the direction toward eutrophic conditions (high algal production). In some cases, however, this movement can be dramatically accelerated due to human activities in a lake or watershed.

Trophic categories are not meant to convey value judgments. Oligotrophic conditions do not necessarily imply "good" water quality or a "healthy" lake. Conversely, eutrophic conditions do not always mean a lake is impaired or has "bad" water quality. Rather, trophic categories describe the amount of nutrient enrichment and biological productivity in a lake, whereas terms like "healthy" and "impaired" refer to the condition of a lake relative to its desired uses or natural condition (Snohomish County, 2003).

In the case of Lacamas Lake, accelerated eutrophication has dramatically altered the lake from its natural historical condition and resulted in conditions that may impair current desired uses such as fishing, swimming, and aesthetic enjoyment. Water quality monitoring during 2007 supports previous conclusions regarding the eutrophic condition of the lake.

Water clarity

Lacamas Lake has low water clarity. In general, an average summertime Secchi disk depth of less than 2.0 meters is indicative of eutrophic conditions. From May through October 2007, Secchi depth averaged 1.8 m and ranged from 0.9 to 3.0 m. Turbidity values were generally low, averaging 5.6 NTU and ranging from 1.5 to 10.4 NTU.


Secchi Disk

Water clarity in Lacamas Lake is impacted primarily by algal cells during the summer months. The lake often takes on a green tint when algal populations are high, and these algal blooms limit light penetration.

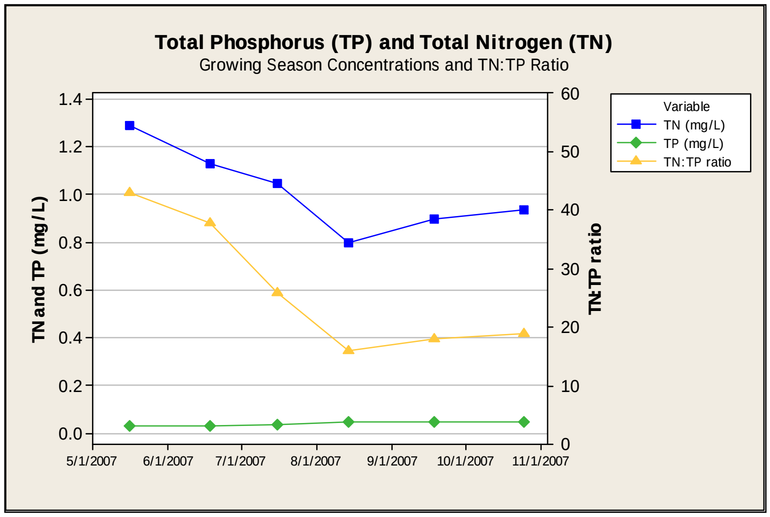
Nutrients

The total phosphorus criterion for preventing nuisance algal blooms and controlling eutrophication is 25 *ug*/L (EPA, 1986). Lacamas Lake had moderate surface phosphorus levels somewhat above this criterion throughout the summer, averaging 42 *ug*/L and ranging from 30 to 50 *ug*/L.

Total nitrogen concentrations were fairly high, averaging 1.02 *mg*/L and ranging from 0.80 to 1.29 *mg*/L.

Nutrient availability to algae is an important aspect of nutrient dynamics in lakes. The ratio of TN to TP is often used to interpret the availability of nutrients relative to one another. Low ratios indicate an abundance of phosphorus and a relatively low amount of nitrogen. Higher ratios indicate a scarcity of phosphorus relative to nitrogen. In these cases we say that the nutrient in shorter supply is "limiting" algal growth. In some cases, the ratio may indicate the potential for either phosphorus or nitrogen to be limiting.

Similar to recent years, TN:TP ratios in the lake were very high during 2007, ranging from 16 to 43. This suggests that phosphorus was the limiting factor for algal growth throughout the summer. This situation may have a positive impact on algal blooms because in a nitrogen-limited system nuisance blue-green algal species can have a competitive advantage.



(Above) Total Nitrogen and Total Phosphorus concentration and ratio, summer 2007

Temperature/Oxygen

Vertical profiles of temperature and oxygen indicate that Lacamas Lake typically stratifies, or separates into layers by temperature. Stratification occurs when solar energy warms the surface water, while the deeper water tends to remain colder because the sun's rays only penetrate a short distance.

The resulting temperature gradient is often strong enough to confine water, nutrients, dissolved oxygen, and suspended materials to a discrete layer, playing a key role in the movement of materials within lakes.

Summer surface water temperatures are typically quite warm in Lacamas Lake. In 2007, surface temperatures almost reached 25 degrees Celsius, about 77 degrees Fahrenheit. Temperatures in this range are sufficient to promote algal growth throughout the summer, and often favor certain species of algae, such as blue-green algae, that may increase to nuisance levels. These temperatures are also above the acceptable range for cold-water fish species such as trout (generally <18 degrees Celsius). Suitable water temperatures were present throughout the summer at depths greater than approximately 5 meters. However, these cold-water areas were often uninhabitable by fish due to extremely low dissolved oxygen concentrations.

Oxygen depletion results from the decomposition of biological material that settles to the lake bottom. Thermal stratification does not allow fresh oxygen from the atmosphere to reach the deeper layer and the oxygen is eventually depleted. The oxygen is only replenished when the stratification breaks down and vertical mixing of the water column occurs during fall.

In Lacamas Lake there is generally insufficient oxygen for most aquatic life uses (<5 mg/L) at depths greater than 4-5 meters from July through September, with essentially no oxygen at all below 6 meters from July through September. This historical pattern was again observed in 2007.

The combination of dissolved oxygen depletion in deeper cool water and elevated surface temperatures in shallower water forces fish and other aquatic life to survive in a very restricted, and sometimes non-existent, band of suitable habitat.

pH

Typically, aquatic life criteria require that pH levels remain close to neutral (6.5) to slightly basic, not to exceed a value of 8.5-9.0 units (EPA, 1986). Lacamas Lake has relatively high pH levels and 2007 data indicated values were highest (~9.0 units) during July and August, most likely due to intense algal growth at these times. By-products of the photosynthetic reactions in algal cells cause a net increase in pH.

Algae

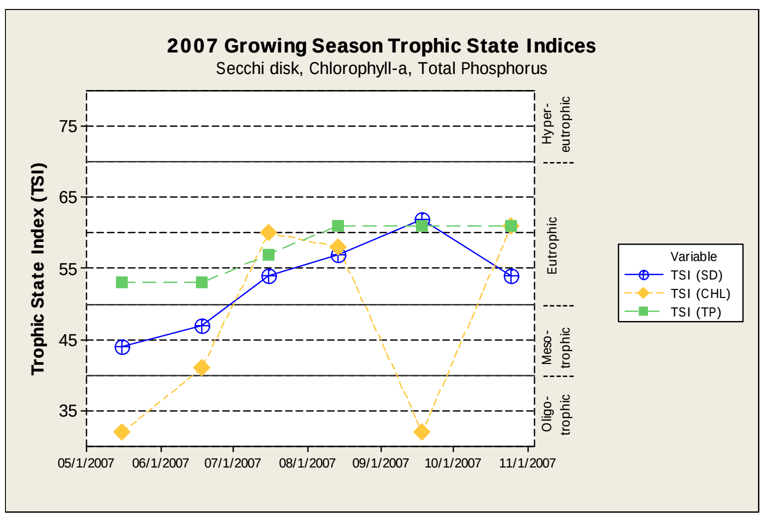
Chlorophyll-a, a pigment present in algae utilized for photosynthesis, is often used to estimate the amount of algae in lakes. The average chlorophyll-a concentration for the May – October 2007 period was 11 *ug*/L and ranged from 1 to 23 *ug*/L. Eutrophic lakes typically have maximum chlorophyll-a concentrations ranging between 20 and 200 *ug*/L (Holdren and others, 2001).

The average chlorophyll-a value for the May-October 2007 period was substantially lower than for the same period in 2005 (excluding comparison with partial data period for 2006).

Algal cell counts were most recently summarized following sampling in summer 2003. The phytoplankton community biovolume was then dominated by species commonly associated with eutrophic conditions. The average biovolume and a general pattern of dominance by the diatom *Fragilaria crotonensis* and blue-green algal species were consistent with results from earlier studies in 1984 and 1995. However, a significant increase in the blue-green alga *Aphanizomenon flos-aquae* since 1984 is a likely indication of advancing eutrophication.

Trophic State

Trophic state indices (TSI) calculated from Secchi disk, chlorophyll-a, and total phosphorus values generally indicated that the lake was eutrophic during much of the summer, meaning the lake is enriched with nutrients and algae. Using all three TSI characteristics on a scale of 0-100, the overall average monthly TSI value for summer 2007 was 53 with individual monthly TSI values ranging from 32 to 62. Values between 50 and 70 are associated with eutrophic lakes. Periodically, monthly Secchi disk and chlorophyll-a TSI estimates suggested short periods for Lacamas Lake that were more similar to mesotrophic or even oligotrophic conditions that may have been associated with zooplankton grazing of algae.



(Above) Trophic State Index (TSI) values, summer 2007

Aquatic Plants

Lacamas Lake is characterized by extensive aquatic plant growth. Based on surface and scuba surveys, scientists in 1984 concluded that at least 97% of the potential colonizable area in Lacamas Lake was populated with aquatic plants. Results from the most recent Washington State Department of Ecology survey in 1999 indicated increasing dominance of the plant community by Brazilian waterweed (*Egeria densa)*, an aggressive exotic species (photo). Since 1984, *Egeria densa* has largely displaced more desirable native species in the shallow-water areas (Parsons, 1999).

Egeria densa

Fish

The most recent Lacamas Lake fish population study was conducted in 1997 by the Washington Department of Fish and Wildlife. Lacamas Lake supports self-sustaining populations of warm-water fish (e.g. perch, bluegill, and largemouth bass).

The native cutthroat trout historically found in the lake are thought to be non-existent. Brown and rainbow trout are introduced through an annual stocking program and support a well-used fishery (Mueller and Downen, 1999).

The 1997 investigation concluded that warm-water species in Lacamas Lake exhibit signs of an unbalanced community, including slow growth, poor condition, and low recruitment. There appeared to be an overpopulation of small, slow growing fish with key size classes lacking.

Food availability did not appear to be a factor in causing the poor fish growth. Rather, the report concluded that poor water quality (primarily dissolved oxygen depletion) causes stress, limits habitat, and may be the greatest impediment to both the cold and warm-water fisheries (Mueller and Downen, 1999).

Summary

Overall conditions in Lacamas Lake were similar in 2007 to those observed over the past several years. Phosphorus levels were slightly higher than EPA's aquatic life criteria to avoid nuisance algal blooms, and nitrogen levels were relatively high. Elevated surface water temperatures combined with low dissolved oxygen conditions in the deeper areas limited summer cold-water fish habitat. Light penetration was consistently low due to abundant algal growth. Trophic state indices for Secchi disk, total phosphorus, and chlorophyll-a all indicated Lacamas Lake was eutrophic.

Algal growth was strongly phosphorus-limited during 2007. This pattern has been noted for the past several years and represents a change from historical conditions that have seen the lake typically shift to nitrogen limitation during late summer. The consistently elevated nitrogen values, compared with relatively low phosphorus inputs could indicate increased nitrogen sources in the watershed and/or an increased role of nitrogen in the ecology of Lacamas Lake.

Consistent limitation of algal growth by phosphorus could be a positive development for the lake, maintaining conditions favorable to desirable algal species. However, despite the limitation by phosphorus in 2007, current phosphorus levels are still easily sufficient to allow high levels of plant and algal growth and maintain a trophic status well into the eutrophic range.

Recommendations

Continued monitoring during the summer season is recommended to track long-term changes in lake conditions and inform future management efforts. Successfully decreasing phosphorus inputs may help limit blue-green algal blooms and, if the decrease was significant enough, potentially move the lake toward a lower trophic status.

Public and agency activities to improve Lacamas Lake have diminished since the major grant-funded restoration effort concluded in 2001. Renewed community interest and support would encourage further measures by state and local agencies to build on earlier successes in improving Lacamas Lake. Focused management efforts within the lake aimed at maintaining beneficial uses, such as mechanically introducing oxygen during the summer, would require consistent funding sources and broad public support.

Acknowledgements

The assistance of Frances Foley for her 2007 Lacamas Lake volunteer monitoring was greatly appreciated.

This report was originally written by Jeff Schnabel and updated by Robert Hutton in June 2008 based on 2007 Lacamas Lake data.

For more information about Lacamas Lake water quality monitoring contact:

Jeff Schnabel
Clark County Water Resources
(360) 397-6118 ext. 4583
jeff.schnabel@clark.wa.gov

Or, visit the Clean Water Program website:
www.clark.wa.gov/water-resources/index.html

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Table 1. Average values for Lacamas Lake monitoring projects; values in parentheses are ranges for the period

Data Source	Date Range	Maximum Surface water temperature *(deg-C)*	Minimum water column oxygen concentration *(mg/L)*	Surface water pH *(units)*	Secchi Depth *(meters)*	Turbidity *(NTU)*	Total phosphorus *(mg/L-P)*	Total nitrogen *(mg/L-N)*	Chlorophyll-a *(ug/L)*
Beak and SRI, 1984	Dec 1983 to Nov 1984	23.2	<0.1	7.7 (6.6 - 9.4)	1.3 (0.6 – 2.0)	7.3	0.070	1.16	19 (0.4 – 65)
Clark County, 1994 (Lafer)	July 1991 to Nov. 1992	23.0	<0.1	8.5 (7.5 – 9.6)	1.7	--	0.030 (0.015 – 0.063)	0.8 (0.4 – 1.6)	25 (est) 64 (max)
E&S, 1996	April to Nov. 1995	25.0	<0.1	7.9 (6.4 – 9.9)	1.4 (0.9 – 2.8)	4.3 (2.0 – 8.5)	0.041 (0.030 – 0.066)	1.13 (0.8– 1.4)	--
E&S, 1997	February to May, 1996	15.2	<0.1	6.4 (6.2 – 6.7)	1.1 (0.9 – 1.3)	6.8 (4.0 – 9.3)	0.102 (0.026 – 0.310)	1.5 (1.1 -1.9)	--
Clark County, 2000 (Schnabel)	Oct. 1998 to Sept. 1999	22.1	<0.1	7.5 (6.7 – 8.9)	1.6 (0.9 -2.1)	--	0.033 (0.018 – 0.050)	--	--
Clark County, 2002 (Schnabel)	Oct. 1999 to Sept. 2001	23.2	<0.1	--	1.4 (0.6 – 3.0)	--	0.030 (0.010 – 0.053)	1.2 (0.6 – 2.3)	--
Clark County, 2004 (Schnabel)	Oct. 2001 to Sept. 2003	25	<0.1	7.9 (6.8 – 9.3)	1.7 (0.5 – 3.0)	--	0.036 (0.010 – 0.079)	1.3 (0.4 – 2.4)	(May-Oct 2003 data unreliable)
Clark County (unpublished)	Oct. 2003 to Oct. 2004	24	<0.1	8.1 (6.9 – 9.0)	1.7 (1.2 – 2.5)	3.5	0.041 (0.023 – 0.144)	1.2 (0.5 – 2.2)	29 (18 – 35)
Clark County, 2006 (Schnabel)	May to Oct. 2005	23.6	<0.1	8.6 (8.0 – 9.0)	1.5 (1.1 – 2.0)	6.0	0.036 (0.021 – 0.58)	1.09 (0.7 – 1.3)	37 (15 – 82)
Clark County, 2007 (Schnabel)	May to Oct. 2006	22.9	<0.1	8.2 (6.6 – 9.2)	1.7 (1.3 – 2.6)	3.6 (1.4 – 6.9)	0.037 (0.023 – 0.060)	1.13 (0.8 – 1.6)	(July-Oct only) 13 (10-13)
Clark County, 2008 (Hutton & Schnabel)	May thru Oct. 2007	24.8	0.13	7.9 (6.5-9.1)	1.8 (0.9-3.0)	5.6 (1.5-10.4)	0.042 (0.030-0.050)	1.02 (0.8-1.29)	11 (1-23)

Lacamas Creek Fecal Coliform, Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load

Water Quality Study Design (Quality Assurance Project Plan)

DEPARTMENT OF ECOLOGY
State of Washington

February 2011

Publication No. 11-03-102

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Author: Trevor Swanson. Phone 360-407-6685.
Communication Consultant: Phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Study Codes

Data for this project are available at Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID is TSWA0003.

Activity Tracker Code (Environmental Assessment Program) is 10-150.

TMDL Study Code (Water Quality Program) is LACR28MP.

Federal Clean Water Act 2008 303(d) Listings Addressed in this Study

Water body: Lacamas Creek	
Parameter	Listing ID
Fecal Coliform	7913, 22016
Dissolved Oxygen	7912, 7921, 7924, 7929, 7897, 7908, 7901, 7946, 7862, 7868, 7894
Temperature	7917, 7923, 7930, 7900, 7907, 7945, 7865, 7869
pH	7947

Water body Numbers:
Lacamas Creek, WA-28-2020; Fifth Plain Creek, WA-28-2024; Shanghai Creek, WA-28-2025; Matney Creek, WA-28-2026; China Ditch, WA-28-2023

Cover photo: Lacamas Creek at Goodwin Road, June 2010. Photo by Stephanie Brock.

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Lacamas Creek Fecal Coliform, Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load

Water Quality Study Design (Quality Assurance Project Plan)

February 2011

Approved by:

Signature:	Date: February 2011
Kim McKee, Client and Unit Supervisor, Water Quality Program, SWRO	
Signature:	Date: February 2011
Steve Eberl, Client's Acting Section Manager, Water Quality Program, SWRO	
Signature:	Date: February 2011
Trevor Swanson, QAPP Author, Project Manager, Principal Investigator, and EIM Data Engineer, EAP	
Signature:	Date: February 2011
Kirk Sinclair, Groundwater Support, EAP	
Signature:	Date: February 2011
Martha Maggi, Groundwater/Forest and Fish Unit Supervisor, EAP	
Signature:	Date: February 2011
George Onwumere, Author's Unit Supervisor, EAP	
Signature:	Date: February 2011
Robert F. Cusimano, Author's Section Manager, EAP	
Signature:	Date: February 2011
Stuart Magoon, Director, Manchester Environmental Laboratory, EAP	
Signature:	Date: February 2011
Bill Kammin, Ecology Quality Assurance Officer, EAP	

Signatures are not available on the Internet version.
SWRO: Southwest Regional Office.
QAPP: Quality Assurance Project Plan.
EAP: Environmental Assessment Program.
EIM: Environmental Information Management database.

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Abstract

Lacamas Creek and four of its tributaries were included on the Washington State 2008 303(d) list of impaired water bodies for fecal coliform bacteria, temperature, dissolved oxygen, and pH violations of water quality standards. Lacamas Creek is located within Water Resource Inventory Area (WRIA) 28, fully within Clark County in southwestern Washington. The lower portion of the stream, including Lacamas and Round Lakes, flows through the City of Camas.

The Washington State Department of Ecology (Ecology) is required under Section 303(d) of the federal Clean Water Act to develop and implement total maximum daily loads (TMDLs) for impaired waters of the state. As a part of the TMDL for Lacamas Creek, this technical study will evaluate 303(d) listed parameters in the watershed by

- Sampling surface water for fecal coliform twice monthly from December 2010 to December 2011.
- Conducting two critical-period (summer 2011) dissolved oxygen, pH, and nutrient synoptic surface-water and groundwater surveys.
- Installing and recording surface-water and groundwater thermistors from spring to fall, 2011.
- Conducting riparian habitat and channel geometry surveys.
- Conducting time-of-travel surveys.
- Storm sampling during the dry and wet seasons.

Fecal coliform will be analyzed using the rollback method and DO, pH, and temperature will be modeled using the QUAL2Kw model (Chapra and Pelletier, 2003; Ecology, 2003b). Data collected will form the basis for allocating contaminant loads to pollutant sources.

Each study conducted by Ecology requires an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives.

The goal of this TMDL project is to ensure that Lacamas Creek and its tributaries above Lacamas Lake attain water quality standards for fecal coliform, stream temperature, dissolved oxygen, and pH. The study area does not include Lacamas Lake, Round Lake, or Lacamas Creek below these lakes. After completion of the 2010-2011 study, a final report describing the results will be posted to the Internet.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. The Act requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of (1) designated uses for protection, such as cold water biota and drinking water supply, and (2) criteria, usually numeric criteria, to achieve those uses.

The Water Quality Assessment and the 303(d) List

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the Clean Water Act Section 303(d) list. In Washington State, this list is part of the Water Quality Assessment (WQA) process.

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The WQA divides water bodies into five categories. Those not meeting standards are given a Category 5 designation, which collectively becomes the 303(d) list.

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data or insufficient data available.

Category 4 – Polluted waters that do not require a TMDL because they:
- 4a. – Have an approved TMDL being implemented.
- 4b. – Have a pollution control program in place that should solve the problem.
- 4c. – Are impaired by a non-pollutant such as low water flow, dams, or culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

Further information is available at Ecology's Water Quality Assessment website.

The Clean Water Act requires that a total maximum daily load (TMDL) be developed for each of the water bodies on the 303(d) list. A TMDL is a numerical value representing the highest pollutant load a surface water body can receive and still meet water quality standards. Any amount of pollution over the TMDL level needs to be reduced or eliminated to achieve clean water.

TMDL process overview

Ecology uses the 303(d) list to prioritize and initiate TMDL studies across the state. The TMDL study identifies pollution problems in the watershed, and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, tribes, agencies, and the community, then develops a strategy to control and reduce pollution sources and a monitoring plan to assess effectiveness of the water quality improvement activities. Together, the study and implementation strategy comprise the *Water Quality Improvement Report* (WQIR).

Once the U.S. Environmental Protection Agency (EPA) approves the WQIR, a *Water Quality Implementation Plan* (WQIP) is developed within one year. The WQIP identifies specific tasks, responsible parties, and timelines for reducing or eliminating pollution sources and achieving clean water.

Who should participate in this TMDL?

Nonpoint source pollutant load targets will likely be set in this TMDL. Because nonpoint pollution comes from diffuse sources, all upstream watershed areas have potential to affect downstream water quality. Therefore, all potential nonpoint sources of pollutants addressed in this TMDL in the watershed must use the appropriate best management practices to reduce impacts to water quality. The area that will be subject to the TMDL is shown in Figure 1.

Similarly, all point source dischargers who release pollutants addressed in this TMDL in the watershed must also comply with the TMDL.

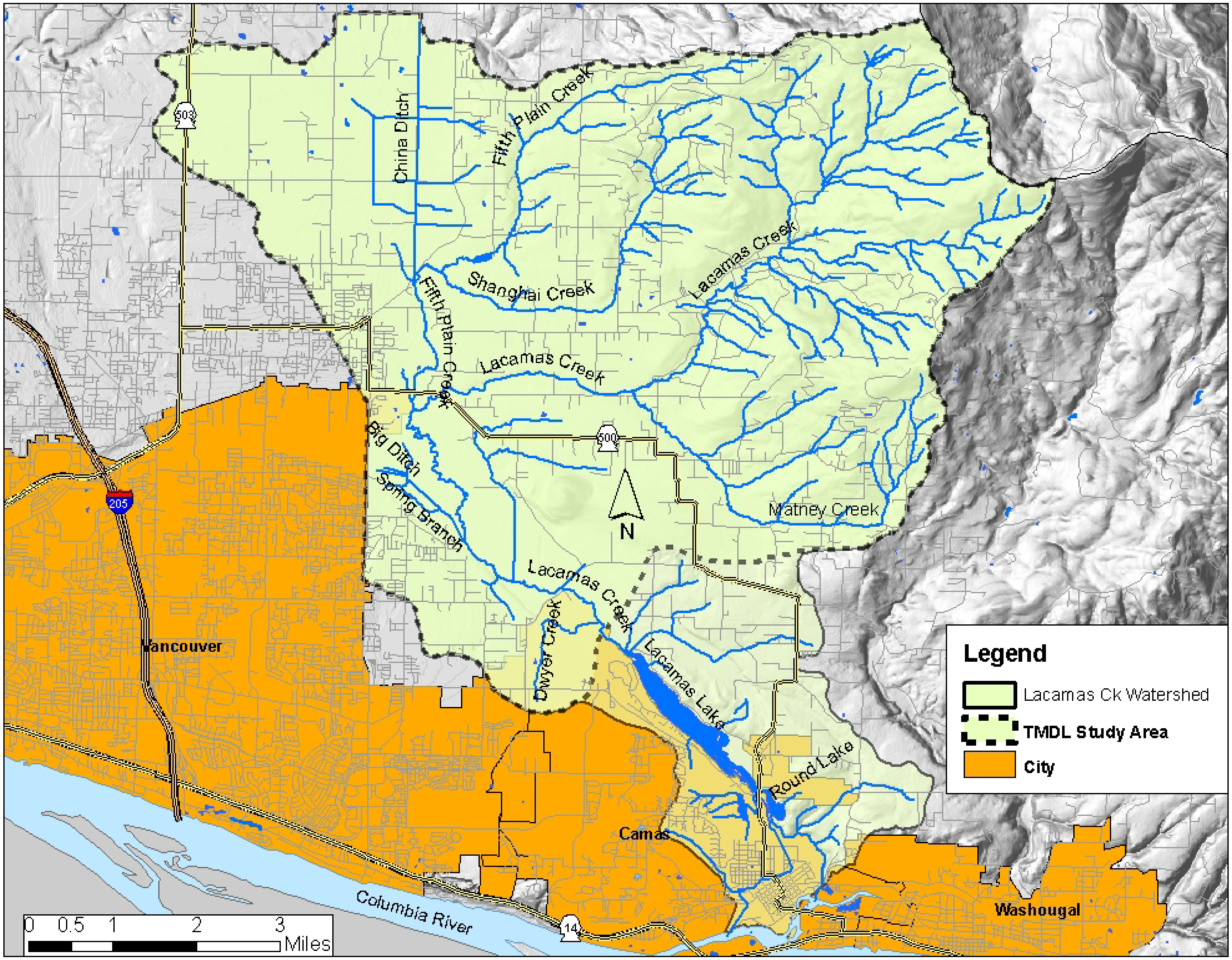

Figure 1. Study area for the Lacamas Creek multiparameter Total Maximum Daily Load study.

Elements the Clean Water Act requires in a TMDL

Loading capacity, allocations, seasonal variation, margin of safety, and reserve capacity

A water body's *loading capacity* is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water's loading capacity assigned to a particular source is a *wasteload* or *load* allocation. If the pollutant comes from a discrete (point) source subject to a National Pollutant Discharge Elimination System (NPDES) permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from diffuse (nonpoint) sources not subject to an NPDES permit, such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

The TMDL must also consider *seasonal variations* and include a *margin of safety* that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A *reserve capacity* for future pollutant sources is sometimes included as well.

Therefore, a TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity.

Why is Ecology Conducting a TMDL Study in This Watershed?

Background

Ecology is conducting a multiple parameter TMDL study on Lacamas Creek because there are several stream reaches that do not meet water quality criteria. The parameters addressed in this study are fecal coliform bacteria (FC), temperature, dissolved oxygen (DO), and pH.

There is a high level of interest in water quality issues in the watershed, especially in Lacamas Lake, demonstrated by cooperative sampling efforts, watershed management, and concerned citizens. Ecology hopes to build on previous data collection and watershed clean-up efforts. Ecology will work with Clark County and any other contributing entities to better understand the water quality problems within the Lacamas Creek watershed.

Ecology will organize and conduct field work from December 2010 to December 2011. The data collected will be used to establish loading capacity as well as load and wasteload allocations for FC, temperature, DO, and pH.

Study area

Lacamas Creek is located within Water Resource Inventory Area (WRIA) 28, fully within Clark County in southwestern Washington. The lower portion of the stream, including Lacamas and Round Lakes, flow through the City of Camas (Figure 1). The TMDL study area lies within the Lacamas Creek watershed and includes Lacamas Creek and its major tributaries and stormwater inputs above Lacamas Lake (Figure 1).

Ecology is not including Lacamas Lake, Round Lake, or Lacamas Creek below Round Lake in this study. Ecology is well aware that the lakes have water quality problems of their own (Table 2). However, because lake systems are much more complicated than stream systems, they require a more expensive and extensive monitoring and modeling effort than Ecology can afford at this time. Focusing on the watershed upstream of Lacamas Lake first will give Ecology insight into the sources of pollution affecting the lakes and lower creek. Previous studies (see Historical Data Review) and the fact that Lacamas Creek is the only major input of surface water to Lacamas and Round Lakes lead Ecology to believe that the major sources of nutrients and other pollutants to the lake come from upstream in Lacamas Creek and its tributaries, not directly to the lakes themselves. Therefore, cleanup efforts above Lacamas Lake may contribute to water quality improvements in the lakes and lower Lacamas Creek.

Impairments addressed by this TMDL

The main beneficial uses to be protected by this TMDL include:

- *Aquatic Life Use* for salmonid spawning, rearing, and migration.
- *Primary Contact Recreation.*
- *Water Supply Uses* for domestic consumption, industrial production, and agriculture or hobby farm livestock.
- *Miscellaneous Uses* for wildlife habitat, harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A-600).

Washington Administrative Code (WAC) 173-201A-600 also states that all lakes and all feeder streams to lakes that have not had individual use designation determinations (173-201A-602) are also to be protected for the designated uses of:

- *Core Summer Salmonid Habitat.*
- *Extraordinary Primary Contact Recreation.*

Because Lacamas Creek and its tributaries flow into Lacamas Lake, this higher level of beneficial use protection is required everywhere in the watershed above the outlet of Round Lake.

Washington State has established water quality standards to protect these beneficial uses. Table 1 lists the water bodies within the study area that violate FC, DO, temperature, and pH criteria established by the water quality standards. These impairments are addressed in this TMDL.

To meet standards for the parameters in Table 1, loading of the following pollutants will need to be decreased:

- FC
- Biochemical Oxygen Demand (BOD)
- Nutrients
- Thermal heat loading

This study will be looking at this watershed more thoroughly and may find other impaired water bodies.

Table 1. Study area water bodies on the 2008 303(d) list for parameter(s).

Water Body	Parameter	Listing ID	Township	Range	Section
Lacamas Creek	Fecal Coliform	7913	02N	03E	51
	Dissolved Oxygen	7912 7921 7924	02N 02N 02N	03E 03E 03E	51 07 10
	Temperature	7917 7923	02N 02N	03E 03E	51 10
Matney Creek	Fecal Coliform	22016	02N	03E	09
	Dissolved Oxygen	7929	02N	03E	09
	Temperature	7930	02N	03E	09
Fifth Plain Creek	Dissolved Oxygen	7897 7908 7901	02N 02N 03N	03E 03E 03E	07 06 32
	Temperature	7900 7907	03N 02N	03E 03E	32 06
Shanghai Creek	Dissolved Oxygen	7946	02N	03E	05
	Temperature	7945	02N	03E	05
	pH	7947	02N	03E	05
China Ditch	Dissolved Oxygen	7862	02N	03E	06
	Temperature	7865	02N	03E	06
China Lateral (tributary of China Ditch)	Dissolved Oxygen	7868	03N	02E	36
	Temperature	7869	03N	02E	36
Dwyer Creek	Dissolved Oxygen	7894	02N	03E	50

There are other Section 303(d) listed segments in the watershed, but this report does not address them directly (Table 2).

Table 2. Section 303(d) listed segments not addressed in the Lacamas Creek TMDL study.

Water Body	Parameter	Medium	Listing ID	Township	Range	Section
Lacamas Lake	PCB	Tissue	43465	02N	03E	34
	Total Phosphorus	Water	6346	02N	03E	34
Round Lake	pH	Water	7935	01N	03E	02
	Dissolved Oxygen	Water	7936	01N	03E	02
Lacamas Creek (below Round Lake)	Temperature	Water	7914	01N	03E	47
	Dissolved Oxygen	Water	7915	01N	03E	47
	pH	Water	7916	01N	03E	47

How will the results of this study be used?

A TMDL study identifies how much pollution needs to be reduced or eliminated to achieve clean water. This is done by assessing the pollution problem and then recommending practices to reduce pollution, and by establishing limits for facilities that have permits. Since the study may also identify the main sources or source areas of pollution, Ecology and local partners will use these results to figure out where to focus water quality improvement activities. Study results may also be used to suggest areas for follow-up sampling to further pinpoint sources for cleanup.

Water Quality Standards and Numeric Targets

The Washington State water quality standards, set forth in Chapter 173-201A of the WAC, include designated beneficial uses, water body classifications, and numeric and narrative water quality criteria for surface waters of the state. This section provides Washington State surface water quality information and those criteria applicable to this study in the Lacamas Creek watershed.

In July 2003, Ecology made significant revisions to the state's surface water quality standards (Chapter 173-201A WAC). These changes included eliminating the classification system the state used for decades to designate uses for protection by water quality criteria (e.g., temperature, DO, turbidity, bacteria). Ecology also revised the numeric temperature criteria assigned to waters to protect specific types of aquatic life uses (e.g., native char, trout and salmon spawning and rearing, and warm water fish habitat).

Ecology submitted the revised water quality standards regulation to EPA for federal approval in July 2003. These standards were approved by EPA on February 11, 2008. The revisions to the existing standards are online at Ecology's water quality standards website: www.ecy.wa.gov/programs/wq/swqs.

The Lacamas Creek watershed is listed on the 2008 303(d) list as impaired for FC, DO, temperature, and pH. Table 3 shows the applicable water quality criteria for these parameters.

Table 3. Washington State water quality criteria for impaired parameters in the Lacamas Creek Watershed.

<table>
<tr><th>Water Quality Parameter</th><th>2008 Use Classification</th><th>2008 Criteria</th></tr>
<tr><td>Temperature</td><td rowspan="3">Core summer salmonid habitat, spawning, rearing, and migration</td><td>16°C 7-DADMax[1]</td></tr>
<tr><td>Dissolved Oxygen</td><td>9.5 mg/L 1-DMin[2]</td></tr>
<tr><td>pH</td><td>6.5 to 8.5 units[3]</td></tr>
<tr><td rowspan="2">Fecal Coliform Bacteria</td><td rowspan="2">Extraordinary primary contact recreation</td><td>Geometric mean: 50 cfu/100 mL</td></tr>
<tr><td>10% not to exceed: 100 cfu/100 mL</td></tr>
</table>

1. 7-DADMax means the highest annual running 7-day average of daily maximum temperatures.
2. 1-DMin means the lowest annual daily minimum oxygen concentration occurring in the water body.
3. A human-caused variation within the above range of less than 0.2 units is acceptable.

Fecal coliform bacteria

Bacteria criteria are set to prevent waterborne illnesses in people who work and play in and on the water. Washington State water quality standards use FC as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). FC in water "indicates" the presence of waste from humans and other warm-blooded animals. Warm-blooded animals' waste is more likely than cold-blooded animals' waste to contain pathogens that will cause illness in humans. The FC criteria are set at levels shown to minimize rates of serious intestinal illness (gastroenteritis) in people.

The *Extraordinary Primary Contact* use classification is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas." To protect this use category, FC organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL" [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures used in combination ensure that bacterial pollution in a water body will be maintained at levels that will not cause a greater risk to human health than intended. While some discretion exists for selecting sampling averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal data sets.

The criteria for FC are based on allowing no more than the pre-determined illnesses to humans that work or recreate in a water body. The criteria used in the state standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact activities. Once the concentration of FC in the water reaches the numeric criterion, human activities that would increase the concentration above the criteria are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring FC concentrations back into compliance with the standard.

Humans are not allowed to contribute any FC bacteria if criteria are already being exceeded due to natural causes. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, warm-blooded animals (particularly those that are managed by humans and thus exposed to human-derived pathogens as well as those of animal origin) are a common source of serious waterborne illness for humans.

Dissolved oxygen

Aquatic organisms are very sensitive to reductions in the level of DO in the water. The health of fish and other aquatic species depends on an adequate supply of oxygen dissolved in the water. Oxygen levels affect growth rates, swimming ability, susceptibility to disease, and the relative ability to endure other environmental stressors and pollutants. Inadequate oxygen can also kill aquatic organisms. The state designed the criteria to maintain conditions that support healthy populations of fish and other aquatic life.

Oxygen levels can fluctuate over the day and night in response to changes in meteorological conditions as well as the respiratory requirements of aquatic plants and algae. Since the health of aquatic species is tied predominantly to the pattern of daily minimum oxygen concentrations, the criteria are the lowest 1-day minimum oxygen concentrations that occur in a water body.

In the state water quality standards, freshwater aquatic life use categories are described using key species (salmonid versus warm-water species) and life-stage conditions (spawning versus rearing). Minimum concentrations of DO are used as criteria to protect different categories of aquatic communities [WAC 173-201A-200; 2003 edition].

In this TMDL the designated aquatic life use to be protected is *Core Summer Salmonid Habitat.* The lowest 1-day minimum oxygen level must not fall below 9.5 mg/L more than once every ten years on average.

The criteria described above are used to ensure that where a water body is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying above the fully protective DO criterion. When a water body is naturally lower in oxygen than the criterion, the state provides an additional allowance for further depression of oxygen conditions due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.2 mg/L decrease below that naturally lower (inferior) oxygen condition. Whether or not the water body is naturally low in oxygen is determined by using a model. The model roughly approximates natural conditions and is appropriate for determining the implementation of the DO criterion.

The water quality standards contain a default that would allow the numeric criteria to be modified to reflect the natural condition, if the natural condition is a lower DO concentration than the numeric criteria.

While the numeric criteria generally apply throughout a water body, they are not intended to apply to discretely anomalous areas such as in shallow stagnant eddy pools where natural features unrelated to human influences are the cause of not meeting the criteria. For this reason, the standards direct that one take measurements from well-mixed portions of rivers and streams. For similar reasons, samples should not be taken from anomalously oxygen rich areas. For example, in a slow moving stream, sampling on surface areas within a uniquely turbulent area would provide data that are erroneous for comparing to the criteria.

pH

The pH of natural waters is a measure of acid-base equilibrium achieved by the various dissolved compounds, salts, and gases. pH is an important factor in the chemical and biological systems of natural waters. pH both directly and indirectly affects the ability of waters to have healthy populations of fish and other aquatic species. Changes in pH affect the degree of dissociation of weak acids or bases. This effect is important because the toxicity of many compounds is affected by the degree of dissociation. While some compounds (e.g., cyanide) increase in toxicity at lower pH, others (e.g., ammonia) increase in toxicity at higher pH.

While there is no definite pH range within which aquatic life is unharmed and outside which it is damaged, there is a gradual deterioration as the pH values are further removed from the normal range. However, at the extremes of pH lethal conditions can develop. For example, extremely low pH values (<5.0) may liberate sufficient CO_2 from bicarbonate in the water to be directly lethal to fish.

The state established pH criteria in the state water quality standards primarily to protect aquatic life and also to protect waters for domestic water supplies. Water supplies that have either extreme pH or that experience significant changes of pH even within otherwise acceptable ranges are more difficult and costly to treat for domestic water purposes. pH also directly affects the longevity of water collection and treatment systems (i.e., low pH waters may cause compounds of human health concern to be released from the metal pipes of the distribution system).

In the state's water quality standards, two different pH criteria are established to protect six different categories of aquatic communities [WAC 173-201A-200; 2003 edition].

In this TMDL, the designated aquatic life use to be protected is *Core Summer Salmonid Habitat*. To protect this designated aquatic life use, pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units.

Temperature

Temperature affects the physiology and behavior of fish and other aquatic life. Temperature may be the most influential factor limiting the distribution and health of aquatic life and can be greatly influenced by human activities.

Temperature levels fluctuate over the day and night in response to changes in climatic conditions and river flows. Since the health of aquatic species is tied predominantly to the pattern of maximum temperatures, the criteria are expressed as the highest 7-day average of the daily maximum temperatures (7-DADMax) occurring in a water body.

In the state water quality standards, aquatic life use categories are described using key species (salmon versus warm-water species) and life-stage conditions (spawning versus rearing) [WAC 173-201A-200; 2003 edition].

In this TMDL, the designated aquatic life use to be protected is *Core Summer Salmonid Habitat.* The highest 7-DADMax temperature must not exceed 16°C (60.8°F) more than once every ten years on average.

Washington State uses the criteria described above to ensure that where a water body is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying below the fully protective temperature criterion. When a water body is naturally warmer than the above-described criterion, the state provides a small allowance for additional warming due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.3°C (0.54°F) increase above the naturally higher temperature condition. Whether or not the water body is naturally high in temperature is determined using a model. The model roughly approximates natural conditions, and is appropriate for determining the implementation of the temperature criterion. This model results in what is called the "system thermal potential" or "system potential" of the water body.

Global climate change

Changes in climate are expected to affect both water quantity and quality in the Pacific Northwest (Casola et al., 2005).

Ten climate change models were used to predict the average rate of climatic warming in the Pacific Northwest (Mote et al., 2005). The average warming rate is expected to be in the range of 0.1-0.6°C (0.2-1.0°F) per decade, with a best estimate of 0.3°C (0.5°F) (Mote et al., 2005). Eight of the ten models predicted proportionately higher summer temperatures, with three of the models indicating summer temperature increases of at least two times higher than winter increases.

The predicted changes to our region's climate highlight the importance of protecting and restoring the mechanisms that help to cool stream temperatures. Stream temperature improvements obtained by growing mature riparian vegetation corridors along stream banks, reducing channel widths, and enhancing summer baseflows may all help to minimize the changes anticipated from global climate change. It will take considerable time, however, to reverse human actions that contribute to elevated stream temperatures. The sooner such restoration actions begin and the more complete they are, the more effective the program will be in offsetting some of the detrimental effects on our stream resources.

Restoration efforts may not cause streams to meet the numeric temperature criteria everywhere or in all years. However, they will maximize the extent and frequency of healthy temperature conditions, creating long-term and crucial benefits for fish and other aquatic species.

Ecology is conducting this TMDL to meet Washington State's surface water quality standards based on current climatic patterns. Potential changes in stream temperatures associated with global climate change may require further modifications to human-source allocations at some future time.

Watershed Description

The Lacamas Creek watershed is about 67 square miles of forest, farm, residential, commercial, and industrial land. Located in southeastern Clark County, the watershed extends from Hockinson in the north to Camas in the south. Roads such as State Route 503 and NE 162nd Avenue follow its western boundary, and the Elkhorn and Livingston Mountains lie on its eastern boundary. Most of the watershed is in unincorporated Clark County. A significant area southwest of Lacamas Lake is within the City of Camas. The eastern edge of Vancouver also extends into the watershed.

Lacamas Creek has five major tributaries: Matney Creek, Shanghai Creek, Fifth Plain Creek, China Ditch, and Dwyer Creek. There are also many smaller streams within the watershed.

Lacamas Creek flows about 18 miles from relatively undisturbed forest headwaters through rural, agricultural, and residential areas into Lacamas and Round Lakes. Below the lakes, Lacamas Creek drops through a series of scenic waterfalls, and finally into the lower Washougal River. Lacamas and Round Lakes are used for boating, water skiing, fishing, canoeing, and swimming. The 3.5-mile Heritage Trail brings access to the entire southwestern shore of Lacamas Lake. Lacamas Park is a 312- acre county park that surrounds Round Lake and offers an extensive system of trails, scenic views, picnic spots, and access to the lake and Lower Lacamas Creek waterfalls (Clark County, 2004).

Beginning in the 1890s, several man-made channels were built in the Brush Prairie area to drain wetlands for farmland and to increase the volume of water available to Camas mills. This area includes almost all the channels in the China Ditch system. Although considered an improvement when built, these channels have unintended consequences. With significantly fewer wetland areas to store runoff from rainstorms, higher volumes of stormwater now funnel more quickly into streams, eroding stream banks and causing increased flooding in low-lying lands (Clark County, 2004).

Geographic setting

Streamflow

Like most lowland perennial streams in the Lower Columbia River Basin, Lacamas Creek is heavily dependent on natural groundwater discharge to sustain it during the dry summer months when precipitation is scarce. During the wet season peak flows are dominated by rainfall events.

Flow gaging

Clark County currently collects continuous flow data from two gages on Lacamas Creek. The gage at Goodwin Road, just before Lacamas Creek enters the lake, and another on NE 217th Avenue, about 7 miles upstream from Goodwin Road, have been in operation since 2003. Table 4 summarizes streamflow statistics at the two gages.

Table 4. Summary streamflow statistics for Clark County stations located on Lacamas Creek.

Clark County Station	Water Years	Flow (cfs)		
		Maximum	Minimum	Mean
Lacamas Ck at Goodwin Road	2004-2009*	1,375	7.5	119
Lacamas Ck at NE 217th Avenue	2003-2009	705	3.0	56

* 1999-2004 data are available from Clark County, but not on their website.

For more detailed flow data, see Clark County's flow monitoring website at www.clark.wa.gov/water-resources/monitoring/flow.html.

Several crest-stage gages are located throughout the watershed. The crest-stage gage is a standard U.S. Geological Survey (USGS) type with a graduated wooden staff and ground cork in a 2-inch galvanized pipe. This gage is a device for obtaining the elevation of the flood crest of streams. The gage is simple, economical, reliable, and easily installed. Crest-stage gages may be referenced in the case of a flood event.

Geology

The bedrock exposed in the Lacamas Creek watershed consists mostly of basalt. In the western part of the watershed, bedrock is buried beneath sediments consisting mostly of detritus carried by the ancestral Columbia River. In middle Pleistocene time, basalt and basaltic andesite erupted from three small volcanoes in the southern half of the watershed. In late Pleistocene time, the Missoula floods deposited poorly sorted gravels in the southwestern part of the Lacamas Creek watershed that grade northward into finer grained sediments. Because of extensive dense vegetation, natural outcrops in the watershed are generally limited to steep cliff faces, landslide scarps, and streambeds (Evarts, 2006).

Climate

Lacamas Creek is located in the West Coast Marine Climate Region that includes the Pacific coast from southeastern Alaska to northern California (City of Vancouver, 2002). The Columbia River and Pacific Ocean moderate temperatures lending to a maritime climate. As a result, the area experiences mild, cool, wet winters and relatively dry, warm summers. The Willapa Range to the west and the relatively taller Cascade Range to the east influence the climate as well. In Vancouver, the average maximum monthly air temperatures range from 44°F in January to near 80°F in August. Severe temperature extremes are infrequent. The foothills in the upper Lacamas Creek watershed receive slightly more rainfall than the lowlands in Camas and Vancouver. Average annual rainfall for Vancouver is just over 40 inches, falling mainly in the winter months.

Wildlife

Historically, the watershed supported native cutthroat trout; however, these fish are almost completely absent today due to changes in water quality. Lacamas and Round Lakes are now stocked annually with about 25,000 brown and rainbow trout from the Vancouver Trout Hatchery. These stocked fish make up the primary species in the lakes, along with introduced warm-water species such as yellow perch, largescale sucker, and largemouth bass. The watershed probably supports other species such as sculpin, shiners, sticklebacks, dace, and lamprey larvae.

There is evidence that salmon use lower Lacamas Creek for spawning and rearing but cannot access the watershed above Round Lake because of natural waterfalls and man-made dams (Schnabel, 2010).

The Lacamas Creek watershed provides habitat for many animal species, particularly along the riparian corridor and wetlands. Both resident and migratory birds rely on the area for food and raising their young. Many types of mammals, amphibians, and reptiles are abundant in the watershed.

Vegetation

Historically, the watershed was forested with some wetland prairies. Tree species such as alder, cottonwood, maple, willow, western hemlock, spruce, Douglas fir, and western red cedar dominated the canopy along most of the riparian corridor. Understory species included vine maple, huckleberry, salal, ferns, and devil's club.

Humans have altered the vegetation dramatically along portions of Lacamas Creek and its tributaries by introducing exotic and invasive plant species and deforesting riparian habitat. China Ditch, Big Ditch, and Spring Branch were dug to drain wetlands and provide dry land for agriculture. These areas now contain many exotic plant species, such as blackberries and reed canary grass.

Hydromodifications

Historically, natural wetlands covered much of the western part of the study area. This area has since been drained for agriculture by a series of ditches that empty into Lacamas Creek. Significant areas of pasture/grassland remain. Drainage Improvement District No. 5 is located in the China Ditch area and is responsible for the maintenance of drainage and diking improvements there (Figure 2). Drainage District No. 7 in the Spring Branch/Big Ditch area is no longer functional.

The largest of the man-made drainages include China Ditch, Spring Branch, and Big Ditch. The Big Ditch and Spring Branch area still floods during the wet season, but eventually drains to Lacamas Creek and infiltrates into the ground in time for spring and summer agriculture.

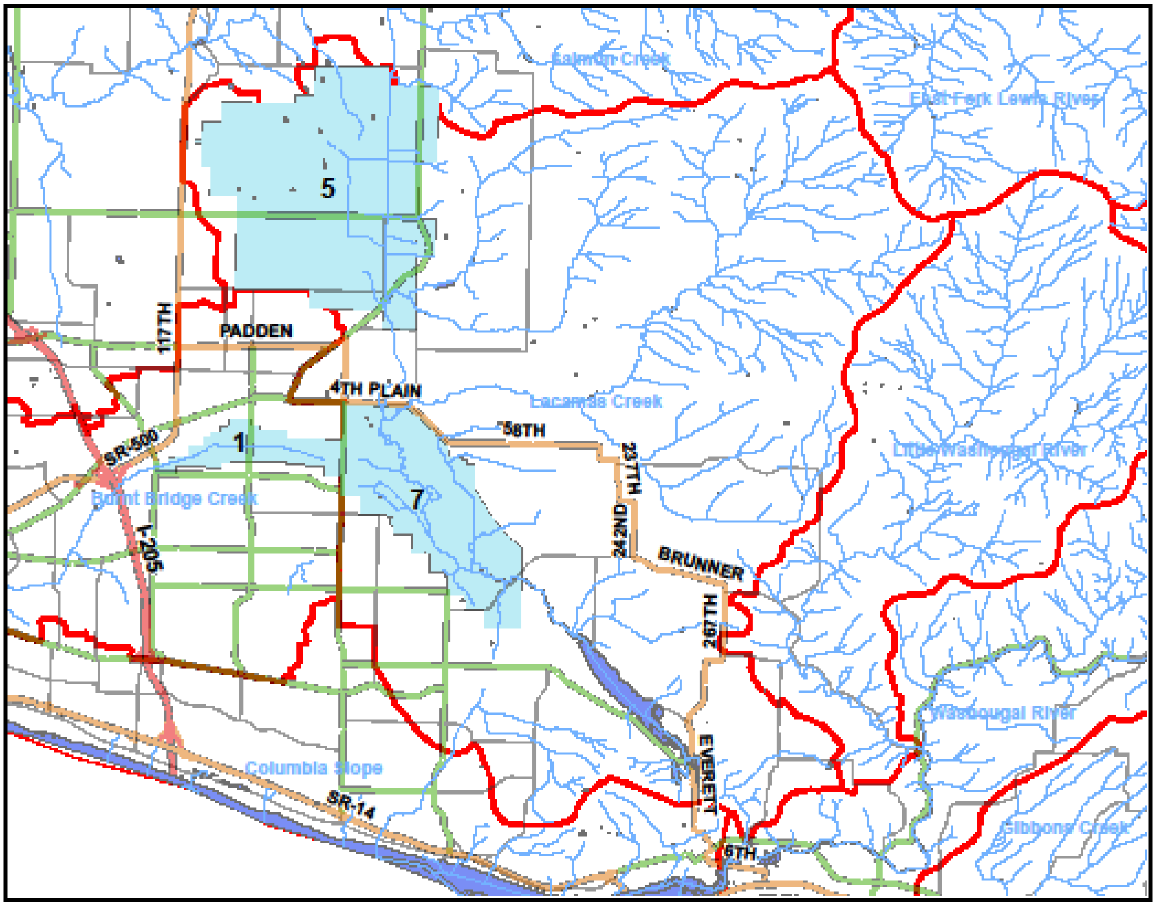

Figure 2. Map of Lacamas Creek watershed showing the locations of Drainage Districts 5 and 7 (blue shaded areas) (Schnabel, 2010).

Potential sources of contamination

Point sources

Three dairies in the study area operate under a Concentrated Animal Feeding Operations (CAFO) General Permit. Ecology administers the general permit to cover CAFO operations. As of July 1, 2003, the jurisdiction was transferred to the Washington State Department of Agriculture (WSDA) under the Livestock Nutrient Management Program. However, until EPA delegates permit authority to WSDA, Ecology will continue to administer the permit, with inspections performed by WSDA. The current general permit does not cover specific provisions relating to a TMDL, but facilities cannot discharge process waters to surface water bodies except under catastrophic conditions. Facilities must be "… designed, constructed, and operated to treat all process generated wastewater plus the runoff from a 25-year 24-hour rainfall event…."

Clark County has an NPDES Phase I Municipal Stormwater Permit and the City of Vancouver has a Phase II Municipal Stormwater Permit (see Stormwater section below). The cities of Camas and Vancouver currently release wastewater into the Columbia River.

There are no other permitted point sources affecting water quality in the study area, although there may be unknown, illicit discharges in the watershed.

Stormwater

During significant rain events, rainwater can wash the surface of the landscape, pavement, rooftops, and other impervious surfaces. This stormwater runoff can accumulate and transport pollutants and contaminants via stormwater drains to receiving waters and can degrade water quality.

Clark County

Ecology issued an NPDES Phase I Municipal Stormwater Permit to Clark County and other western Washington jurisdictions in January 2007 and revised it in June 2009. Phase I permittees are cities and counties that operate large and medium municipal separate storm sewer systems (MS4s). Governmental bodies, such as state highway departments and drainage districts, are also required to meet permit requirements within their boundaries. State highways in the Lacamas watershed include SR 500 and SR 503. The permit regulates stormwater discharges to waters of Washington State from the permittees' MS4s in compliance with Washington Water Pollution Control Law (Chapter 90.48 RCW) and the federal Clean Water Act (Title 33 USC, Section 1251 et seq.).

Clark County has a new Stormwater Management Plan (2010) that outlines the county's responsibilities to protect water through stormwater management. The Plan can be found at www.clark.wa.gov/water-resources/SWMP/stormwater_plan.html.

More information on Phase I permits and Clark County can be found at www.ecy.wa.gov/programs/wq/stormwater/municipal/Phase1equivalentstormwatermanualsWestern.html

City of Vancouver

The City of Vancouver encompasses a very small portion in the western part of the watershed near the confluence of Fifth Plain and Lacamas Creeks (Figure 1).

Ecology issued the Western Washington Phase II Municipal Stormwater Permit in January 2007. Under the Phase II permit, the City of Vancouver must follow the prescribed guidelines to manage stormwater before it discharges to surface water. Permit requirements fall under five basic categories: public education and outreach, public involvement and participation, illicit discharge detection and elimination, the control of runoff from development, and pollution prevention. General information on the Phase II permit is available at www.ecy.wa.gov/programs/wq/stormwater/municipal/phaseIIww/wwphiipermit.html.

In 1996, the City of Vancouver established a city-wide Surface Water Utility. The utility manages the city's stormwater flowing into Lacamas Creek. The city is currently mapping all stormwater drainages and lines, and inspecting the lines using a submersible camera (Kardouni, 2010).

At this time the Surface Water Utility is well established with an existing surface water utility rate structure, and the City of Vancouver has implemented the required NPDES Phase II Permit program elements. As part of the Phase II Permit, the city has developed a Stormwater Management Program. Documentation of the program and the annual report summarizing how the city is complying with each section of the Phase II Permit are available on the city website. Outside of the city, Clark County must follow Phase I of the NPDES municipal stormwater guidelines to manage stormwater before it discharges to surface water.

Ecology's five-volume Stormwater Management Manual is available on the internet at www.ecy.wa.gov/programs/wq/stormwater/manual.html.

Nonpoint sources

Nonpoint pollution sources are dispersed and thus not controlled through discharge permits. Potential nonpoint sources within the Lacamas Creek watershed include:

- Residential properties adjacent to the creek
- Riparian residential development
- Agricultural land
- Golf courses
- Wildlife waste
- Pet waste
- Human waste
- Failing onsite septic systems

Nonpoint sources are important to understand due to their impacts on stream water quality, and also as a major component of stormwater runoff.

The water quality standards use FC as indicators of pathogenic organisms associated with fecal contamination. FC are produced in the guts of warm-blooded animals and are present in high concentrations in fecal material. Potential sources of FC include humans, domestic animals, and wildlife. Fecal contamination of water poses a human public health threat when humans ingest FC while recreating in the water or when they drink the water.

Fecal coliform bacteria

FC from nonpoint sources are transported to the creeks by direct and indirect means. For example, manure that is spread over fields during certain times of the year can enter streams via surface runoff or fluctuating water levels. Livestock often have direct access to water. Manure is deposited in the riparian area of the access points where fluctuating water levels, surface runoff, or constant trampling can transport the manure into the water. The Big Ditch and Spring Branch area often floods during the winter, which can lead to overland flow of fecal material.

Some residences may have wastewater illegally piped to waterways or may have malfunctioning on-site septic systems where effluent seeps to nearby waterways. Pet waste concentrated in public parks, on creek-side trails, or private residences can be a source of contamination, particularly in urban areas. Swales, subsurface drains, and flooding through pastures and near homes can carry FC, nutrients, and other pollutants from sources to waterways. Even illegal campsites can be a source of human waste, carrying bacteria and nutrients to streams.

Dissolved oxygen and pH

Nonpoint sources may also contribute to DO or pH impairments. Depressed DO may result from increased nutrient loads that stimulate algae and plant growth, referred to as productivity. The decomposition of dead algae and other organic matter consumes DO. Productivity may be limited by a specific nutrient (usually phosphorus in streams and lakes), by light to fuel photosynthesis, or by retention time in a water body.

Activities or mechanisms that produce nutrients or enhance nutrient transport include the following:

- Septic systems.
- Stormwater runoff from paved and pervious lands.
- Improper manure storage or disposal from commercial and non-commercial agriculture.
- Vegetation removal without erosion control from construction areas or forest harvest.
- Channel bank erosion or bed scour due to high flows or constrained reaches.
- Poor fertilizer and irrigation water management.
- Removal of riparian zone vegetation (riparian trees and other vegetation naturally filter nutrients and other pollutants and also reduce solar radiation reaching the stream surface, which may limit algal growth).

The diel cycle of algal growth adds DO during the daylight hours as the plants photosynthesize, but reduces DO levels to a minimum around daybreak as respiration occurs. Increased nutrient loading from anthropogenic sources can enhance algal growth and increase the diel DO fluctuation. This can result in lower levels of DO than would have resulted under conditions where humans were absent.

These same processes affect pH. Algae and other aquatic plants consume CO_2 during photosynthesis reducing the amount of CO_2 and bicarbonate in the water. Alkalinity stays essentially constant while pH responds by increasing. This process is exacerbated as more sunlight reaches the stream and as temperatures and nutrient concentrations increase. The pH in streams with high algal productivity typically increases during the daylight hours to its maximum around mid to late afternoon and returns to near background levels at night when plants are respiring and not taking carbon out of the water. This diel swing can be dramatic enough to increase the daily high and/or decrease the daily low pH of streams and lakes beyond state criteria.

In addition, the pH of rain in western Washington is 4.8 to 5.1 (NADP, 2004). Therefore, stormwater may have a low pH due to regional atmospheric rather than local watershed conditions. Wetland systems also affect pH by enhancing natural decomposition processes, which results in acidic pH levels.

Wetlands can affect pH. The high residence time and high organic matter loading in wetlands, for example, produce low DO and pH levels. Some wetland complexes exist within the Lacamas Creek system and may contribute to the low levels recorded in the mainstem and the tributaries.

Groundwater inputs can also affect stream DO and pH, as well as temperature. Groundwater can warm a stream in winter and cool a stream in the summer, and the amount of DO is often lower in groundwater. In the adjacent watershed (Burnt Bridge Creek), groundwater pH values ranged from 6.3 to 7.2 (Sinclair, 2010).

Anthropogenic activities can lower pH as well. For example, decomposing organic material, such as that found in logging slash, and even acid deposition can lower pH below the state criterion.

Some streams have a naturally low buffering capacity, which makes them more susceptible to pH changes. These streams can have both low and high pH in the same stretch, though often during different times of the year.

Wildlife and background sources

A variety of wildlife lives within the Lacamas Creek watershed. Wildlife presents a potential source of FC, BOD, and nutrients. Open fields, riparian areas, and wetlands provide feeding and roosting grounds for some birds whose presence can increase FC counts, BOD, and nutrients in runoff.

Usually these sources are dispersed and may not elevate FC counts or affect DO and pH in streams significantly enough to violate state surface water quality criteria. Sometimes animal populations become concentrated and can cause water quality violations. Concentrated wildlife (for example, nutria, raccoons, beaver, deer, and birds) in the watershed will be noted during sampling surveys.

Historical Data Review

Ecology ambient monitoring

Ecology established an ambient monitoring station (28I120) on Lacamas Creek at Goodwin Road in October 2006 and sampled there once per month until October 2007. Table 5 shows data collected during the one year sampling effort. The data show routinely elevated FC concentrations, and also indicate periods with depressed DO levels and elevated temperatures. Details and results can also be found at www.ecy.wa.gov/apps/watersheds/riv/station.asp?sta=28I120.

Table 5. Ecology's ambient monitoring data for Lacamas Creek at Goodwin Road, October 2006 to October 2007.

Date	Time	Cond.	FC		Flow	Ammonia		Nitrate + Nitrite	Sol. Reactive Phos.	Oxygen	pH		Susp. Solids	Temp	Total Phos.	Total Persulfate Nitrogen	Turb.
		(umhos/ cm)	(#/ 100 ml)		(cfs)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(s.u.)		(mg/L)	(deg C)	(mg/L)	(mg/L)	(NTU)
10/16/06	15:30	122	480		29.5	0.01*	U	2.42*	0.025	9.9	7.2		5	12	0.033	1.92*	5
11/13/06	14:25	63	-		461	0.07		1.24	0.113	8.1	6.6		2	9.6	0.095	1.55	7.9
12/18/06	14:00	60	3		326	0.01	U	1.25	0.025	12.3	-		3	3.7	0.032	1.35	5.7
1/22/07	14:20	76	23		147	0.02		1.24	0.015	11.8	7.2		2	5.8	0.026	1.26	6.5
2/12/07	14:20	93	160	J	83.1	0.22		1.21	0.0348	11	7		6	8	0.069	1.47	12
3/19/07	12:35	81	74		92.2	0.03		1.15	0.016	10.22	7.2		6	10.6	0.031	1.26	6.1
4/23/07	12:40	82	47		93.8	0.04		1.02	0.015	10.82	7.1		2	11.2	0.038	1.12	6.2
5/21/07	12:40	106	510		45.8	0.03		1.2	0.021	10	7.3	J	4	11.9	0.033	1.34	5
6/11/07	13:00	113	77		22.7	0.01		1.4	0.024	10.95	7.6		3	14.7	0.035	1.6	5.5
7/16/07	15:10	152	110		12.5	0.01	U	2.61	0.0324	10.39	7.8		5	19.2	0.036	3.06	6
8/20/07	14:03	153	430		10.2	0.01	U	2.52	0.0367	9.4	7.4		5	16.2	0.037	3.51	7.5
9/24/07	13:50	149	180		7.76	0.01	U	2.64	0.0301	10.3	7.6		3	13.4	0.036	2.36	4.1

Common data qualifiers: U: not detected at the reported level; J: estimated value
Asterisk * indicates possible quality problem for the result.
Sol: Soluble; Phos: Phosphorus; Susp: Suspended; Turb: Turbidity

Clark County Public Works

Recent studies, data, and focus sheets can be found on Clark County's Water Resources and Clean Water Program website at www.clark.wa.gov/water-resources/index.html.

Some reports include:

- *2001 Matney Creek and Dwyer Creek Subwatershed Survey: Habitat and Benthic Macroinvertebrates* by Jeff Schnabel, March 2002.
- *Long-Term Index Site Monitoring Project: 2002 Physical Habitat Characterization* by Jeff Schnabel, December 2003.

- *Lacamas Lake: Nutrient Loading and In-lake Conditions* by Jeff Schnabel and Bob Hutton, April 2004.
- *Clark County Stormwater Management Plan* by Clark County Environmental Services, Clean Water Program, 2010.
- *Clark County 2010 Stream Health Report* by Clark County Environmental Services, Clean Water Program, 2010.

Historical and recent streamflow data can be accessed at www.clark.wa.gov/water-resources/monitoring/flow.html.

Lacamas Lake eutrophication studies

Many water quality studies have taken place in the Lacamas Creek watershed since the early 1980s. While most of them focused directly on Lacamas Lake and its eutrophication problems, a few have focused on Lacamas Creek and its tributaries as a source of pollution to Lacamas Lake. Data from past studies suggest that Lacamas Creek is the major source of nutrient loading to Lacamas Lake. Some of the more relevant studies are described below.

The 1983-1984 Lacamas Lake Diagnostic and Restoration Analysis (BCI, 1985) measured phosphorous loading to the lake and estimated target loading levels. In the 1984 water year, the lake received 15,046 kg of total phosphorous: 95.6% from Lacamas Creek, 4.0% from Dwyer Creek, and 0.4% from precipitation. The study recommended reducing the lake's phosphorous external loading 84% to reduce its trophic status with 90% certainty, which corresponds to an overall target lake concentration of 0.012 mg/L and a target concentration of 0.015 mg/L for Lacamas Creek.

Water quality monitoring by Clark County Water Quality Division in 1991 and 1992 found that Lacamas and Round Lakes continued to exhibit eutrophic conditions. Overall water quality in the lakes did not improve between 1984 and 1992. Decreases in tributary phosphorus levels were evident, but limited data and the influence of substantial differences in precipitation and streamflow made validation of any trends statistically impossible. The report highlighted the need for long-term water quality data to verify water quality trends and take into account variability associated with weather, land use, and the effects of restoration efforts.

In March 2002, Clark County Water Resources Section summarized results from nutrient loading investigations and in-lake monitoring during water year 2000 and water year 2001. Clark County also discussed current lake conditions, assessed trends in nutrient loading from 1983 to 2001, and compared current conditions to original program goals. Phosphorus loading and in-lake phosphorus concentrations had decreased by approximately 50% since 1983. The program goal was to achieve an 84% reduction in phosphorus. Despite the significant decrease in phosphorus, in-lake conditions had not improved and all applicable indicators suggested that the lake remained eutrophic.

Other studies

In 1987 Southwest Washington Health District evaluated septic system function for 52.8% of the approximately 2,061 homes in the Lacamas basin. Based on the survey results, the report concluded that septic tank systems contribute less than 2.5% of the annual phosphorus load to Lacamas Lake and have little impact on water quality in the lake.

Also in 1987, Clark County Intergovernmental Resource Center inventoried 1,087 agricultural parcels (29,000 acres) and identified 42 different best management practices (BMPs) that were needed to address problems on 437 individual agricultural operations in the basin. Farms were prioritized according to a problem severity ranking process. Total cost of cleanup was estimated at $3,170,000. Assuming full BMP implementation on the worst 122 operations, it was estimated that a 50-75% reduction in phosphorus loading to Lacamas Lake could potentially be realized.

In 1995 the United States Department of Agriculture's Natural Resources Conservation Service summarized implemented BMPs to date. At that time, 42 landowners had installed 35 waste management and 66 riparian BMPs, for a total of 101 BMP installations. Inspections of the installed BMPs during 1995 indicated that 88 of these 101 BMPs were completely fulfilling their conservation objectives.

Ecology's TMDL evaluation (1996)

In 1996, Ecology published the Lacamas Creek Watershed TMDL Evaluation (www.ecy.wa.gov/biblio/96307.html). The evaluation showed that Lacamas Creek violated state water quality criteria for temperature, DO, pH, and FC and was therefore included on the 303(d) list requiring formulation of a TMDL. The report evaluated whether past assessment and control activities in the watershed were sufficient to meet EPA requirements for a TMDL. The evaluation was accomplished by an examination of each element of a TMDL in terms of EPA requirements, work completed in the basin, and an evaluation of completeness. TMDL requirements were not fully achieved by the current program. An outline of additional actions needed for a complete TMDL submittal was provided.

Goals and Objectives

Project goal

The goal of the proposed TMDL study is to ensure that Lacamas Creek and its tributaries above Lacamas Lake attain Washington State water quality standards for pH, DO, FC, and temperature. Lacamas Lake, Round Lake, and Lacamas Creek below Round Lake will not be included in this study.

Study objectives

Objectives of the TMDL study are as follows:

- Collect high quality data during field surveys from December 2010 to December 2011.
- Characterize FC concentrations and loads from all major tributaries, point sources, and drainages into Lacamas Creek under various seasonal and hydrological conditions.
- Calculate percent reductions and establish FC load and wasteload allocations.
- Identify relative contributions of FC loading to Lacamas Creek based on source areas so clean-up activities can focus on the largest sources.
- Characterize processes governing DO and pH in Lacamas Creek above Lacamas Lake, including the influence of tributaries, nonpoint sources, and groundwater.
- Develop a model to simulate biochemical processes and productivity in Lacamas Creek above Lacamas Lake. Using critical conditions in the model, determine the capacity to assimilate biochemical oxygen demand and nutrients.
- Characterize stream temperatures and processes governing the thermal regime in Lacamas Creek above Lacamas Lake. This includes the influence of tributaries and groundwater/surface water interactions on the heat budget.
- Develop a predictive temperature model for Lacamas Creek above Lacamas Lake. Using critical conditions in the model, determine the creek's capacity to assimilate heat. Evaluate the system potential temperature (approximate natural temperature conditions) for Lacamas Creek.
- Establish load allocations for nonpoint sources to meet temperature and DO water quality standards and protect beneficial uses.
- Use the calibrated model to evaluate future water quality management decisions for the Lacamas Creek watershed.

Study Design

Overview

TMDL study objectives will be supported by data collected by Ecology during field monitoring surveys from 2010-2011. The study may also be supported with pertinent existing data collected by Clark County, Ecology, and others.

DO, pH, temperature, and associated conventional parameters will be monitored at a fixed network of sampling sites during the summer critical season. These sites include locations at the mouths of all tributaries, significant drainage/discharges, and key locations along Lacamas Creek.

FC sampling will occur twice monthly for one year at the same locations as the other parameters, but also upstream in tributaries and where sources may be present.

Streamflow will be measured or calculated at all sites at the time of sampling.

The water quality models will be calibrated to field data. The calibrated models will then be used to evaluate the water quality in Lacamas Creek in response to various alternative scenarios of pollutant loading. Only the loading capacity of Lacamas Creek above Lacamas Lake will be evaluated. In addition, load allocations for nonpoint sources will be evaluated. The models will be used to determine (1) how much nutrients and biochemical oxygen demand need to be reduced to meet DO and pH water quality criteria and (2) how much effective shade is necessary to bring stream temperature into compliance with water quality criteria. Components and descriptions of the models are summarized in the following section.

FC TMDL allocations will be set based on applying a statistical method to measured data (the numeric water quality model will not be used). The statistical roll-back method, described in the following section, will be used to determine how much (in terms of percent) FC concentrations need to be reduced at each sampling site.

Modeling and analysis framework

The QUAL2Kw model (Chapra and Pelletier, 2003; Ecology, 2003b**)** or similar modeling framework will be developed to simulate both observed and critical conditions. The specific modeling framework will depend on a review of available frameworks at the time when modeling tasks are conducted. Critical conditions for temperature and DO are characterized by a period of low flows and high water and air temperatures. Sensitivity analyses will be run to assess the variability of the model results. Model resolution and performance will be measured using the root-mean-square-error (RMSE), a commonly used measure of model variability (Reckhow, 1986). The RMSE is defined as the square root of the mean of the squared difference between the observed and simulated values.

Model bias will be assessed either mathematically or graphically. Bias is the systematic deviation between a measured (i.e., observed) and a computed value. Bias in this context could result from uncertainty in modeling or from the choice of parameters used in calibration.

Mathematically, bias is calculated as relative percent difference (RPD). This statistic provides a relative estimate of whether a model consistently predicts values higher or lower than the measured value.

> RPD = (| Pi – Oi | *2) / (Oi + Pi), where
> Pi = ith prediction
> Oi = ith observation

QUAL2Kw graphically represents observed and measured values along the length of the modeled stream segment. Therefore, bias will also be evaluated by observing modeled trends and over- or under-prediction between computed vs. measured values.

Means, maximums, minimums, and 90th percentiles will be determined from the data collected at each monitoring location. For temperature, the maximum, minimum, and daily average will be determined. Estimates of groundwater inflow will be calculated by constructing a water mass balance from continuous and instantaneous streamflow data and piezometer studies.

Temperature

The QUAL2Kw model (Chapra and Pelletier, 2003; Ecology, 2003b**)** or similar modeling framework will be used to evaluate the system potential temperature in the river. The model will be used to evaluate various heat budget scenarios for future water quality management decisions in the Lacamas Creek basin.

GIS coverage of riparian vegetation in the Lacamas Creek study area will be created from information collected during the 2011 temperature field study as well as from 2007 and 2009 Clark County digital aerial orthophotographs. Riparian vegetation coverage will be created by qualifying four attributes: vegetation height, general species type or combinations of species, percent vegetation overhang, and average canopy density of the riparian vegetation.

Data collected during this TMDL effort will allow the development of a temperature simulation methodology that is both spatially continuous and spans full-day lengths. The model will be calibrated to observed (2011) conditions measured by this study design. The GIS and modeling analysis will be conducted using specialized software tools:

- Ecology's Ttools extension for ArcView will be used to sample and process GIS data for input to the shade and temperature models.
- Ecology's shade calculator (Ecology, 2003a) will be used to estimate effective shade along Lacamas Creek. Effective shade will be calculated at 50- to 100-meter intervals along the streams, and then averaged over 500- to 1000-meter intervals for input to the temperature model.

- The QUAL2Kw model (Chapra and Pelletier, 2003; Ecology, 2003b) will be used to calculate the components of the heat budget and simulate water temperatures. The temperature model simulates diurnal variations in stream temperature using the kinetic formulations for the components of the surface water heat budget that are described in Chapra (1997).

QUAL2Kw will be applied by assuming that flow remains constant (i.e., steady flows) for a given condition such as a 7-day or 1-day period (using daily average flows), but key variables other than flow will be allowed to vary with time over the course of a day. For QUAL2Kw temperature simulation, the solar radiation, air temperature, relative humidity, headwater temperature, and tributary water temperatures are specified or simulated as diurnally varying functions.

Dissolved oxygen and pH

Water quality modeling for DO and pH will also be conducted using QUAL2Kw (Chapra and Pelletier, 2003; Ecology, 2003b) or with a similar biogeochemical modeling framework. The water quality model will use kinetic formulations for simulating DO and pH in the water column. The model will be calibrated and corroborated using data collected during the synoptic surveys and historical data to the extent possible.

Fecal coliform

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution of transformed data. Streamflow data will be frequently reviewed during the field data survey season to check longitudinal water balances. FC mass balance calculations will be performed on a reach basis. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, and regressions) will be made using WQHYDRO (Aroner, 2003) and Excel® (Microsoft, 2001) software.

The statistical rollback method (Ott, 1995) will be applied to determine the necessary reduction for both the geometric mean value (GMV) and 90_{th} percentile bacteria concentration (Joy, 2000) to meet water quality criteria. Ideally, at least 20 data are needed from a broad range of hydrologic conditions to determine an annual FC distribution. If sources of FC vary by season and create distinct critical conditions, seasonal targets may be required. Fewer data will provide less confidence in FC reduction targets, but the rollback method is robust enough to provide general targets for planning implementation measures. Compliance with the most restrictive of the dual FC criteria determines the bacteria reduction needed.

The rollback method uses the statistical characteristics of a known data set to predict the statistical characteristics of a data set that would be collected after pollution controls have been implemented and maintained. In applying the rollback method, the target FC GMV and the target 90_{th} percentile are set to the corresponding water quality criteria.

The rollback factor, $f_{rollback}$, is

$f_{rollback}$ = minimum { (50/sample GMV), (100/sample 90_{th} percentile) }.

The percent reduction ($f_{reduction}$) needed is

$$f_{reduction} = (1 - f_{rollback}) \times 100\%,$$

which is the percent reduction that allows both GMV and 90_{th} percentile target values to be met. The result is a revised target value for either the GMV or the 90_{th} percentile. In most cases, a reduction of the 90_{th} percentile is needed, and application of this reduction factor to the study GMV yields a target GMV that is usually more restrictive than the water quality criterion. The 90_{th} percentile is used as an equivalent expression to the "no more than 10%" criterion found in the second part of the water quality standards for FC.

Details

Fixed-network sampling

The following describes the study design for each Section 303(d)-listed parameter covered by this TMDL. Streamflow, time-of-travel, and groundwater sampling will also be discussed.

Figure 3 and Table 6 show the fixed-network of sampling locations. Table 7 shows the proposed survey schedule. Stations were selected based on 303(d) listings, historical site locations, spatial resolution, and location of tributaries. One reference station, outside the study area, will be sampled below Round Lake at 3rd Avenue, but data will not be used in the TMDL evaluation. See Table 6. Data from this site may be useful for comparison purposes and for future studies in the watershed.

Sites may be added or removed from the sampling plan depending on access and new information provided during the field observation and preliminary data analysis.

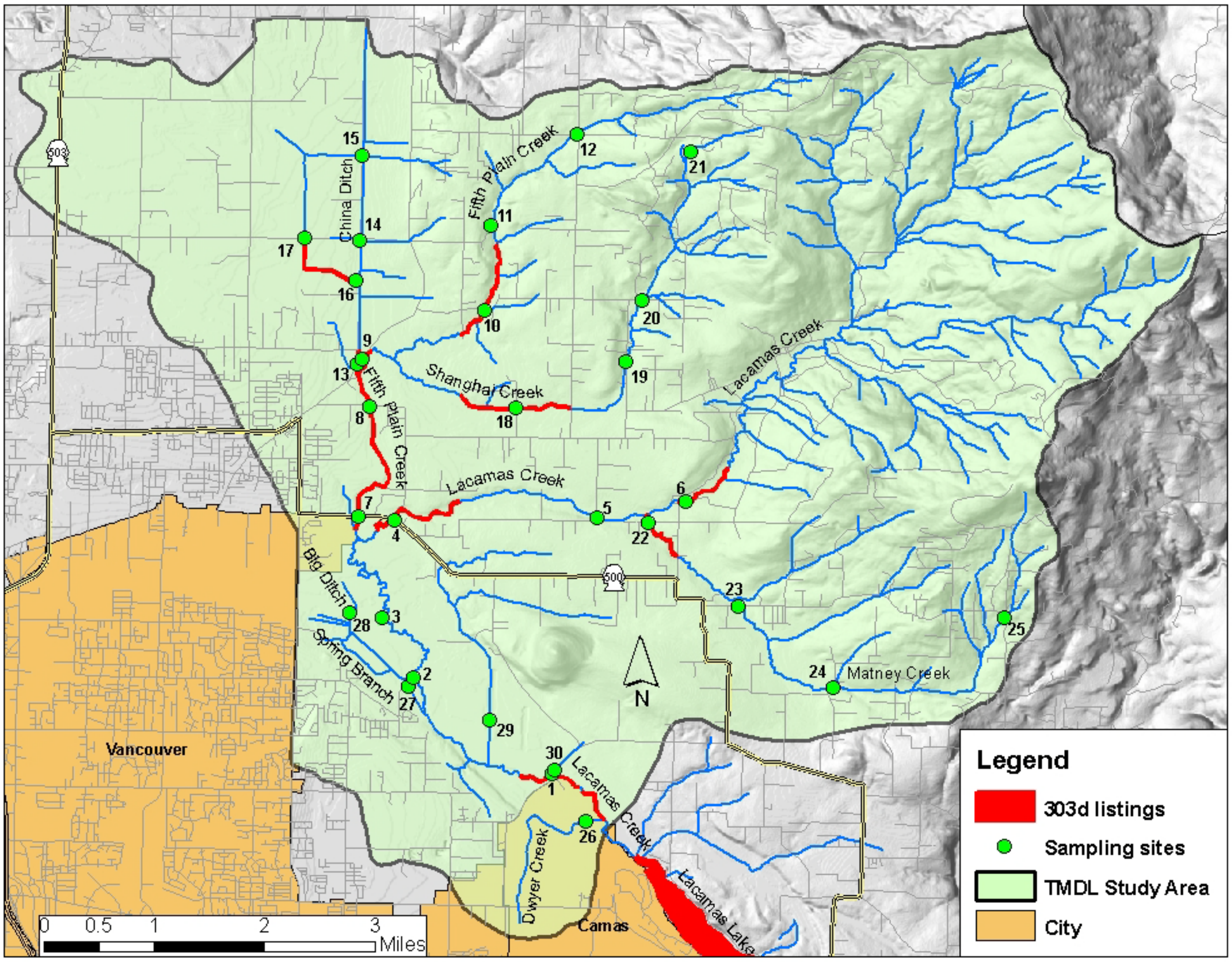

Figure 3. Fixed-network sampling locations in the Lacamas Creek watershed.

Table 6. Ecology’s proposed sampling locations in the Lacamas Creek watershed.

Site ID	Map #	Bacteria	Synoptic survey [1]	H20 Thermometer	Air Thermometer	Continuous diel monitoring [2]	Relative humidity probe	Piezometer [3]	County flow gage	Ecology flow gage	Description	NAD 83 Latitude	NAD 83 Longitude
28-LAC-0.2	-	X	X	X	X						Lacamas Ck at NE 3rd Ave (below lake and study area)	45.58897	-122.39078
28-LAC-5.6	1	X	X	X	X	X	X		X		Lacamas Ck at Goodw in Rd	45.63878	-122.45697
28-LAC-7.5	2	X	X	X	X	X	X	X			Lacamas Ck upstream of Spring Branch off 182nd and 38th	45.65105	-122.48349
28-LAC-9.1	3	X	X	X	X	X	X	X			Lacamas Ck near Big Ditch	45.65872	-122.48950
28-LAC-11.1	4	X	X	X	X	X	X	X			Lacamas Ck at 4th Plain NE (SR 500)	45.67170	-122.48783
28-LAC-13.3	5	X	X	X	X	X			X		Lacamas Ck at NE 217th Ave	45.67262	-122.44988
28-LAC-14.8	6	X	X	X	X	X	X	X			Lacamas Ck just upstream of Camp Bonneville border	45.67503	-122.43331
28-FIF-0.2	7	X	X	X	X	X				X	5th Plain Ck at 4th Plain NE (SR 500)	45.67198	-122.49457
28-FIF-1.4	8	X									5th plain Ck at 88th St	45.68657	-122.49293
28-FIF-1.9	9	X	X	X		X					5th Plain Ck at NE Ward Rd and 172nd Ave intersection	45.69280	-122.49449
28-FIF-3.4	10	X	X	X	X	X		X			5th Plain Ck at NE Davis Rd	45.69956	-122.47187
28-FIF-4.3	11	X									5th Plain Ck at Sliderberg Rd and 122nd Circle	45.71074	-122.47104
28-FIF-5.5	12	X									5th Plain Ck at NE 212th Ave near intersection w ith NE 139th St	45.72300	-122.45527
28-CHI-0.0	13	X	X	X	X	X	X	X		X	China Ditch at NE Ward Rd and 172nd Ave intersection	45.69203	-122.49551
28-CHI-1.2	14	X	X	X	X			X			China Ditch at intersection of NE 172nd Ave and NE 119th St	45.70839	-122.49560
28-CHI-1.9	15	X									China Ditch north of 131st St on NE 172nd Ave	45.71945	-122.49564
28-CHB-0.0	16	X	X	X	X						China Ditch trib branch at Hockinson Meadow s Park	45.70299	-122.49603
28-CHB-0.8	17	X									China Ditch trib branch at NE corner of Hockinson Meadow s Park	45.70848	-122.50595
28-SHA-1.3	18	X	X	X	X	X	X				Shanghai Ck at NE 202nd Ave	45.68687	-122.46555
28-SHA-2.7	19	X		X	X			X			Shanghai Ck at NE 222nd Ave	45.69327	-122.44520
28-SHA-3.4	20	X									Shanghai Ck at NE 109th St	45.70130	-122.44241
28-SHA-5.0	21	X									Shanghai Ck at 39th Loop at end of NE 139th St	45.72103	-122.43393
28-MAT-0.1	22	X	X	X	X	X				X	Matney Ck at NE 68th St	45.67218	-122.44010
28-MAT-1.4	23	X									Matney Ck at NE 53rd St	45.66142	-122.42297
28-MAT-2.8	24	X									Matney Ck at NE 261st Ave	45.65106	-122.40480
28-MAT-4.9	25	X									Matney Ck at Livingston Rd	45.66085	-122.37292
28-DWY-0.1	26	X	X	X	X	X					Dw yer Ck at golf course maintenance shop	45.63267	-122.45051
28-SPR-0.3	27	X	X	X	X	X		X			Spring Branch Ck at 182nd Ave and 38th Way	45.64985	-122.48429
28-BIG-0.2	28	X		X				X			Big Ditch near Lacamas Ck	45.65913	-122.49566
28-TUG-0.0	29	X	X	X	X						Unnamed tributary to Lacamas Ck below Tug Lake	45.64564	-122.46890
28-GOL-0.0	30	X	X	X							Unnamed trib to Lacamas Ck entering at Goodw in Rd (left bank)	45.63886	-122.45695
Total		31	19	21	18	14	7	10					

[1] Includes sampling all parameters in Table 10 and periphyton. Groundwater will be sampled at piezometer sites for parameters in Table 9.
[2] Flux chambers will also be deployed where possible. Parameters monitored include dissolved oxygen, pH, conductivity, and temperature.
[3] Monitored parameters for groundwater are shown in Table 9.

Table 7. Proposed survey schedule for the Lacamas Creek TMDL study.

	2010	2011 →									
Survey type and frequency	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
FC bacteria sampling	2	2	2	2	2	2	2	2	2	2	2	2
Piezometer water level measurements and thermistor downloads	1*	1*	1*	1*	1*	1	1	1	1	1	1	1*
Air and surface water thermistor downloads						1	1	1	1	1	1	
Stormwater+					1	1	1	1	1	1	1	1
Dissolved oxygen, pH, and nutrient synoptic surface water and groundwater sampling^								1		1		
Time-of-travel (dye) study								1		1		
Habitat and channel geometry								1	1			
Periphyton sampling										1		

* If possible. Water levels may be too high to access some piezometers.
\+ Weather permitting. The goal is to sample one summer storm for nutrients and FC and three fall through spring storms for FC.
^ Includes Hydrolab and benthic flux chamber deployment

Fecal coliform bacteria

The fixed-network sites will be sampled twice monthly from December 2010 to December 2011.

Data from the fixed-network will provide FC data sets to meet the following needs:

- Provide an estimate of the annual and seasonal geometric mean and 90th percentile statistics FC counts. The schedule should provide 24 samples per site to develop the annual statistics. This will include 10 samples per site during the dry season (June - October), and 14 samples per site during the wet season (November - May).
- Provide reach-specific FC load and concentration comparisons to define areas of FC loading increases (e.g., malfunctioning on-site septic systems, livestock, wildlife, or manure spreading) or decreases (e.g., settling with sediment, die-off, or dilution). With accurate streamflow monitoring, tributary and source loads also can be estimated.

Sites may be added if land access permissions are granted, better or more access to streams are found during sampling, or data from investigatory surveys show areas of concern or areas that need further bracketing. Conversely, sampling at some sites may be discontinued if data isn't useful to the TMDL analysis or the site does not help bracket pollution sources.

Dissolved oxygen and synoptic surveys

DO and associated conventional parameter data will be collected synoptically[1] from the fixed-network of stations (Figure 3 and Table 6). In early morning and late afternoon, field teams will record in-situ parameters (temperature, DO, pH, and conductivity) and will collect representative grab samples for laboratory analysis. Synoptic surveys will be conducted at least 2 times during the course of the project to provide model calibration and corroboration data sets.

The fixed-network synoptic sampling will occur during the summer low-flow months (June to September) to capture critical conditions. Synoptic sampling will include grab samples of DO[2], chloride, total suspended solids, total non-volatile suspended solids, turbidity, ammonia, nitrite/nitrate, orthophosphate, total phosphorous, total persulfate nitrogen, dissolved and total organic carbon, alkalinity, chlorophyll-*a*, and streamflow.

Continuous diel monitoring for pH, DO, conductivity, and temperature will be conducted at several of the fixed-network sites with Hydrolab DataSondes® or MiniSondes® following standard operating procedures (Swanson, 2010). Sediment oxygen demand may be characterized by installing sediment flux chambers in up to 4 representative reaches along the creek or tributaries during the synoptic surveys if resources allow (Roberts, 2007). The benthic chambers will remain in place for at least 24 hours. Once deployed, Winkler DO grab samples will be taken at dawn and dusk. Periphyton sampling will occur at each fixed-network sampling site to determine biomass and chlorophyll-*a* levels.

Temperature

Continuous temperature dataloggers (thermistors) will be deployed at several fixed-network sites (Figure 3 and Table 6). Each site will have at least two thermistors: one to measure water temperature and another to measure air temperature. The thermistors will measure temperature at 30-minute intervals. Instream thermistors are deployed in the thalweg of a stream, suspended off the stream bottom and in a well-mixed area, typically in riffles or swift glides. Some sites may also have a datalogger measuring air relative humidity (Table 6).

The temperature assessment of Lacamas Creek will use effective shade as a surrogate measure of heat flux. Effective shade is defined as the fraction of the potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface. Human activities increase water temperature when the removal of riparian vegetation reduces effective shade.

Heat loads to the stream will be calculated using a heat budget that accounts for surface heat flux and mass transfer processes. Heat loads are of limited value in guiding management activities needed to solve identified water quality problems. Shade will be used as a surrogate to heat load as allowed under EPA regulations (defined as "other appropriate measure" in 40 CFR § 130.2(i)). A decrease in shade due to inadequate riparian vegetation causes an increase in solar radiation and heat load upon the affected stream section. Other factors influencing the

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[1] All stations sampled over a short period of time.
[2] Winkler dissolved oxygen samples for lab check of field measurements.

effect of the solar heat load on stream temperatures will also be assessed, including human-caused changes in stream morphology, streamflow, and groundwater interactions.

Groundwater and synoptic surveys

Groundwater and surface-water interactions will be assessed via a combination of field techniques. Instream piezometers were installed in September 2010 at 10 of the fixed-network sites (Figure 3 and Table 6) in accordance with standard EA Program methodology (Sinclair and Pitz, 2010). Most of these sites are in the mid to lower watershed where soft sedimentary deposits make installation possible. Piezometer installation will be difficult or impossible in the upper watershed due to the presence of near-surface bedrock or consolidated sediments. Where piezometers cannot be installed, natural seeps will be targeted and sampled where possible. The piezometers will be used at discrete points along the creek to monitor surface-water and groundwater head relationships, streambed water temperatures, and groundwater quality.

The piezometers are 5 foot by 1.5-inch galvanized pipes that are crimped and perforated at the bottom. The upper end of each piezometer will be fitted with a standard pipe coupler to provide a robust strike surface for installation and capping between sampling events. The piezometers will be driven into the streambed, within a few feet of the shoreline, to a maximum depth of approximately 5 feet. Keeping the top of the piezometer underwater and as close to the streambed as possible will reduce the influence of heat conductance from the exposed portion of the pipe. Following installation, the piezometers will be developed using standard surge and pump techniques to assure a good hydraulic connection with the streambed sediments.

Each piezometer will be instrumented with up to three thermistors for continuous monitoring of streambed water temperatures (Figure 4). In a typical installation, one thermistor will be located near the bottom of the piezometer, one at a depth of approximately 0.5 feet below the streambed, and one roughly equidistant between the upper and lower thermistors. The piezometers will be accessed monthly to download thermistors and to make spot measurements of stream and groundwater temperatures for later comparison against and validation of the thermistor data. The monthly spot measurements will be made with properly maintained and calibrated field meters in accordance with standard Ecology Environmental Assessment (EA) Program methodology (Ward, 2007).

During the monthly site visits, surface-water stage and instream piezometer water levels will be measured using a calibrated electric well probe, a steel tape, or a manometer board (as appropriate) in accordance with standard EA Program methodology (Sinclair and Pitz, 2010). The water level (head) difference between the piezometer and the creek provides an indication of the vertical hydraulic gradient and the direction of flow between the creek and groundwater. When the piezometer head exceeds the creek stage, groundwater discharge into the creek can be inferred. Similarly, when the creek stage exceeds the head in the piezometer, loss of water from the creek to groundwater storage can be inferred.

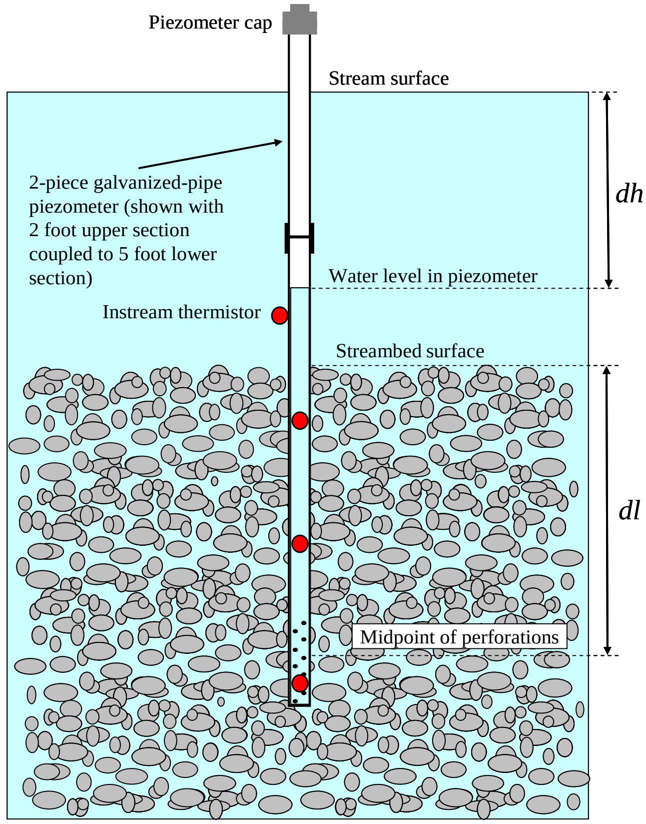

Figure 4. Instream piezometer conceptual diagram (diagram not to scale).

Two groundwater quality sampling events (scheduled to coincide with synoptic surface-water sampling events) will be conducted to assess the quality of groundwater discharging to the creek. During the synoptic surveys, groundwater samples will be collected from piezometers in gaining stream reaches or seeps if necessary. The samples will be submitted to the laboratory for analysis of FC, alkalinity, chloride, orthophosphate, total phosphorus, nitrate/nitrite, ammonia, total persulfate nitrogen, dissolved organic carbon, and iron concentration analysis. Temperature, water level, conductivity, pH, and DO will also be measured in the piezometers during the surveys.

To confirm the instream piezometer dataset, Ecology will (where necessary) also attempt to arrange access to shallow off-stream domestic wells to monitor local groundwater levels, temperatures, and groundwater quality. When selecting wells, preference will be given to shallow, properly documented wells in close proximity to Lacamas Creek. Wells selected for monitoring will be visited monthly during the 2010-2011 study period to measure groundwater levels. Where owner’s permission is granted and site conditions allow, logging thermistors may also be deployed in the wells. Ecology also hopes to collect water quality samples from a subset of the off-stream wells during each of the two instream piezometer sampling events described above.

Time of travel to determine average stream velocities

Travel times will be estimated within several reaches of Lacamas Creek to further understand how water and pollutants move through the system and to calibrate the model. Time-of-travel studies will use fluorescent dye (20% Rhodamine WT) to trace the movement of a dye cloud from an upstream point to a downstream point to calculate the average velocity of that body of water. Rhodamine WT dye is used by Ecology, the USGS, and others to provide safe and effective time-of-travel measurements. The methods and protocols used in this survey will follow those prescribed by Kilpatrick and Wilson (1982).

Field measurements of dye concentration in the stream will be made using a Hydrolab DataSonde® equipped with a rhodamine fluorometer, recording measurements every 5-10 minutes at key locations downstream from the initial point of dye release. Over a period of time in the stream, the dye will dissipate becoming visually undetectable. These studies will take place at different streamflow regimes during summer and fall. Dye studies will coincide with the synoptic surveys.

Ecology will notify Clark County Environmental Services and other appropriate officials and local emergency contacts before injecting the dye. Announcing the dye studies will prevent unnecessary emergency actions in the event a spills complaint is submitted (i.e., someone calls the sheriff or Ecology spills hotline because the river just turned red/pink).

Establishing a continuously recording stream gage network to measure streamflows

Ecology's Freshwater Monitoring Unit plans to install and maintain three continuous streamflow gages for this project. These gages will help quantify streamflows in Lacamas Creek or its tributaries. Proposed sites are Matney Creek at 68th St., Fifth Plain Creek at Fourth Plain Rd. (SR 500), and China Ditch near Ward Rd.

Continuously recorded streamflow data, instantaneous streamflow measurements conducted during baseflow conditions, piezometer vertical hydraulic gradient measurements, and the resulting flow mass balance will be used to determine surface-water and groundwater interactions. The major surface-water inputs to Lacamas Creek, including tributaries and point discharges, will be measured during each field visit, if possible.

Riparian habitat and channel geometry surveys

Effective shade inputs to the water quality model (QUAL2Kw) require an estimate of the aerial density of vegetation shading the stream. Ground truthing is necessary, so a hemispherical lens and digital camera will be used to take 360° pictures of the sky to calculate the shade provided by vegetation and topography at the center of the stream. These photographs will be taken at each fixed-network site and at a few reference reaches to verify existing riparian vegetation compared to aerial photos. The digital images will be processed and analyzed using the HemiView© software program (Stohr, 2008).

Ecology will also use Solar Pathfinder™ equipment to collect effective shade data at each site. The Solar Pathfinder™ uses a polished, transparent, convex plastic dome. A panoramic view of the area is reflected in the dome. Trees, hills, bridges, or other obstacles to sunshine are plainly visible as reflections on the polished surface of the dome. Since the dome is transparent, the user can also look through the dome to a sun chart within the Solar Pathfinder™. This chart shows the Sun's path through the sky for all months of the year. The chart is also calibrated by the hours of the day. The dome has slots in its sides and the user traces the outline of the horizon's reflection of the dome onto the sun chart. The traced line shows exactly at what hours of the day, and months of the year an obstacle will shade the stream.

Ecology will follow Timber-Fish-Wildlife stream temperature survey methods for the collection of data during thermal reach surveys (Schuett-Hames et al., 1999). The surveys will be conducted during the summer of 2011 at the fixed-network sites. Depending on stream access, field measurements will be taken at 10 locations per site. Measurements will consist of bankfull width and depth, wetted width and depth, substrate composition, canopy density, and channel type.

Riparian habitat field data collection includes 150 feet on both banks of Lacamas Creek (Johnston et al., 2005). Vegetation heights will be measured in the field using a laser range/ height finder. Comparing the field data collected to aerial photos, a GIS map layer will be made and will include vegetation type, general height class, and vegetation density. Additional Riparian Management Zone characteristics, such as active channel width, effective shade, bank incision, and bank erosion will be recorded during the thermal reach surveys.

Stormwater monitoring

Stormwater will be evaluated as part of the TMDL. The Ecology project team will attempt to capture up to three storm events during the fall/winter season and one during the summer low-flow season to characterize the impact of these events. Winter storms will be sampled for bacteria only. The summer storm will include grab samples for nutrients, sediment, bacteria, and carbon.

The purpose of storm monitoring is to better characterize potential sources of contaminant loading to Lacamas Creek. During rain events, greater than average loading may occur when surface-water flushes into the creeks. For this TMDL, a storm event is defined as a minimum of 0.2 inches of rainfall in a 24-hour period, with an antecedent dry period of 24 hours in winter, 72 hours in summer. Daily rainfall data will be obtained from local sources.

During the wet season, Ecology will try to sample all fixed-network sites twice during each storm event. This may not be possible if resources are scarce. When grab samples are collected, streamflow will be measured with a flow meter, estimated using stage and rating curves, compared with other monitoring locations and calculated using regression analysis, or calculated or estimated using other measures as appropriate. Local weather forecasts and predictive models will allow anticipation of significant storm events suitable for sampling.

Ecology will attempt to sample one summer storm event. During this storm event, sites and representative outfalls will be monitored for bacteria, total organic carbon (TOC), dissolved organic carbon (DOC), total suspended solids (TSS), and nutrients (ammonia, nitrite-nitrate, total persulfate nitrogen, orthophosphate, and total phosphorus).

The stormwater sampling sites will include all fixed-network sites plus up to 10 outfalls, ditches, small creeks, or drains representing runoff from the different major land uses in the watershed. Ecology will search the watershed further and work with regional staff during the project to find suitable sampling sites. Urban, farm, and roadside ditches or outfalls will likely be targeted.

Practical constraints and logistical problems

Seasonal conditions may affect access to some sampling locations. For example, sites in the Big Ditch/Spring Branch area may not be accessible in the winter because of flooding.

Inclement weather, such as heavy rainfall resulting in temporary flooding or heavy snowfall, may also limit access to some sites.

Although rare, logistical problems such as scheduling conflicts, sample bottle delivery errors, vehicle or equipment problems, or the limited availability of personnel or equipment may interfere with sampling as well.

Sampling Procedures

Field sampling and measurement protocols will follow those listed by Ecology's EA Program quality assurance guidance and methodology procedures www.ecy.wa.gov/programs/eap/quality.html.

Grab samples will be collected directly into pre-cleaned containers supplied by Ecology's Manchester Environmental Laboratory (MEL) and described in their *Lab Users Manual* (MEL, 2008). Samples will be collected according to the standard operating procedures (SOPs) for surface water and bacteria sampling (Joy, 2006; Mathieu, 2006). DO sampling (Winkler method) will follow the SOP for measuring DO in surface waters (Mathieu, 2007). Sample parameters, containers, volumes, preservation requirements, and holding times are listed in Table 8. All samples for laboratory analysis will be labeled, stored on ice, and delivered to MEL within 24 hours of collection via FedEx and Ecology courier.

A minimum of 10% of the samples (20% of FC samples) will be field duplicates used to assess total (field and lab) variability. Samples will be collected in the thalweg and just under the water's surface.

Periphyton field sampling protocols are adapted from the USGS protocols (Porter et al., 1993)

Temperature monitoring stations and piezometers will be checked monthly to obtain field measurements and to clear accumulated debris away from the thermistors. Documentation of the temperature monitoring stations will include:

- Global Positioning System (GPS) coordinates and a sketch of the site (during installation only).
- Depth of the instream thermistor under the water surface and height off the stream bottom.
- Stream temperature.
- Serial number of each thermistor and the action taken with the thermistor (i.e., downloaded data, replaced thermistor, or noted any movement of the thermistor location to keep it submerged in the stream).
- The date and time before the dataloggers are installed or downloaded, and the date and time after they have been returned to their location. All timepieces and PC clocks should be synchronized to the atomic clock using Pacific Daylight Savings Time. Pacific Standard Time will be reported if thermistors are still in place during the time change.

Table 8. Containers, preservation requirements, and holding times for surface water samples (MEL, 2008).

Parameter	Sample Matrix	Container	Preservative	Holding Time
Fecal Coliform	Surface water, groundwater, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
Dissolved Oxygen	Surface water	300 mL BOD bottle & stopper	2 mL manganous sulfate reagent + 2 mL alkaline-azide reagent	4 days
Chloride	Surface water, groundwater, & runoff	500 mL poly	Cool to 4ºC	28 days
Total Suspended Solids; TNVSS[1]	Surface water & runoff	1000 mL poly	Cool to 4ºC	7 days
Turbidity	Surface water & runoff	500 mL poly	Cool to 4ºC	48 hours
Alkalinity	Surface water, groundwater, & runoff	500 mL poly – No Headspace	Cool to 4°C; Fill bottle *completely*; Don't agitate sample	14 days
Ammonia	Surface water, groundwater, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Dissolved Organic Carbon	Surface water, groundwater, & runoff	60 mL poly with: Whatman Puradisc™ 25PP 0.45um pore size filters	Filter in field with 0.45um pore size filter; 1:1 HCl to pH<2; Cool to 4°C	28 days
Nitrate/Nitrite	Surface water, groundwater, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Total Persulfate Nitrogen	Surface water, groundwater, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Orthophosphate	Surface water, groundwater, & runoff	125 mL amber poly w/ Whatman Puradisc™ 25PP 0.45um pore size filters	Filter in field with 0.45um pore size filter; Cool to 4°C	48 hours
Total Phosphorous	Surface water, groundwater, & runoff	60 mL clear poly	1:1 HCl to pH<2; Cool to 4°C	28 days
Total Organic Carbon	Surface water & runoff	60 mL clear poly	1:1 HCl to pH<2; Cool to 4°C	28 days
Dissolved Iron	Groundwater	500 mL HDPE[2] bottle	Filter; Then HNO3 to pH<2 3; Cool to 4°C	6 months
Chlorophyll a	Surface water & periphyton	1000 mL amber poly	Cool to 4°C; If filtered in the field, freeze filters in acetone at -20°C	24 hrs to filtration; 28 days after filtration

TNVSS[1]: Total Nonvolatile Suspended Solids.
HDPE[2]: High-density polyethylene.

Two groundwater sampling events will be conducted in summer 2011 to assess the quality of groundwater discharging to the creek along gaining stream reaches. The samples will be evaluated for the parameters shown in Table 9.

Table 9. Groundwater sampling parameters including test methods and detection limits.

Parameter	Equipment Type and Test Method	Detection limit
Field Measurements		
Water level	Calibrated E-tape	0.01 foot
Temperature	Sentix® 41-3 probe[2]	0.1°C
Specific Conductance	Tetracon® 325 probe[2]	1 uS/cm
pH	Sentix® 41-3 probe[2]	0.1 s.u.
Dissolved Oxygen	Cellox® 325 probe[2]	0.1 mg/L
Laboratory Analyses		
Coliform, fecal (MF)	SM 9222D	1 CFU/100 mL
Alkalinity	SM 2320B	5 mg/L
Chloride	EPA 300.0	0.1 mg/L
Orthophosphate[1]	SM 4500-P G	0.003 mg/L
Total phosphorus[1]	SM 4500-P F	0.005 mg/L
Nitrate+nitrite-N[1]	SM 4500 NO_3^- I	0.01 mg/L
Ammonia[1]	SM 4500-NH_3^-H	0.01 mg/L
Total persulfate nitrogen-N[1]	SM 4500NB	0.025 mg/L
Dissolved organic carbon[1]	EPA 415.1	1 mg/L
Iron[1]	EPA 200.7	0.05 mg/L

[1] Dissolved fraction.
[2] Probe used with a WTW multiline P4 meter.
MF: Membrane filter method.
s.u.: Standard units.

Measurement Procedures

Field measurements will include conductivity, temperature, pH, and DO using a calibrated Hydrolab DataSonde® or MiniSonde® (Swanson, 2010). DO will also be collected and analyzed using the Winkler titration method (Mathieu, 2007).

Measurement of relative head conditions between the piezometer and the creek will be accomplished by direct comparison measurements using standard procedures for calibrated electric well probes (Marti, 2009; Sinclair and Pitz, 2010). Temperature dataloggers will also be downloaded monthly or bi-monthly using SOP protocols (Bilhimer and Stohr, 2009).

Instantaneous flow measurements will follow the EA Program protocol (Sullivan, 2007).

Continuous flow volumes at Ecology gages will be calculated from stage height records and rating curves developed during the project at three locations in the watershed. Proposed sites are Matney Creek at 68th St., China Ditch near Ward Road, and Fifth Plain Creek at Fourth Plain Road (SR 500). Stage height will be measured by pressure transducer and recorded by a datalogger every 15 minutes. All dataloggers will be downloaded monthly or bi-monthly to reduce potential data loss due to vandalism, theft, or equipment malfunction. Staff gages or tape-down measurements may be established at other selected sites. During the field surveys, staff gage/tape-down readings will be recorded at all stations, and streamflow will be measured when possible. A flow rating curve will be developed for sites with a staff gage or tape-down reference point so gage readings can be converted to a discharge value.

All continuously recording dataloggers will be synchronized to official U.S. time. The official time can be found at: www.time.gov/timezone.cgi?Pacific/d/-8/java. This information is available through (1) the National Institute of Standards and Technology (NIST), a Department of Commerce agency, and (2) the U.S. Naval Observatory (military counterpart of NIST). All date and time stamps will be recorded in Pacific Daylight Savings Time.

Data Quality Objectives

Field sampling procedures and laboratory analyses inherently have associated uncertainty which results in data variability. Measurement quality objectives state the desired data variability for a project. *Precision* and *bias* are data quality criteria used to indicate conformance with measurement quality objectives. The term *accuracy* refers to the combined effects of precision and bias.

Precision is defined as the measure of variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for replicate samples will be expressed as percent relative standard deviation (% RSD).

Bias is defined as the difference between the population mean and true value of the parameter being measured. Bias will be minimized by strictly following sampling and handling protocols. Field equipment will be pre-calibrated and post-checked and compared in a side by side manner with other calibrated instruments. Relative percent difference (RPD) will be used as a measure of bias where appropriate.

Field sampling precision and bias will be addressed by submitting field blanks and replicate samples. Manchester Laboratory will assess precision and bias in the laboratory through the use of check standards, duplicates, spikes, and blanks.

Field equipment and laboratory analytical methods, precision and bias objectives, method reporting limits and resolution, and estimated range for field and laboratory measurements are shown in Table 10. The targets for analytical precision of laboratory analyses are based on historical performance by MEL for environmental samples taken around the state by the EA Program (Mathieu, 2006). The laboratory's measurement quality objectives and quality control procedures are documented in the MEL *Lab Users Manual* (MEL, 2008).

A WTW 340i multi-meter will be used to measure water conductivity and temperature of groundwater in piezometers. A Hydrolab DataSonde® or MiniSonde® will be used to measure DO, temperature, pH, and conductivity of surface waters.

Table 10. Measurement quality objectives for measurement systems.

Analysis	Equipment Type and Method	Precision (Percent Relative Standard Deviation, %RSD)	Bias (Relative Percent Difference, RPD)	Method Lower Reporting Limit and/or Resolution	Estimated Range
Field Measurements					
Stream Velocity	Marsh McBirney Flo-Mate Model 2000	10%	NA	0.01 ft/s	0.01 – 10 ft/s
Water Temperature[1]	Hydrolab MiniSonde®	+/- 0.2° C	NA	0.01° C	0 – 30° C
Specific Conductivity	Hydrolab MiniSonde®	5%	10%	0.1 umhos/cm	20 – 1000 umhos/cm
pH[1]	Hydrolab MiniSonde®	+/- 0.05 s.u.	NA	0.01 s.u.	1 – 14 s.u.
Dissolved Oxygen[1]	Hydrolab MiniSonde®	+/- 0.2 mg/L	NA	0.1 mg/L	0 – 15 mg/L
Dissolved Oxygen[1]	Winkler Titration	+/- 0.2 mg/L	NA	0.1 mg/L	0 – 15 mg/L
Laboratory Analyses					
Fecal Coliform – MF	SM 9222D	50% of replicate pairs < 20% RSD; 90% of replicate pairs <50%[2]	40%	1 cfu/100 mL	1 – >5000 cfu/100 mL
Chloride	EPA 300.0	5%[3]	If sample is >5 times reporting limit, then 20% RPD	0.1 mg/L	0.1 – 250 mg/L
Total Suspended Solids	SM 2540D	15%[3]	See above	1 mg/L	1 – 5000 mg/L
Total Non-Volatile Suspended Solids	SM 2540 D, E	15%[3]	See above	1 mg/L	1 – 5000 mg/L
Turbidity	SM 2130	10%[3]	See above	1 NTU	1-100 NTU
Alkalinity	SM 2320B	10%[3]	See above	5 mg/L	5 – > 100 mg/L
Ammonia	SM 4500-NH_3^-H	10%[3]	See above	0.01 mg/L	0.01 – 20 mg/L
Dissolved Organic Carbon	EPA 415.1	10%[3]	See above	1 mg/L	1 – 20 mg/L
Nitrate/Nitrite	SM 4500-NO_3^- I	10%[3]	See above	0.01 mg/L	0.01 – 10 mg/L
Total Persulfate Nitrogen	SM 4500 NO_3^-B	10%[3]	See above	0.025 mg/L	0.025 – 20 mg/L
Orthophosphate	SM 4500-PG	10%[3]	See above	0.003 mg/L	0.003 – 1 mg/L
Total Phosphorous	SM 4500-PF	10%[3]	See above	0.005 mg/L	0.005 – 10 mg/L
Total Organic Carbon	EPA 415.1	10%[3]	See above	1 mg/L	1 – 20 mg/L
Chlorophyll-*a*	SM 10200H(3)	20%[3]	See above	0.05 ug/L	1 – 100 ug/L

[1] as units of measurement, not percentages.
[2] replicate results with a mean of less than or equal to 20 cfu/100 mL will be evaluated separately.
[3] replicate results with a mean of less than or equal to 5X the reporting limit will be evaluated separately.

SM: Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, 1998).
EPA: EPA Method Code.

Table 11 summarizes the manufacturer's stated accuracy (precision and bias) and resolution of the equipment used in groundwater and temperature surveys. Certain instruments are used exclusively for water temperature and others for air as noted in the table.

Table 11. Accuracy (precision and bias) and resolution of field equipment used for temperature and groundwater surveys.

Measurement/ Instrument Type	MQO* and Manufacturer's Stated Accuracy	Required Resolution
Continuous temperature/ Hobo Water Temp Pro v2	±0.2°C at 0 to 50°C (± 0.36°F at 32° to 122°F)	0.2°C for water temperature
Continuous temperature/ StowAway Tidbits -5°C to +37°C model	±0.4°F (±0.2°C) at +70°F	0.2°C for water temperature
Continuous temperature / StowAway Tidbits -20°C to +50°C model	±0.8°F (±0.4°C) at +70°F	0.4°C for air temperature
Hobo Pro Relative Humidity	±3% RH	n/a
Instantaneous conductivity and temp./ TetraCon 325C probe and WTW 340i multi-meter	±1% of value (conductivity) 0.2°C (temperature)	0.2°C for temperature

*Measurement Quality Objective

Representative sampling

The study is designed to have enough sampling sites and sufficient sampling frequency to meet study objectives. Some parameter values, especially FC, are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard procedures and collecting quality control samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the parameter value. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time. Laboratory and field errors are further expanded by estimate errors in seasonal loading calculations.

Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for the Lacamas Creek TMDL is to correctly collect and analyze 100% of the samples for each of the 31 sites, and 100% of the storm event samples and groundwater samples. However, problems occasionally arise during sample collection that cannot be controlled; this can interfere with the goal. Example problems are flooding, inadequate rain for storm sampling, site access problems, or sample container shortages. A lower limit of five samples per season per site will be required for comparison to Washington State criteria. This should easily be met with the current sampling design. For bacteria, WAC 173-201A states:

"When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period….and [the period of averaging] should have sample collection dates well distributed throughout the reporting period."

Investigatory samples may be collected at sites not included in this QA Project Plan, or, if necessary, a site may be added to further characterize problems in an area. Such sampling that does not meet the lower limit criteria of five samples per season (wet or dry) per site will still be useful for source location identification, recommendations, or other analyses. But such sampling will not be used to set load or wasteload allocations.

Quality Control

Total variability for field sampling and laboratory analysis will be assessed by collecting replicate samples. Replicate samples are a type of quality assurance/quality control (QA/QC) method. Sample precision and bias will be assessed by collecting replicates for 10-20% of samples in each survey. MEL routinely duplicates sample analyses in the laboratory to determine laboratory precision. The difference between field variability and laboratory variability is an estimate of the sample field variability.

Laboratory

MEL will analyze all samples. The laboratory's measurement quality objectives and QC procedures are documented in the MEL *Lab Users Manual* (MEL, 2008). Field sampling and measurements will follow QC protocols described in Ecology (1993). If any of these QC procedures are not met, the associated results may be qualified by MEL or the project manager and used with caution, or not used at all.

Bacteria samples tend to have a high relative standard deviation (RSD) between replicates compared to other water quality parameters. Bacteria sample precision will be assessed by collecting replicates for approximately 20% of samples in each survey.

Standard Methods (APHA, 1998) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for non-potable water tested for compliance purposes. MEL has a maximum holding time for microbiological samples of 24 hours (MEL, 2008). Standard Methods (APHA, 1998) recommends a holding time of less than 30 hours for drinking water samples and less than 24 hours for other types of water tested when compliance is not an issue. Microbiological samples analyzed beyond the 24-hour holding time are qualified as estimates with a *J* qualifier code. MEL accepts samples Monday through Friday, which means Ecology can sample Sunday through Thursday.

To identify any problems with holding times, two comparison studies were conducted during the Yakima Area Creeks TMDL (Mathieu, 2005). A total of 20 FC samples were collected in 500-mL bottles and each split into two 250-mL bottles. The samples were driven to MEL within 6 hours. One set of the split samples was analyzed upon delivery. The other set was stored overnight and analyzed the next day. Both sets were analyzed using the membrane filter (MF) method.

The combined precision results between the different holding times yielded a mean RSD of 19%. This is comparable to the 23% mean RSD between field replicates for 12 EA Program TMDL studies using the MF method, suggesting that a longer, 24-hour holding time has little effect on FC results processed by MEL. Samples with longer holding times did not show a significant bias towards higher or lower FC counts compared to the samples analyzed within 6-8 hours.

Field

Three instantaneous streamflow measurements will be replicated during each summer synoptic survey to check precision. Multiple flow meters may be compared to check for instrument bias or error. If a significant difference is found between flow meters (>5%), the instruments will be recalibrated or not used. Instantaneous flows may also be compared to Ecology or Clark County continuous stream gage results as an additional QA/QC measure.

QA/QC for field measurements begins with a calibration check of dataloggers. The Onset StowAway Tidbits© and the Hobo Water Temp Pro© thermistors will have a calibration check both pre- and post-study in accordance with Ecology Temperature Monitoring Protocols (Stohr, 2009). This check is done to document instrument accuracy at representative temperatures. A NIST-certified reference thermometer will be used for the calibration check. The calibration check may show that the temperature datalogger differs from the NIST-certified thermometer by more than the manufacturer-stated accuracy of the instrument (range greater than ±0.2°C or ±0.4°C).

A datalogger that fails the pre-study calibration check (outside the manufacturer-stated accuracy range) will not be used. If the temperature datalogger fails the post-study calibration check, the actual measured value will be reported along with its degree of accuracy based on the calibration check results. As a result, these data may be rejected or qualified and used accordingly.

Variation for field sampling of instream temperatures and potential thermal stratification will be addressed with a field check of stream temperature at all monitoring sites upon deployment, during regular site visits, and during instrument retrieval at the end of the 2011 study period. Air temperature data and instream temperature data for each site will be compared to determine if the instream thermistor was exposed to the air due to stream stage falling below the installed depth of the stream thermistor.

The WTW 340i multi-meter will be calibrated at the beginning of each sampling survey using commercially prepared conductivity standards and reference solutions in accordance with the manufacturer's calibration procedures. The calibration will be rechecked at the end of each survey.

Hydrolab MiniSonde® and DataSonde® DO, pH, and conductivity sensors will be calibrated according to manufacturer's recommendations and the Hydrolab SOP (Swanson, 2010). Temperature is factory-calibrated. Hydrolabs will be calibrated before each sampling survey and checked afterward using certified standards and reference solutions. During regular, non-synoptic surveys, Winkler DO samples will be taken at one or two sites each day and compared to the Hydrolab's DO measurements. Hydrolab results will be accepted, qualified, rejected, or corrected, as appropriate.

Three or more Winkler samples will be taken at each Hydrolab location during long-term deployments (up to one week during summer synoptic surveys) for comparison purposes. Conductivity, pH, and temperature will also be checked with another calibrated Hydrolab at the same time. The two Hydrolab's measurements will be compared and results from the deployed Hydrolab will be accepted, qualified, rejected, or corrected, as appropriate.

Corrective actions

QC results may indicate problems with data during the course of the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective action might include:

- Retrieving missing information.
- Re-calibrating the measurement system.
- Re-analyzing samples within holding time requirements.
- Modifying the analytical procedures.
- Collecting additional samples or taking additional field measurements.
- Qualifying results.

In addition, Hydrolab data may be corrected to a known standard or more accurate measurement. For example, if diel DO data from a Hydrolab is plotted on an Excel® chart and shows bias from the Winkler DO check values, the whole diel curve may be adjusted to “fit” or overlap the Winkler values. Winkler DO results are generally considered more accurate than Hydrolab DO results. Thus, correcting the Hydrolab results using the Winkler results will give us a more accurate representation of the true diel curve of DO throughout the course of the 24-hour period. If Ecology decides to correct any Hydrolab data (usually DO or pH) it will be noted. Raw data will still be included in the report. If any data is corrected, the correction methods will be explained in the final report.

Data Management Procedures

Field measurements will be entered into a water-resistant field book and then transferred into Excel® spreadsheets (Microsoft, 2001) as soon as practical after returning to the office. The spreadsheets will be used for preliminary analysis and to create a table to upload data into Ecology's Environmental Information Management database (EIM).

Sample result data received from MEL through Ecology's Laboratory Information Management System (LIMS) will be exported prior to entry into EIM and added to a cumulative spreadsheet for laboratory results. This spreadsheet will be used to informally review and analyze data during the course of the project.

All continuous data will be stored in a project database that includes station location information and data QA information. This database will facilitate summarization and graphical analysis of the temperature data and also create a temperature data table for uploading to the EIM geospatial database.

An EIM user study ID (TSWA0003) has been created for this TMDL. All monitoring data will be available via the internet once the project data have been validated. The URL address for this geospatial database is: http://apps.ecy.wa.gov/eimreporting/search.asp. After reviewing project data for quality and finalizing, the EIM data engineer will upload the data.

All final spreadsheet files, paper field notes, and final GIS and modeling products created as part of the data analyses and model building will be kept with the project data files.

Any existing data or non-Ecology data used in the TMDL analysis must meet the same precision and bias criteria as data collected by Ecology during the study.

Audits and Reports

The project manager will submit quarterly progress reports and the final technical study report to Ecology's Water Quality Program client (TMDL coordinator) according to the project schedule (Table 13).

Data Verification

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Lab Users Manual* (MEL, 2008). Lab results will be checked for missing and improbable data. Variability in lab duplicates will be quantified using the procedures outlined in the *Lab Users Manual* (MEL, 2008). Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each sampling event.

Field notebooks will be checked for missing or improbable measurements before leaving each site. The Excel® Workbook file containing field data will be labeled "Draft" until data verification and validation is complete. Data entry will be checked against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Validated data will be moved to a separate file labeled "Final."

As soon as FC data are verified by MEL, the laboratory microbiologist will notify the field lead about results greater than 200 cfu/100 mL. The field lead will then notify the Southwest Regional Office client staff contact and the Water Quality Program section manager of these elevated counts in accordance with EA Program Policy 1-03. The TMDL coordinator will notify local authorities or permit managers as appropriate.

The field lead will check data received through LIMS for omissions against the Request for Analysis forms. Data can be in Excel® spreadsheets (Microsoft, 2001) or downloaded tables from EIM. These tables and spreadsheets will be located in a file labeled "Draft" until data verification and validation is completed. Field replicate sample results will be compared to quality objectives in Table 10. The project manager will review data requiring additional qualifiers.

Data for instream temperature monitoring stations will be verified against the corresponding air temperature station to ensure the stream temperature record represents water temperatures and not temperatures recorded during a time the instream thermistor was dewatered. Measurement accuracy of individual thermistors is verified using a NIST-certified reference thermometer and field measurements of stream temperature at each thermistor location several times during the study period.

After data verification and data entry tasks are completed, all field, laboratory, and flow data will be entered into a file labeled "Final" and then uploaded into EIM. Another EA Program field assistant will independently review 10% of the project data in EIM for errors. If significant data entry errors are discovered, a more intensive review will be undertaken.

Data Quality (Usability Assessment)

The field lead will determine if measurement and other data quality objectives have been met for each monitoring station and each survey. The field lead will determine this by examining the data and all of the associated QC information. Data that does not meet the project data quality criteria will either be qualified or rejected. The final data set or report will not include rejected data. The field lead will produce a station QA report that will include site descriptions, data QA notes, and graphs of all continuous data, for inclusion in the project report.

Project Organization

Table 12 shows the roles and responsibilities of Ecology staff.

Table 12. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
(To be declared - position currently vacant) WQP, SWRO Phone: (360) 690-4664	Overall Project Lead	Acts as point of contact between EAP staff and interested parties. Coordinates information exchange. Forms technical advisory team and organizes meetings. Reviews the QAPP and technical section of the joint TMDL report. Prepares and implements the joint TMDL report for submittal to EPA.
Kim McKee WQP, SWRO Phone: (360) 407-6407	Unit Supervisor of Project Lead	Approves TMDL report for submittal to EPA. Temporarily fills role of Project Lead while position is vacant.
Trevor Swanson DSU/WOS/EAP Phone: (360) 407-6498	QAPP Author, Project Manager/ Field Lead/ EIM Engineer	Defines project objectives, scope, and study design. Writes the QAPP. Develops TMDLs for temperature, bacteria, and DO, including writing the technical section of the joint TMDL report. Manages the data collection program. Coordinates and conducts field survey and data collection. Enters project data into the EIM system and conducts data quality review.
Stephanie Brock DSU/WOS/EAP Phone: (360) 407-6517	Modeler and Mentor	Provides mentorship for modeling temperature, pH, DO, and associated parameters and technical portion of joint TMDL report.
Kirk Sinclair GFFU/EAP Phone: (360) 407-6557	Hydrogeologist	Provides hydrogeologic assistance with study design including interpretation of historical geology and groundwater data in the basin, groundwater data collection, data analysis, and report writing.
Chuck Springer FMU/WOS/EAP Phone: (360) 407-6997	Hydrogeologist	Deploys and maintains continuous flow gages and staff gages. Produces records of streamflow data at sites selected for this study.
George Onwumere DSU/WOS/EAP Phone: (360) 407-6730	Unit Supervisor of Project Manager	Reviews and approves the QAPP, staffing plan, technical study budget, and the technical sections of the joint TMDL report.
Robert F. Cusimano WOS/EAP Phone: (360) 407-6596	Section Manager of Project Manager	Approves the QAPP and technical sections of the joint TMDL report.
Stuart Magoon MEL/EAP Phone: (360) 871-8801	Director	Provides laboratory staff and resources, sample processing, analytical results, laboratory contract services, and quality assurance/quality control (QA/QC) data. Approves the QAPP.
William R. Kammin EAP Phone: (360) 407-6964	Ecology Quality Assurance Officer	Provides technical assistance on QA/QC issues. Reviews the draft QAPP and approves the final QAPP.

DSU: Directed Studies Unit.
EAP: Environmental Assessment Program.
EIM: Environmental Information Management database.
FMU: Freshwater Monitoring Unit.
GFFU: Groundwater/Forest and Fish Unit.
MEL: Manchester Environmental Laboratory.
QAPP: Quality Assurance Project Plan.
SWRO: Southwest Regional Office.
WOS: Western Operations Section.
WQP: Water Quality Program.

Project Schedule

Table 13 shows the proposed project schedule for the Lacamas TMDL study.

Table 13. Proposed schedule and assignments for completing field work, laboratory work, report writing, and data entry into EIM.

Field and laboratory work	
Field work completed	December 2011
Laboratory analyses completed	January 2012
Environmental Information Management database (EIM)	
EIM data engineer	Trevor Swanson
EIM user study ID	TSWA0003
EIM study name	Lacamas Creek Fecal Coliform Bacteria, Temperature, Dissolved Oxygen, and pH TMDL
Data due in EIM	April 2012
Quarterly/annual reports	
Author lead	Trevor Swanson
Schedule	
1st quarterly/annual report	March 2011
2nd quarterly/annual report	June 2011
3rd quarterly/annual report	September 2011
4th quarterly/annual report	January 2012
Groundwater report	
Activity Tracker code	(Not assigned yet)
Author lead	Kirk Sinclair
Schedule (estimate)	
Draft due to supervisor	(Not assigned yet)
Draft due to client/peer reviewer	(Not assigned yet)
Draft due to external reviewer	(Not assigned yet)
Final report due on web	November 2012
Final report	
Author lead	Trevor Swanson
Schedule	
Draft due to supervisor	June 2013
Draft due to client/peer reviewer	July 2013
Draft due to external reviewer	September 2013
Final report due on web	March 2014

Laboratory Budget

Table 14 presents the estimated laboratory budget for this study. The budget and lab sample load are based on:

1. Sampling bacteria at each fixed-network site twice per month.
2. One periphyton assessment.
3. Two synoptic surface-water surveys.
4. Two groundwater quality surveys (corresponding with 3 above).
5. Two storm sampling events for bacteria.
6. One summer storm sampling event for bacteria, nutrients, TSS + TNVSS, TOC and DOC.

The greatest uncertainty in the laboratory workload and cost estimate is with the synoptic storm survey work since the storm sites have not yet been selected. However, efforts will be made to keep the submitted number of samples within the estimate provided here.

Table 14. Laboratory budget.

Parameter	Cost*/ Sample	# of Sites	Times Sampled per day	Number of Samples (including field QA)	Number of Surveys	Total Number of Samples	Total Cost
Turbidity	11.42	19	2	42	2	84	959
Total Suspended (TSS) + TNVSS**	36.34	19	2	42	2	84	3053
Alkalinity	17.65	19	2	42	2	84	1483
Chloride	13.50	19	2	42	2	84	1134
Chlorophyll-a (lab filtered)	57.10	19	2	42	2	84	4796
Ammonia (NH3)	13.50	19	2	42	2	84	1134
Nitrite-Nitrate (NO2/NO3)	13.50	19	2	42	2	84	1134
Total Persulfate Nitrogen (TPN)	17.65	19	2	42	2	84	1483
Orthophosphate (OP)	15.57	19	2	42	2	84	1308
Total Phosphorus (TP)	18.69	19	2	42	2	84	1570
Periphyton (biovolume, ID)	80.10	19	1	21	2	42	3364
Dissolved Organic Carbon	37.34	19	2	42	2	84	3137
Total Organic Carbon	34.26	19	2	42	2	84	2878
Fecal Coliform	23.88	31	1	37	24	888	21205
Two bacteria storm sampling events, plus one summer storm sampling event for all parameters							$8,745
Additional samples (e.g., for additional storm sampling or unknown sources)							$5,000
Groundwater sampling (including iron)							$5,557

*Costs include 50% discount for Manchester Laboratory. Total $67,939

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Anthropogenic: Human-caused.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day, and falls during the night).

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10- to 10,000- fold over a given period. The calculation is performed by either:

(1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load allocation: The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, storm water, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, municipal separate storm sewer systems, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: Water quality constituent being measured (analyte).

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Phase II stormwater permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reserve Capacity: A calculated amount of pollutant loading sometimes incorporated into the TMDL to allow for uncertainty and future growth.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

System potential: The design condition used for TMDL analysis.

System potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system potential condition uses best estimates of *mature riparian vegetation, system potential channel morphology, and system potential riparian microclimate* that would occur absent any human alteration.

Synoptic sampling: All site sampled in over a short period of time (usually one day).

Thalweg: The deepest moving portion of a stream's channel.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Turbidity: A measure of the amount of suspended silt or organic matter in water. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest

7-day average flow that can be expected to occur once every ten years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

Acronyms and Abbreviations

BMP	Best management practices
DO	(See Glossary above)
EA	Environmental Assessment
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
FC	(See Glossary above)

MEL	Manchester Environmental Laboratory
NAD	North American Datum
NIST	National Institute of Standards and Technology
NPDES	(See Glossary above)
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
TMDL	(See Glossary above)
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cfu	colony forming units
ft	feet
mg	milligrams
mg/L	milligrams per liter (parts per million)
mL	milliliters
NTU	nephelometric turbidity units
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
umhos/cm	micromhos per centimeter
uS/cm	microsiemens per centimeter, a unit of conductivity

Water Quality Standards rule making

- Brief outline of Rule
- Governors proposal
- Risks/concerns
- Path forward

Water Quality Standards rule making

- Proposed changes to WAC 173-201A,Water Quality Standards for Surface Waters of the State embedding Human Health Criteria (HHC) for toxic compounds into the standards.
- Toxic compound list attached, includes PCBs, mercury, arsenic, pesticides, metals…
- Proposals driven by EPA mandates for all States to implement updates to toxic rules
- Rule would apply to all dischargers to Surface Waters of the State, including Public and Private discharges for sewer and stormwater
- Impacts will be community specific depending on the make up of discharge and the water body you are discharging to.

Water Quality Standards rule making

- Governors proposal/draft rule
  - Embed HHC rules in WAC 173-201A by changing formula in water quality standards including fish consumption, cancer risk and other variable parameters. (discussion of DEIS alternatives)
  - Implementation tools for NPDES permits include intake credits, compliance schedules and variances.
  - Implement State authority to remove toxic chemicals at source. Currently part of legislative agenda.
- AWC's position – see attachment

Water Quality Standards rule making

- Risks associated with supporting Governors package:
  - Requested legislation to manage toxic materials at source is not passed or Environmental/Tribal sue/appeal package as not restrictive enough
  - EPA rejects current rule making effort and takes lead for implementation
- Risks associated with not supporting Governors package:
  - Governor/Ecology come back with more restrictive rule package and/or EPA intervenes with Federal rule.
- Oregon adoption 3 years ago
  - Included same fish consumption amount and more conservative cancer risk assumption
  - Describe cost impacts to municipal dischargers they have experienced, if any

Water Quality Standards rule making

- Local discussion
  - Meet with Camas business stakeholders to inform them of the process and gather concerns/comments
  - Complete a preliminary discharge assessment for the Camas WWTP as it relates to the Toxic Chemical list.
  - Draft recommended comments for Council consideration as part of the rule making testimony and legislative process.
  - Consider working with Discovery Clean Water Alliance to evaluate regional impacts as details of the process emerge.

Water Quality Standards rule making

- Timeline
  - Draft rule published
  - Feb 2 Workshop presentation
  - Feb 10 meet with Camas stakeholder group to provide information and feedback
  - Feb 17th update Council
  - Rule making Public Hearings March, 2015 throughout the State
  - Staff recommended comments March 16 council meeting
  - Submit comments by March 23rd, 2015 on draft rule
  - Track legislative action and rule making. Engage with regional partners. Update Council

Water Quality Standards rule making

- Questions?

JAY INSLEE
Governor

Policy Brief
July 2014

"It is clear to me that Washington state needs to reach beyond the confines of our historical regulatory approaches and recognize how water pollution has changed in the 40 years since the Clean Water Act became law."

Governor Jay Inslee

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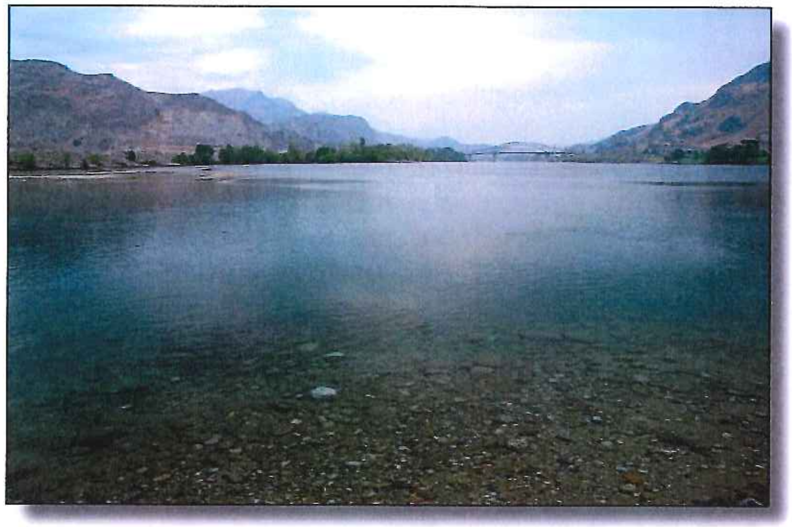


Ensuring Safe, Clean Water for Healthy People and a Strong Economy:

Updating Washington's water quality standards to meet today's toxic threats

The federal Clean Water Act requires that waterways be safe for the public's intended uses. If a lake is used for swimming, it needs to be clean enough that people can swim in it safely. If people eat fish from a lake or bay, the fish need to be safe enough to eat. How a water body is used helps determine how clean it needs to be.

Washington state is in the process of updating its clean water standards, as required under the Clean Water Act. If the state does not act soon, the federal government could step in and impose its own standards on Washingtonians.

Our water quality regulations, which are designed to protect Washington's water bodies, apply to "permitted dischargers," or those facilities owned by businesses or local governments that discharge pollution to Washington waters. These facilities are regulated through permits that control how much pollution they are allowed to discharge.

When the Clean Water Act was passed more than 40 years ago, the main concern was uncontrolled pollution coming out of large pipes from large facilities. Today, pollution from those facilities is controlled through a mature regulatory system and technological responses. While there's more work to be done, we've come a long way. Today, our bigger concern is the uncontrolled release of chemical pollutants that come from diffuse, largely unregulated sources — from the brakes on our cars to the flame retardants in our furniture. Under the old regulatory approach, we would continue to ratchet down limits for permitted facilities without getting at the real problem and without adequately protecting Washingtonians from real toxic threats. It's time for a new approach.

Governor Inslee's approach

In updating Washington's water quality standards, Governor Jay Inslee believes we must find an approach that recognizes how water pollution has changed in the four decades since the Clean Water Act became law. And he has insisted that Washington's approach must do three things: protect all Washingtonians, including those who eat a lot of fish; protect clean water; and protect our economy. Choosing between these priorities is not an option. After close study and much work, the Governor has charted an innovative new course that accomplishes this goal by tightening standards to protect high consumers of Washington fish and going after toxic pollution at its source while making it possible for businesses and local governments to meet the new standards.

Revising our water quality standards

Current standards — set in the early 1990s — assumed that people eat 6.5 grams of Washington fish per day, or about a serving a month. We know that many people in this state — such as Native Americans and recreational fishers — eat much more fish than this. Our regulations need to reflect this fact and protect all Washingtonians.

Under the Governor's approach, water quality standards will be designed to protect people who eat 175 grams (about one serving) of Washington fish per day, instead of today's unrealistically low rate.

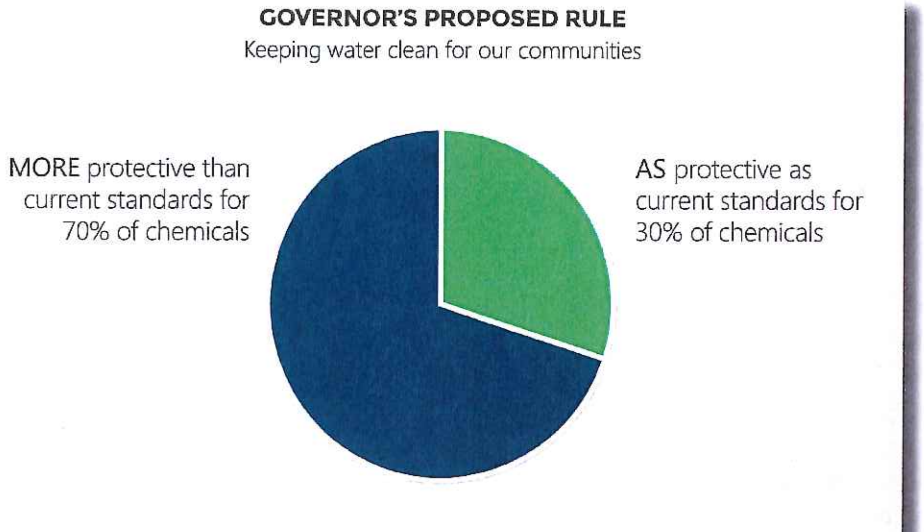
The state's cancer risk rate will be set at 10^{-5}, meaning that if a person were to eat a 175-gram serving of fish from Washington waters every day for 70 years, he or she would have a 1-in-100,000 chance of developing cancer. In about 70 percent of cases, standards will be more protective. In other cases where this cancer risk rate would result in a less protective standard than we currently have, today's standards will be maintained.

A separate approach will be used for arsenic, which is a naturally occurring element in waters throughout the state. Our current standard for arsenic is not attainable and essentially meaningless because it is set below levels that occur naturally in much of our surface water and groundwater. Governor Inslee proposes to use the federal drinking water standard for arsenic. By setting the new standard at drinking water levels, industrial dischargers won't be asked to meet an impossible standard.

Ensuring compliance with standards is possible

In some cases it will be difficult or impossible to meet these new standards without regulatory tools that recognize this challenge. A permitted discharger may be required to comply with limits on a chemical even if it isn't the source of that chemical in the discharge. In some cases, technologies may not yet be available to remove toxics down to the standards. And in some cases, reduction efforts could take far longer than the standard five-year period of most permits. The Governor's proposal includes implementation tools to address these situations while requiring dischargers to take all appropriate actions to reduce pollution.

This will include a tool the state has never used: variances. When meeting certain standards is not possible, variances could provide municipalities and businesses the time needed to achieve compliance as long as they are taking active and consistent steps toward meeting those standards.



The Governor's proposed water quality rule will result in standards that are more protective for 70% of regulated toxics. A majority of those will be 2-20 times more protective.

Attacking pollution at its source

While we are increasing levels of protection on discharges from permitted facilities, the fact remains that facilities are often not the sources of the chemicals we are most concerned about. Focusing only on these facilities will have limited benefit in reducing toxics regulated under this rule and will not address the larger universe of unregulated contaminants.

Much of this unregulated pollution is simply unnecessary, existing only because there are no requirements or incentives to avoid the use of chemicals that threaten people and the environment. Governor Inslee is proposing a new approach that targets known, unregulated toxic threats, discourages introducing problem chemicals into widespread commerce when safer approaches are available, and focuses efforts to find and eliminate sources of toxic pollution across the state.

The Governor's proposal would:

1. ***Move immediately to combat known, high-priority pollution.***
   - » Direct the departments of Health and Ecology to identify and report on actions to address the following toxic threats:
     - PCBs, a toxic chemical found in fish around the state
     - Phthalate plasticizers, a suspected endocrine disruptor found in many consumer products
     - Toxic flame retardants that pose cancer and reproductive risks in the home and workplace
     - Zinc, which is harmful to aquatic invertebrates and plants and comes from sources such as roofing and tires
   - » Direct the Department of Ecology to use Chemical Action Plans to identify actions to reduce threats from priority chemicals.

2. Get toxic chemicals out of consumer products.

» Pass legislation to require industries to look for safer, alternative approaches when we identify a toxic chemical in commerce that threatens our health or environment.

» Authorize the Department of Ecology to ban the use of certain toxic chemicals when we know that such use is creating unacceptable exposure risk and safer alternatives are available.

» Accelerate "green chemistry" to advance the availability of safer chemicals in manufacturing processes.

» Direct the Department of Enterprise Services to work with the Department of Ecology to provide recommendations that ensure state purchasing practices require safer products when available.

3. Find and eliminate specific sources of problem chemicals in polluted watersheds.

» Where pollution levels are elevated, attack pollution sources — permitted and unpermitted — in partnership with local, federal and tribal governments.

» Conduct voluntary Lean management exercises, in partnership with businesses, to eliminate the unnecessary use of toxic chemicals in industrial processes, which saves money and reduces potential pollution.

4. Fund efforts to better understand sources of toxic pollution and new technologies to address them.

» Increase monitoring to better identify pollution sources and measure the effectiveness of cleanup actions.

» Investigate possible sources of toxic pollution — such as certain roofing materials and associated components — to inform prevention efforts.

» Expand research into pervious pavement, rain gardens and other technologies to reduce toxic pollution in stormwater.

» Fund Washington State University efforts to understand why salmon die from stormwater runoff before they can spawn.

5. Provide accountability and transparency to ensure the job gets done.

» Invite regular input from the public, stakeholders and local, federal and tribal governments to ensure we're prioritizing the right chemicals in the right parts of the state.

» Regularly report to the public and the Legislature on progress and obstacles, to be accountable and ensure we make real gains.

Results that count

Many have seen this issue as a choice between healthy people, clean water or the economy. By looking beyond federally mandated regulations, Governor Inslee has laid out a course that advances all three goals. This approach protects Washingtonians who eat large amounts of local fish, recognizes and responds to the changing face of toxic pollution in Washington, and confirms the need for predictability and certainty for permitted dischargers.

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PUBLISHED ON FRIDAY, JULY 11, 2014

Governor Inslee Announces New Approach on Major Water Quality Standards – the "Fish Consumption" Issue

Yesterday afternoon Governor Inslee announced a new approach on the contentious water quality standards update commonly referred to as the "fish consumption" rule. The rule will have a significant impact on the regulation of wastewater and stormwater over the coming decades, as water quality standards will become more stringent for many chemicals that may appear in municipal wastewater and stormwater. Cities have been engaged with this rule for several years, participating in several official and informal advisory bodies with the Governor and the Department of Ecology (DOE).

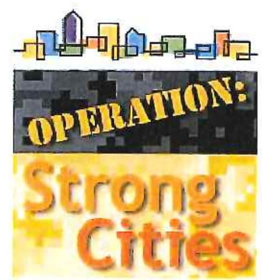
> *"We greatly appreciate the Governor's personal time and involvement in understanding how this issue affects the cities and utility ratepayers of Washington,"* said Mike McCarty, AWC CEO. *"We have learned over the last several years how incredibly complicated this issue is, so we are looking forward to seeing the details before we make a final assessment. However, we are encouraged with the Governor's efforts to put forward a balanced plan to improve the health and safety of Washingtonians."*

Below you will find a brief background of this issue, information on how this proposal advances the discussions, and specific technical details and timelines for Governor Inslee's proposal.

Background

This water quality standards update has come to be known as the "fish consumption" rule since a central element of the formula that generates the standards is based on the daily amount of fish consumed by a person (fish consumption rate). The general idea of how fish consumption relates to water quality, is that the quality of the State's water will have an impact on the health of the fish living within it. The health of those fish will ultimately impact the health of the people who eat them - depending on how much fish a person eats. Under the current standards, the consumption rate is set at 6.5 grams of fish per person per day. There has been a multi-year effort by DOE to raise the consumption rate to more accurately reflect populations who generally consume higher amounts of fish, such as tribal members. The current standards also assume a theoretical cancer risk rate of 10^{-6}. This means that if a person were to eat a 6.5 gram serving of fish from Washington waters every day for 70 years, he or she would have a one-in-one-million chance of developing cancer. Whether or not to adjust that cancer risk rate to other levels allowed by the EPA has also been a significant part of the discussion. This decision has a significant impact on the resulting standards and attainability.

Cities have participated in the rulemaking process for water quality standards, and support strong standards to protect water quality and human health. Since city utility ratepayers will ultimately be asked to fund systems that can meet these standards, AWC has focused on what the costs and benefits of these new standards would be, and whether potential new standards could actually be met with current technology. AWC has also expressed concern that severe problems with meeting standards may arise if elements of the formula are adjusted without careful consideration of what that will do to the ultimate water quality standards that we have to meet, and without providing additional flexibility and other adjustments within the rule.



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Moving Forward

The recent announcement from the Governor begins a new phase in the discussions regarding water quality standards. In addition to announcing his proposed pathway forward on the standards, he also announced that his solution would be broader than just a water quality standard update. It would include a package of actions that attempt to focus on the sources of toxic pollutants instead of focusing solely on changes to standards for discharging entities. AWC has been advocating for the need for this broader approach because regulated dischargers, such as municipalities and industrial dischargers, are a small portion of the total water quality picture.

We are encouraged with the direction this proposal is taking, but cautious that a complicated issue such as this encompasses many details that need to be fully understood, and in some cases developed. In some senses, it is more straightforward how these proposals will impact wastewater facilities; however, significant questions remain on what this means for stormwater regulations. We have outlined the technical details of the new approach below.

AWC will continue to be closely involved with this process. If you have questions or comments, please contact Carl Schroeder.

Technical Details of Governor Inslee's Proposal:

- Increases the Fish Consumption Rate to 175 grams per day.
- Applies a 10^{-5}cancer risk level except where that would result in water quality standards becoming less stringent than they are today. This decision has a significant impact on the standards for certain toxics, and is a change from current policy that results in standards that are more likely to be attainable for local governments.
- Incorporates a unique approach for Arsenic that reflects the fact that it is a naturally occurring toxic.
- Includes a set of implementation tools designed to make compliance easier for permittees/dischargers, including variances and compliance schedules that are longer than currently practiced. This is a key component of the proposal for cities, and we need to carefully review details as they become available.
- Outlines a suite of actions on non-point toxics centered around authority for the Department of Ecology to evaluate alternatives to certain priority toxic chemicals in manufacturing, and potentially ban the use of those with safer alternatives. Additional actions include: funding support for local source control efforts, monitoring and research, investment in new cleanup technology, and others. Details on these efforts are yet to be fleshed out, and will emerge over the next several months.

Timeline

The Governor has directed the Department of Ecology to issue a preliminary draft rule no later than September 30. Governor Inslee will submit legislation to the Legislature in 2015 to enact elements of the broader toxic reduction package, and will make a decision on whether to adopt the final rule only after seeing the outcome of the session. He will then ask EPA to consider the benefits of the full package in determining federal approval of Washington's clean water standards.

Categories: Environment and land use, Stormwater

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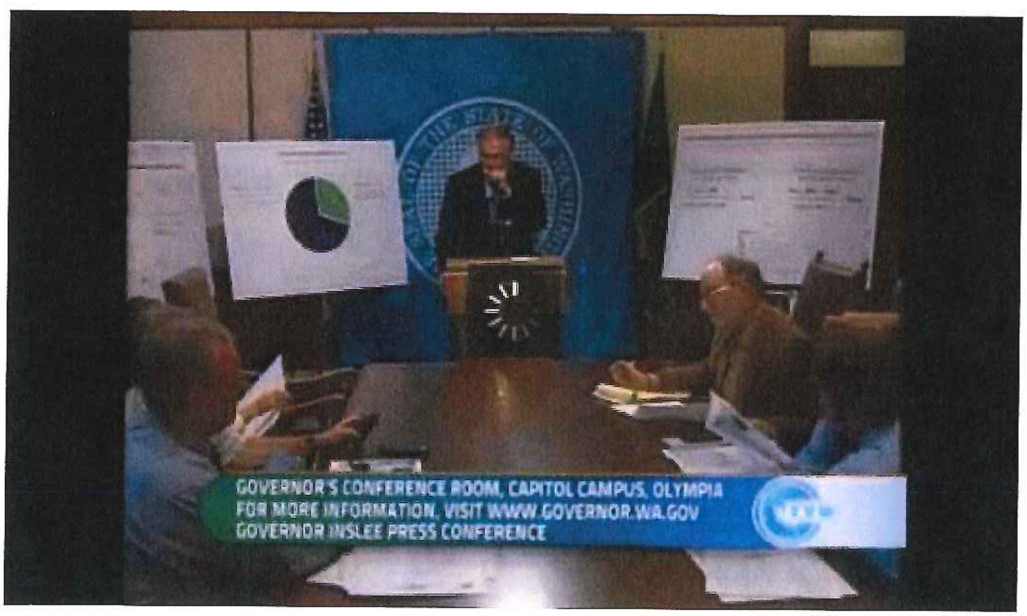
GRAHAM & DUNN

Governor Inslee Issues His Policy Brief on Updating Washington's Water Quality Standards

By Doug Steding on July 10th, 2014

Governor Inslee held a press conference yesterday morning, where he presented his policy brief on Washington's ongoing efforts to update its water quality standards to account for higher fish consumption rates. This has been a long time coming, and is a significant development on what is arguably the most important environmental rulemaking effort Washington has seen in years.

The video of the press conference is here, my summary and thoughts follow:



The Governor's proposed approach is consistent with what we've been hearing from Ecology and other sources over the past few months. Governor Inslee proposes to adjust the fish consumption rate (used to calculate water quality criteria for toxics) from 6.5 grams a day (the default in the National Toxics Rule, the current applicable water quality standards for toxics in Washington) to 175 grams per day. This adjustment has been coming for some time, so the new 175 gram per day number isn't surprising. What is also not surprising is the proposal to use the federal drinking water standard for arsenic instead of the current standard, which is below background because of high levels of naturally occurring arsenic in Washington's waters.

The most controversial part of his plan has to do with the acceptable cancer risk used in calculating the new criteria. Governor Inslee is proposing to adjust the acceptable excess cancer risk level from one in a million to one in one hundred thousand, with the potential to offset the impact that the much higher fish consumption rate has on numeric criteria for toxics. This is a concept that has emerged over the past year as a work-around to the exceedingly low (and often unattainable) numeric criteria that result from the ~30 fold increase in fish consumption rate. The native tribes in Washington are not enthusiastic about this change, nor is EPA Regional Administrator Dennis McLerran, although the adjustment in excess cancer risk is consistent with EPA's Clean Water Act regulations and guidance. Had the Governor gone beyond the one in one hundred thousand risk level, EPA policies may have required more robust consideration of the public interest (although it appears the Governor has deeply considered many aspects of the public interest) and EPA policies also require more robust quantification of the actual risk level because of the decreasing amount of conservatism built into higher risk levels. Finally, when this adjustment to the excess cancer risk results in an increase to an individual numeric criterion as compared to the old NTR criterion, Governor Inslee is proposing to retain the older, lower, numeric criterion.

There has been much debate about whether the new criteria are attainable, with the adjustment of the excess cancer risk being driven by the concerns of industrial and municipal dischargers. The new criteria will still be, in some instances, exceedingly difficult to attain for dischargers. As a result, the Governor is including in his proposal more robust implementation tools, including schedules of compliance with longer timeframes, and, for the first time, waterbody-specific variances to allow individual dischargers to achieve compliance with the new criteria. The use of variances is important because it is likely that many of the issues faced by dischargers in achieving compliance with the proposed criteria will be location-specific. But, variances require EPA approval, and it remains to be seen how such variances can be adopted in an era of decreasing agency resources (and perhaps cooling relations between Ecology and Region 10 if the disagreement over excess cancer risk rate isn't resolved).

The most sweeping and ambitious part of the Governor's proposal is the inclusion of a wide variety of proposed measures designed to address the disconnect between using the 40-year-old Clean Water Act to address toxics that are coming from diffuse (and not CWA-regulated) sources. These proposals are aimed to compensate for the adjustment to the excess cancer risk, and, politically, appear to represent the Governor's attempt at balancing the various interests on various sides of this debate. The Governor is including in his proposal a number of action items to address these diffuse sources of toxics to fish (many of which likely will require legislative action), including:

1. Directing the Department of Health and Ecology to perform studies and identify actions to address a number of toxics, including PCBs, phthalates, flame retardants, and zinc.

2. Pass legislation to require industries to look for safer alternatives to toxics in consumer products.

3. Authorize Ecology to ban the use of certain toxic chemicals.

4. "Attack" pollution sources in watersheds in partnership with local, federal, and tribal governments.

5. Funding of various studies related to sources of toxics and technologies to address those sources.

6. Soliciting feedback from stakeholders and provide information to the legislature.

What are my initial reactions? First, it is important to not lose track of the lawsuit filed against EPA for allegedly failing to act in response to Washington's delay in revising its water quality standards. If the Plaintiffs prevail, this lawsuit has the potential to derail the Governor's efforts, although if I had to bet, I think EPA and Ecology will prevail. The bigger unknown here is whether the Governor can build the political consensus needed to pass the legislative package that he is including in this proposal. It is likely that we won't know the answer to that question until the next legislative session ends in late April 2015, and the Governor very clearly noted that he will not share the final water quality standard package with EPA for review and approval until the Legislature has acted on his yet-to-be seen legislative agenda. This legislative timeline presents a potential problem for the Governor, as EPA Regional Administrator McLerran has promised publicly to promulgate toxics standards for Washington if Ecology does not revise the standards by the end of the year. Whether Mr. McLerran softens his position is probably an issue of tribal acceptance, which, so far, is mixed at best.

In sum? The devil will be in the details of the legislation Governor Inslee will be proposing, and the nature of that legislation will probably determine whether Governor Inslee maintains support from businesses and unions, or gains the support of tribes and environmental interests (many of whom declined to participate in the roundtable effort that led up to this proposal). This effort shows the difficulty of building political consensus with respect to such a highly controversial issue. If the Governor does not get tribal approval for this plan, I am wondering if a lawsuit based on treaty rights is looming. If the Governor does not get Region 10 to back off a bit, he may run into issues at the end of the year with EPA stepping into Ecology's shoes and promulgating new water quality standards that lack the flexibility and pragmatism that is contained in the Governor's proposal. And, at the end of the rulemaking process, if he doesn't craft a final rule that appropriately balances the competing interests, a lawsuit led by the unhappy stakeholders is a strong possibility.

Governor Inslee deserves credit for making difficult choices on a politically charged issue. He also deserves credit for acknowledging the lack of a "fit" with respect to the Clean Water Act and modern environmental challenges, and the need to think differently in terms of reducing toxics in the environment. From a science, law and policy perspective, the next year or so will be an interesting time and the results of this effort will likely shape the environmental law and compliance landscape for years to come.

Graham & Dunn
Pier 70
2801 Alaskan Way - Ste 300
Seattle, WA 98121-1128
Phone: 206.624.8300
Fax: 206.340.9599
Email: info@grahamdunn.com

SCIENCE, LAW & THE ENVIRONMENT

Emerging Topics in Environmental Law

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Ecology Releases Preliminary Draft Rule Adjusting Washington's Water Quality Standards to Account for Higher Fish Consumption Rates

By Doug Steding on September 30th, 2014

As directed by Governor Inslee back in July, the Washington Department of Ecology released a preliminary draft rule that will ultimately lead to the amendment of Washington's Water Quality Standards for toxics. This is the next step in a multi-year process under which Washington is adjusting its WQS to account for a higher fish consumption rate. The documents released today include:

1. Draft rule language for toxics;

2. Draft rule language for implementation tools, such as variances, intake credits, and compliance schedules;

3. A preliminary draft cost benefit and least burdensome alternative analysis;

4. A memorandum explaining why the proposed rule is exempt from the requirement under the Regulatory Fairness Act to prepare a Small Business Economic Impact Statement (because Ecology has concluded that the proposed rule amendments do not impose cost on existing businesses in any industry);

5. A preliminary implementation plan after the rule is adopted;

6. An overview of key decisions made in the rule amendments; and

7. A SEPA determination of significance and scoping notice.

The rule language for the toxics criteria is consistent with what we've expected, and covers 96 total chemicals. The new fish consumption rate under the proposed rule is 175 grams per day, and the excess cancer risk changes from one-in-a-million to one-in-one hundred thousand. And, consistent with Governor Inslee's announcement in July, where the application of these new variables results in a greater numeric criterion as compared to the old WQS for toxics (the values in the National Toxics Rule), the new criterion will default to the old NTR number, which, as characterized by Ecology, means that there will be no new standards that are less protective of human health as the old standards. The three exceptions to this framework are arsenic, copper and asbestos, all of which will have new criteria based on the Safe Drinking Water Act. In addition, the rule has a narrative criteria that address chemicals not included on the list of 96 for which numeric criteria are proposed.

The implementation tools are also what we expected. Those tools include a new section that allows for intake credits that account for pollutants already present in water that are simply passing through a permitted facility; a new definition and rule language related to compliance schedules, which deletes the current ten year limit on such schedules (consistent with recent changes to RCW 90.48.605 made by the legislature); and new rule language defining a "variance" and establishing minimum qualifications for granting variances to individual dischargers.

However, what caught my eye in all of the above documents was the draft cost-benefit analysis. One of the main controversies surrounding this process was the potential for new criteria based on a higher fish consumption rate to cause many dischargers to not be able to meet the revised standards, for instance, municipal dischargers projected that standards based on the 175 gram per day rate (and an excess cancer risk of one in a million) would have resulted in unattainable standards for many municipal wastewater treatment plants. Governor Inslee's proposal back in July to adjust the excess cancer risk upward by a factor of ten was in response to these types of concerns. The draft cost-benefit analysis contains a detailed analysis of the projected impacts on a number of permitted dischargers, and concludes that, of the 415 (183 industrial and 232 municipal) permit holders in Washington, none would be impacted. The draft cost-benefit analysis also concludes that 55 waterbodies will be listed as impaired under Section 303(d) of the CWA (which leads to the development of Total Maximum Daily Loads or "TMDLs") as a result of the adoption of the new WQS, but 50 of the 55 waterbodies did not have NPDES permitted dischargers on them–leading Ecology to conclude that only three dischargers would be impacted by the change in 303(d) listings.

Ecology also looked at the benefits to fish consumers associated with the new rule. This is sure to be a controversial subject during the comment period that opens in January. Ecology went through an exercise where it calculated that the new rule would result in cancer risk reductions valued at $6 million to $90 million (related to reduced mortality from cancer) and reduced treatment costs of $400 thousand to $2 million. These benefits, according to Ecology, far outweigh the costs of the rule.

The public comment period for the proposed rule opens in January, timed with the legislative session, where the Governor will be pursuing a broader agenda to address toxics in the environment from sources not regulated by the Clean Water Act. We'll keep reporting on developments as they come up.

Graham & Dunn
Pier 70
2801 Alaskan Way - Ste 300
Seattle, WA 98121-1128
Phone: 206.624.8300
Fax: 206.340.9599
Email: info@grahamdunn.com

Missoulian

Big stakes in Washington state fish consumption debate

June 07, 2014 12:30 pm • By PHUONG LE, Associated Press (0) Comments

SEATTLE – A bitter fight over how much fish people eat – and thus how clean Washington waters should be – has pitted tribes, commercial fishermen and environmental groups against Boeing, business groups and municipalities.

The state Department of Ecology appears ready to boost the current fish consumption rate, an obscure number that has huge ramifications for the state because it drives water quality standards. A higher number means fewer toxic pollutants would be allowed in waters.

"So much is at stake," said Kelly Susewind with the Department of Ecology, adding: "People are worried about what we might do. Are we going to be protective enough? Are we going to drive business out of the state? That ups the ante."

Meanwhile, the regional head of the U.S. Environmental Protection Agency has warned the state that the EPA intends to take over the process if the state doesn't finalize a rule by the 2014. And a coalition of environmental groups is asking a federal judge in Seattle to get the EPA to step in and force the state to complete a rule or to do it themselves.

The state missed its own March deadline to release a draft rule. With "strong guidance" from Gov. Jay Inslee, the state is still deliberating and may not have a draft rule until later this summer, Susewind said.

Inslee has gotten personally involved in the issue, calling a taskforce representing tribal, business and environmental interests to advise him.

It's a political balancing act for the Democratic governor, who has made the environment a central issue but also has shown a willingness to accommodate companies like Boeing Co. The aerospace giant in March raised concerns to Inslee that the proposals "will have unintended consequences for continued Boeing production in the state."

Inslee spokesman David Postman said the governor believes a balance is possible and "that's what he's working for."

For years, the state has known it needs to update its fish consumption rate, which federal regulators say doesn't sufficiently protect those who eat the most fish, particularly Native Americans and Pacific Islanders.

Studies have shown Washington residents eat more fish than other people nationwide, but the state currently assumes people eat about 6 1/2 grams a day – or about a small fillet once a month.

The state is now certain to boost that amount, and is considering a fish consumption rate between 125 and 225 grams of fish a day. Oregon set its rate at 175 grams a day, the highest for a U.S. state.

While a higher fish rate would make standards more stringent, Ecology is also considering changing another factor in the complicated formula that would likely make standards less stringent. The proposal would increase by tenfold the excess cancer risk rate from certain cancer-causing chemicals.

The Northwest Indian Fisheries Commission, Puget Soundkeeper Alliance and others groups have told Inslee that a less-protective cancer risk level is unacceptable, and would disproportionately harm those who eat the most fish. They worry that a higher cancer risk level would offset gains elsewhere.

The Association of Washington Business, local governments such as Everett and others, meanwhile, have told Inslee that keeping the cancer risk factor at its current rate is "unacceptable" and, coupled with a high fish consumption rate, would result in "unmeasurable incremental health benefits, and predictable economic turmoil."

Tags Jay Inslee, Washington, Fish Products, Fish, Boeing, United States Environmental Protection Agency, Seattle, Boeing Co., Oregon

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November 7, 2013 in City, Health

State's fish consumption rates to be updated

Becky Kramer The Spokesman-Review

Tags: Boeing Department of Ecology fish consumption standards Kelly Susewind water quality

Timeline

The Department of Ecology expects to release a draft rule on fish consumption rates early next year.

With the Pacific Ocean for one border and the Columbia River for another, it's no surprise that fish is a regular part of many Washington residents' diets.

But when it comes to setting water quality standards to protect fish eaters, the state has been using outdated data.

Washington's estimate for fish consumption is one 8-ounce fillet per person per month, despite studies that reveal much higher rates for American Indians, people of Asian heritage and recreational fishermen and fisherwomen.

On Wednesday, the Washington Department of Ecology unveiled several proposals for updating the rates. The proposals are intended to reduce cancer risks and exposure to toxins for people who eat lots of fish and shellfish, said Kelly Susewind, manager of the department's water quality program.

The highest consumption rate being considered is a daily 8-ounce fish meal. It's based on high levels of fish and other seafood in the diets of members of Puget Sound's Suquamish Tribe and some people who fish recreationally. The state is also considering Oregon's standard, equivalent to about 24 8-ounce fillets per month, and another standard of 16 fillets monthly.

Fish is rich in healthy omega oils, but eating fish also exposes people to mercury, lead, arsenic, PCBs and other toxins. Increasing the state's fish consumption rates will tighten pollution standards for industries that discharge into lakes, rivers and bays.

The standards under consideration would require reducing pollution discharges by 50 percent to 97 percent, Susewind said during a Wednesday meeting.

"The more fish you eat, the cleaner the water has to be," he said. "We know that some of those standards will take a long time to achieve ... We know that people can't meet those levels today."

Earlier efforts to update Washington's fish consumption rates were hampered by opposition from aerospace giant Boeing and the pulp and paper industry. Last month, environmental groups and commercial fishing interests sued the U.S. Environmental Protection Agency, charging that EPA has let the state dither too long over updating the standards.

In response to questions, Susewind said Gov. Jay Inslee is committed to a "balanced approach" that protects the health of Washington residents without driving business away from the state.

The Department of Ecology expects to release a draft rule on fish consumption rates early next year.

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Anger over wolf attacks rekindles at Washington agency meeting - The Spokesman-Review
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THE SPOKESMAN-REVIEW

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Appendix B

Criteria values for each alternative and current detection limits

Freshwater Human Health Criteria (HHC) alternatives and corresponding methods and levels for analysis.

	Freshwater HHC (Consumption of water & organisms)				Analytical Methods and Quantitation Levels*	
Chemical Name	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**EPA or Standard Methods (SM) Method**	**Quantitation Level**
1,1,2,2-Tetrachloroethane	0.17	1.4	0.17	0.12	624	2
1,1,2-Trichloroethane	0.60	5.0	0.60	0.44	624	2
1,1-Dichloroethylene	0.057	1,300	0.057	230	624	2
1,2,4,5-Tetrachlorobenzene	NC	NC	NC	0.11	NL	NL
1,2,4-Trichlorobenzene	NC	36	36	6.4	625	0.6
1,2-Dichlorobenzene	2,700	614	614	110	624	7.6
1,2-Dichloroethane	0.38	4.0	0.38	0.35	624	2
1,2-Dichloropropane	NC	4.4	4.4	0.38	624	2
1,2-Diphenylhydrazine	0.040	0.16	0.040	0.014	1625B	20
1,2-Trans-Dichloroethylene	NC	703	703	120	624	2
1,3-Dichlorobenzene	400	91	91	80	624	7.6
1,3-Dichloropropene	10	10	10	0.30	624	2
1,4-Dichlorobenzene	400	91	91	16	624	17.6
2,3,7,8-TCDD (Dioxin)	0.000000013	0.000000064	0.000000013	0.00000000051	1613B	0.000005
2,4,5-TP	NC	NC	NC	10	NL	NL
2,4,5-Trichlorophenol	NC	NC	NC	330	1653	2.5
2,4,6-Trichlorophenol	2.1	2.6	2.1	0.23	625	4

(Cont'd). Freshwater Human Health Criteria (HHC) alternatives and corresponding methods and levels for analysis.

	Freshwater HHC (Consumption of water & organisms)				Analytical Methods and Quantitation Levels*	
Chemical Name	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**EPA or Standard Methods (SM) Method**	**Quantitation Level**
2,4-D	NC	NC	NC	10	NL	NL
2,4-Dichlorophenol	93	26	26	23	625	1
2,4-Dimethylphenol	NC	87	87	76	625	1
2,4-Dinitrophenol	70	71	70	62	625	2
2,4-Dinitrotoluene	0.11	1.0	0.11	0.084	609/625	0.4
2-Chloronaphthalene	NC	171	171	150	625	0.6
2-Chlorophenol	NC	16	16	14	625	2
2-Methyl-4,6-Dinitrophenol	13.4	11	11	9.2	625/1625B	2
3,3'-Dichlorobenzidine	0.040	0.031	0.031	0.0027	605/625	1
4,4'-DDD	0.00083	0.00036	0.00036	0.000031	608	0.05
4,4'-DDE	0.00059	0.00025	0.00025	0.000022	608	0.05
4,4'-DDT	0.00059	0.00025	0.00025	0.000022	608	0.05
Acenaphthene	NC	108	108	95	625	0.4
Acrolein	320	1.0	1.0	0.88	624	10
Acrylonitrile	0.059	0.20	0.059	0.018	624	2
Aldrin	0.00013	0.000057	0.000057	0.0000050	608	0.05
alpha-BHC	0.0039	0.0051	0.0039	0.00045	608	0.05
alpha-Endosulfan	0.93	9.7	0.93	8.5	608	0.05
Anthracene	9,600	3,310	3,310	2,900	625	0.6
Antimony	14	15	14	5.1	200.8	1
Arsenic	0.018	0.047	10	2.1	200.8	0.5
Asbestos	7,000,000 fbrs/L	7,000,000 fbrs/L	7,000,000 fbrs/L	7,000,000 fbrs/L	NL	NL
Barium	NC	NC	NC	1,000	200.8	2
Benzene	1.2	18	1.2	0.44	624	2

(Cont'd). Freshwater Human Health Criteria (HHC) alternatives and corresponding methods and levels for analysis.

	Freshwater HHC (Consumption of water & organisms)				Analytical Methods and Quantitation Levels*	
Chemical Name	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**EPA or Standard Methods (SM) Method**	**Quantitation Level**
Benzidine	0.00012	0.00020	0.00012	0.000018	625	24
Benzo(a)Anthracene	0.0028	0.015	0.0028	0.0013	625	0.6
Benzo(a)Pyrene	0.0028	0.015	0.0028	0.0013	610/625	1
Benzo(b)Fluoranthene	0.0028	0.015	0.0028	0.0013	610/625	1.6
Benzo(k)Fluoranthene	0.0028	0.015	0.0028	0.0013	610/625	1.6
beta-BHC	0.014	0.018	0.014	0.0016	608	0.05
beta-Endosulfan	0.93	9.7	0.93	8.5	608	0.05
Bis(2-Chloroethyl)Ether	0.031	0.23	0.031	0.020	611/625	1
Bis(2-Chloroisopropyl) Ether	1,400	1,300	1,300	1,200	625	0.6
Bis(2-Ethylhexyl) Phthalate	1.8	2.3	1.8	0.20	625	0.5
Bromoform	4.3	38	4.3	3.3	624	2
Butylbenzyl Phthalate	NC	215	215	190	625	0.6
Carbon Tetrachloride	0.25	1.2	0.25	0.10	624/601 or SM6230B	2
Chlordane	0.00057	0.00093	0.00057	0.000081	608	0.05
Chlorobenzene	680	421	421	74	624	2
Chlorodibromomethane	0.41	3.6	0.41	0.31	624	2
Chloroform	5.7	301	5.7	260	624 or SM6210B	2
Chloromethyl ether, bis	NC	NC	NC	0.000024	NL	NL
Chrysene	0.0028	0.015	0.0028	0.0013	610/625	0.6
Copper	NC	1,300	1,300	1,300	200.8	2
Cyanide	700	700	700	130	335.4	10
Dibenzo (a,h) Anthracene	0.0028	0.015	0.0028	0.0013	625	1.6
Dichlorobromomethane	0.27	4.9	0.27	0.42	624	2
Dieldrin	0.00014	0.000061	0.000061	0.0000053	608	0.05

(Cont'd). Freshwater Human Health Criteria (HHC) alternatives and corresponding methods and levels for analysis.

	Freshwater HHC (Consumption of water & organisms)				Analytical Methods and Quantitation Levels*	
Chemical Name	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**EPA or Standard Methods (SM) Method**	**Quantitation Level**
Diethyl Phthalate	23,000	4,300	4,300	3,800	625	7.6
Dimethyl Phthalate	313,000	96,000	96,000	84,000	625	6.4
Di-n-Butyl Phthalate	2,700	455	455	400	625	1
Dinitrophenols	NC	NC	NC	62	NL	NL
Endosulfan Sulfate	0.93	9.7	0.93	8.5	608	0.05
Endrin	0.76	0.034	0.034	0.024	608	0.05
Endrin Aldehyde	0.76	0.034	0.034	0.030	608	0.05
Ethylbenzene	3,100	934	934	160	624	2
Fluoranthene	300	16	16	14	625	0.6
Fluorene	1,300	441	441	390	625	0.6
gamma-BHC (Lindane)	0.019	1.0	0.019	0.17	608	0.05
Heptachlor	0.00021	0.000091	0.000091	0.0000079	608	0.05
Heptachlor Epoxide	0.00010	0.000045	0.000045	0.0000039	608	0.05
Hexachlorobenzene	0.00075	0.00033	0.00033	0.000029	612/625	0.6
Hexachlorobutadiene	0.44	4.1	0.44	0.36	625	1
Hexachlorocyclo-hexane, technical	NC	NC	NC	0.0014	NL	NL
Hexachloro-cyclopentadiene	240	174	174	30	1625B/625	1
Hexachloroethane	1.9	3.3	1.9	0.29	625	1
Indeno (1,2,3-cd) Pyrene	0.0028	0.015	0.0028	0.0013	610/625	1
Isophorone	8.4	304	8.4	27	625	1
Manganese	NC	NC	NC	NC	200.8	0.5
Methoxychlor	NC	NC	NC	100	NL	NL
Methyl Bromide	48	42	42	37	624/601	10
Methylene Chloride	4.7	49	4.7	4.3	624	10

(Cont'd). Freshwater Human Health Criteria (HHC) alternatives and corresponding methods and levels for analysis.

	Freshwater HHC (Consumption of water & organisms)				Analytical Methods and Quantitation Levels*	
Chemical Name	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**	**EPA or Standard Methods (SM) Method**	**Quantitation Level**
Methylmercury	NC	NC	NC	NC	NL	NL
Nickel	610	156	156	140	200.8	0.5
Nitrates	NC	NC	NC	10,000	NL	NL
Nitrobenzene	17	16	16	14	625	1
Nitrosamines	NC	NC	NC	0.00079	NL	NL
N-Nitrosodibutylamine	NC	NC	NC	0.0050	NL	NL
N-Nitrosodiethylamine	NC	NC	NC	0.00079	NL	NL
N-Nitrosodimethylamine	0.00069	0.0078	0.00069	0.00068	607/625	4
N-Nitrosodi-n-Propylamine	NC	0.052	0.052	0.0046	607/625	1
N-Nitrosodiphenylamine	5.0	6.3	5.0	0.55	625	1
N-Nitrosopyrrolidine	NC	NC	NC	0.016	NL	NL
Pentachlorobenzene	NC	NC	NC	0.15	NL	NL
Pentachlorophenol	0.28	1.7	0.28	0.15	625	1
Phenol	21,000	10,700	10,700	9,400	625	4
Polychlorinated Biphenyls (PCBs)	0.00017	0.000073	0.00017	0.0000064	608	0.5
Pyrene	960	331	331	290	625	0.6
Selenium	NC	141	141	120	200.8	1
Tetrachloroethylene	0.80	2.7	0.80	0.24	624	2
Thallium	1.7	0.24	0.24	0.043	200.8	0.36
Toluene	6,800	4,100	4,100	720	624	2
Toxaphene	0.00073	0.00032	0.00032	0.000028	608	0.5
Trichloroethylene	2.7	16	2.7	1.4	624	2
Vinyl Chloride	2.0	0.26	0.26	0.023	624/SM6200B	2
Zinc	NC	2,300	2,300	2,100	200.8	2.5

*From Attachment A – Effluent characterization for permit application.

(Available online at: http://www.ecy.wa.gov/programs/wq/permits/forms.html.)

HHC Alternative 1	Not proceed with any rule revisions and remain under the National Toxics Rule for human health criteria. This uses a fish consumption rate of 6.5 grams/day and a risk level of one in a million for the carcinogenic chemicals.
HHC Alternative 2	This uses a fish consumption rate of 175 grams/day and a risk level of one in 100,000 for the carcinogenic chemicals.
HHC Alternative 3	This is the preferred alternative and the alternative presented in the September 30, 2014 preliminary draft rule. This uses a fish consumption rate of 175 grams/day, a policy overlay that no calculated criteria will be less protective than the existing NTR and a decision to use a risk level of one in 100,000 for the carcinogenic chemicals.
HHC Alternative 4	Adopt criteria identical to the criteria adopted in Oregon State.

General Notes:

All criteria and analytical level values are expressed as µg/L unless noted otherwise

Red Font indicates Carcinogen

NC = No Criterion

NL = Not Listed

HHC Alternative 1 (NTR) calculated using a Body Weight (BW) of 70 kg; HHC Alternatives 2 & 3 use a BW of 80 kg.

HHC Alternatives 1, 2, & 3 calculated using a Drinking Water Intake (DI) of 2 L/day.

HHC Alternative 4 (Oregon Criteria) generally calculated using a FCR = 175 g/day, BW = 70kg, DI = 2 L/day, and Risk = 10^{-6}.
See Oregon Criteria (online at http://www.deq.state.or.us/wq/standards/toxics.htm) for additional details

Gray & Osborne, Inc.
CONSULTING ENGINEERS

January 15, 2015

Mr. Steve Wall, P.E.
Public Works Director
City of Camas
616 NE Fourth Avenue
Camas, Washington 98642

SUBJECT: PROPOSAL FOR NPDES PERMIT REVIEW – 2015 AMENDMENT
CITY OF CAMAS, CLARK COUNTY, WASHINGTON
G&O #12454.00

Dear Mr. Wall:

Per your request, Gray & Osborne, Inc. is submitting this proposal for an amendment to our existing contract for NPDES Permit Review.

For this project, I will continue to serve as Project Manager. As indicated in the attached Exhibit B, the estimated cost of the attached scope of work is the not-to-exceed amount of $9,750.

Please advise us should you require any additional information concerning this proposal.

Sincerely,

GRAY & OSBORNE, INC.

Jay L. Swift, P.E.

JLS/hhj
Encl.

cc: Mr. Jim Hodges, Capital Projects Manager, City of Camas

701 Dexter Avenue N., Suite 200 Seattle, Washington 98109 (206) 284-0860 Fax (206) 283-3206

CITY OF CAMAS – NPDES PERMIT REVIEW – 2015 AMENDMENT

Gray & Osborne, Inc. is hereby authorized to proceed with the engineering services as noted herein and under the terms and conditions of our current On-Call Water and Wastewater Engineering Services Contract dated December 2, 2013, for a cost not to exceed $9,750 as noted herein without further written direction and authorization of the City.

Name (Print)	Title
Signature	Date

EXHIBIT A

SCOPE OF WORK

CITY OF CAMAS
NPDES PERMIT REVIEW – 2015 AMENDMENT
ENGINEERING SERVICES

The following provides a scope of work for Gray & Osborne, Inc. to provide engineering services as an amendment for our existing NPDES Permitting Support scope. The scope of work includes evaluation of a: (1) the draft state waste discharge permit for Linear Technology Corporation, and (2) a new draft and final NPDES permit for the City's Wastewater Treatment Facility (WWTF).

PROPOSED SCOPE OF WORK

The proposed scope of work is described below.

1. Review the draft State Waste Discharge (SWD) Permit for Linear Technology Corporation. Evaluate the proposed sulfate limits in the SWD Permit and in WWTF influent for consistency with past MAHL (maximum allowable headworks loading) limits established in the *Neutralized Sulfuric Acid Disposal Study* (Gray & Osborne, April 2010). Provide comments to the City and draft response letter language for the City's use.

2. Conduct an "entity review" of the draft NPDES Permit for the City's WWTF. Evaluate the new permit for changes from the previous permit, impact to the City's operations, regulatory risk, and costs. Evaluate consistency of the new permit with the City's Wastewater Facility Plan and General Sewer Plan and understandings/agreements with Ecology. Review and verify key calculations. Prepare a draft comment letter for the City's review. Incorporate City comments into the review letter and submit it to Ecology.

3. Perform a "public review" of the draft NPDES Permit for the City's WWTF for the same issues described in Task 2. Prepare a draft comment letter for the City's review. Incorporate City comments into the review letter and submit it to Ecology.

4. Review the final permit and Ecology's responses to comments, and provide recommendations for any follow-up actions by the City.

5. Provide additional NPDES or SWD permitting support as directed by the City.

6. Attend up to two meetings.

EXHIBIT B

ENGINEERING SERVICES
SCOPE AND ESTIMATED COST

City of Camas - NPDES Permit Review - 2015 Amendment

Tasks	Principal Hours	Project Manager Hours	Project Eng. Hours
1 Linear Technology Corporation Permit Review		8	2
2 Review and Comment - "Entity Review" Draft NPDES Permit for City's WWTF	2	16	4
3 Review and Comment - "Public Review" Draft NPDES Permit for City's WWTF	1	8	2
4 Review and Comment - Final NPDES Permit for City's WWTF	1	4	1
5 Additional Permit Review as Directed by City		8	4
6 Meetings	3	6	
Hour Estimate:	7	50	13
Direct Labor Cost Billing Rate Range:	$35 to $59	$35 to $56	$33 to $43
Estimated Hourly Rates:	$55	$42	$37
Direct Labor Cost:	$385	$2,100	$481

Subtotal Direct Labor:	$	2,966
Indirect Costs (180%):	$	5,339
Total Labor Cost:	$	8,305
Fee (15%):	$	1,246
Subtotal Labor & Fees:	$	9,551
Direct Non-Salary Cost:		
Mileage & Expenses (Mileage @ $0.57/mile)	$	199
TOTAL ESTIMATED COST:	**$**	**9,750**

* Actual labor cost will be based on each employee's actual rate. Estimated rates are for determining total estimated cost only.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

January 8, 2015

CERTIFIED MAIL 7013 1710 0002 3967 6472

Mr. Eric Levison
Public Works Director
City of Camas
616 Northeast 4th Avenue
Camas, WA 98607

Re: National Pollutant Discharge Elimination System (NPDES) Permit No. WA0020249, City of Camas Wastewater Treatment Plant

Dear Mr. Levison:

The Department of Ecology (Ecology) has completed processing your NPDES permit application. Enclosed for your review are a draft permit and fact sheet. The purpose of sharing these drafts with you at this time is to identify any factual errors prior to the draft permit and fact sheet being released for public comment. Please submit written information on any factual errors you find in these documents no later than **15 days** from the date of this letter to:

Carey Cholski
Permit Administrator
Water Quality Program
Southwest Regional Office
P.O. Box 47775
Olympia, WA 98504-7775

If you have hired a consultant to help with the permitting process, you should contact them to help you with your review.

We plan to start the formal public comment period on your draft permit shortly after the 15-day comment period ends. At that time, you will receive a copy of the public review draft of the fact sheet and permit. You should carefully review the draft documents and submit comments during the public review period.

Following the public review period, Ecology will consider all comments received; we will then prepare a final permit and responsiveness summary to all comments received. The responsiveness summary will become an appendix to the fact sheet which accompanies the final permit. Changes may be made to the draft permit as a result of the public review process.

If you have any questions about the permit and fact sheet, please contact Dave Knight at 360-407-6277, or by e-mail at david.j.knight@ecy.wa.gov. If you have any questions about the schedule for issuing the permit, please call me at 360-407-6279, or e-mail me at carey.cholski@ecy.wa.gov.

Sincerely,

Carey Cholski

Carey Cholski
Permit Administrator
Water Quality Program
Southwest Regional Office

CC(0020249)
Enclosures

cc: Bob Busch, City of Camas

TUALATIN · VANCOUVER · SALEM
9600 NE 126TH AVENUE, SUITE 2520 · VANCOUVER, WA 98682
AKS ENGINEERING & FORESTRY
WWW.AKS-ENG.COM
P: (360) 882-0419 F: (360) 882-0426

January 26, 2015

City of Camas
Attn: Steve Wall
PO Box 1055
Camas, WA 98607

RE: Professional services proposal for the Jones 2015 Timber Sale.

Mr. Wall:

Attached is our estimate to provide professional forest management, forest engineering and turbidity monitoring for the Jones 2015 Timber Sale located in Clark County, Washington.

This proposal is based on the adopted City of Camas Boulder Creek and Jones Creek Forest Management Plan and our extensive experience working on similar projects throughout the Pacific Northwest and for the City. We look forward to working with you on this project. Please give me a call if you have any questions or comments.

Sincerely,
AKS Engineering & Forestry Vancouver, LLC

Alexander H. Hurley, PE, PLS
Principal

LETTER OF AGREEMENT FOR PROFESSIONAL SERVICES

This agreement is made between the City of Camas (Client) and AKS Engineering & Forestry Vancouver, LLC (AKS) to provide professional forestry, forest engineering, and turbidity monitoring for the Jones 2015 Timber Sale located in the Boulder Creek and Jones Creek Watershed (Sections 3,4,9, and 12, T2N, R4E, W.M., Clark County, Washington).

PROJECT UNDERSTANDING

The City would like to implement the second harvest entry into the Boulder Creek and Jones Creek Watershed. The project deliverables will include contract administration of the Jones 2015 Timber Sale Contract, tree planting administration and monitoring services for the harvested units, and turbidity monitoring at one location within the watershed downstream of the proposed harvest units. The project will also include consultation with the City in regards to coordination with the BPA about their proposed access roads and transmission lines within the City's watershed.

SCOPE OF WORK

The following list of items outlined are services AKS will be responsible for completing.

TIMBER SALE ADMINISTRATION

CONTRACT ADMINISTRATION:
The following services described below will be provided for the duration of the Jones 2015 Timber Sale Contract:

- Attend pre-work conference to meet selected Contract Buyer and subcontractors to review Timber Sale Contract and determine plan of operations.
- Perform site visits as necessary during sale operations to ensure compliance with the timber sale contract. Up to one visit per day during active operations may be necessary.
- Review log truck tickets and payments to ensure the City is receiving adequate payments for forest products removed.
- Timber Sale close-out procedures to ensure all contract terms have been met.

POST-SALE ADMINISTRATION

TREE PLANTING ADMINISTRATION:
These services will include the following activities to re-plant the Jones 2015 Timber Sale harvest units:
- Reserve seedlings on behalf of the City.
- Prepare tree planting contract documents (City is responsible for legal portion of contract and bidding).
- Provide Contract Administration of the Tree Planting Contract to ensure compliance.

Note that the cost of purchasing trees is not included and tree seedling costs can fluctuate.

TREE SURVIVAL MONITORING:
Monitoring services include performing site visits and tree survival surveys for the first three years following tree planting. It is required under the Forest Practice Act to replant and ensure the planted trees survive the initial years and be determined as “Satisfactory Reforestation”. This will require 1-2 site visits to perform survival surveys and report findings to the State with an additional site visit to monitor competing vegetation. AKS will provide recommendations for any site vegetation management that may be required to release the planted trees from any competing vegetation.

BPA COORDINATION
These services include coordination with the City in regards to meeting with the BPA and/or their sub consultants to discuss and provide advice on the proposed transmission lines, tower locations, and access roads within the City’s watershed. AKS anticipates up to three meetings and a two site visits will be required to assist the City’s decision making process for final access road locations. Providing existing road replacement values, maintenance considerations and reviews of the BPA road design plans are included in this scope.

REIMBURSABLE EXPENSES

AKS anticipates the following reimbursable expenses correlated with the contract administration, post-sale administration, and BPA coordination services:

- Mileage
- Copies
- Deliveries
- Clerical

TURBIDITY MONITORING:
AKS understands that the City wants to begin gathering information on possible impacts on water quality prior to harvesting operations above the water intake facilities. Monitoring turbidity levels is the best procedure to ascertain a correlation between stormwater runoff before and following timber harvest above the intake facilities. The initial monitoring efforts will occur over a 2 year time frame surrounding the Jones 2015 Timber Sale. During this time frame, a baseline for turbidity levels can be established for either Jones Creek or Boulder Creek and an analysis can be performed on potential effects of the Jones 2015 Timber Sale. A threshold of exceedance of turbidity, measured in NTUs, should also be established from this data to set parameters for determining when action should be taken. For example, if there is an elevated turbidity reading that exceeds the determined baseline, further investigation measures should be taken to determine if there was a naturally occurring slide or a slide from a harvesting operation. Mitigation, if deemed appropriate, could be determined at that point in time.

EQUIPMENT AND MONITORING STATION
Continuous monitoring of the turbidity levels within a single stream will require complete dedication of the equipment for the duration of the monitoring. The recommended equipment for monitoring turbidity includes a single-parameter sonde with a turbidity sensor and associated field cables. A monitoring station will need to be established by using miscellaneous items such as PVC-pipe, steel t-posts and steel cables to try to secure and protect the equipment from the public and stream debris. AKS will purchase the necessary equipment for this monitoring station and anticipates approximately two man days will be required to fabricate and install the monitoring station in the designated stream location.

CONTINUOUS MONITORING AND REPORTING

A 15 minute sampling interval is recommended in order to capture natural events (peak rain fall, slides, etc.) and maintain continuous monitoring of the turbidity levels at the monitoring station. Monitoring services will continue from February 2015 through May 2017 to capture several months of the following wet weather season in order to provide comparable data throughout the timber harvesting process. Services to maintain the monitoring efforts will include the following:

-Initial site calibration: this includes verifying accurate measurements through the use of a portable turbidity meter, downloading data from the sonde after multiple data collection intervals, and reducing the data to ensure the equipment is functioning properly.
-Site visits: based on projected battery life, site visits are assumed to be necessary every three weeks to ensure uninterrupted data collection due to dead batteries. However, during the first three months of operations, frequency of site visits will be varied from 1 week to 4 weeks to test actual battery life. Depending on observed battery life, the frequency of site visits during long term monitoring efforts will be adjusted to minimize costs.
-Data reduction and semiannual reports: the collected turbidity data will be reduced with the necessary software and semiannual reports will be produced. The semiannual reports will include graphs and general statistics about the turbidity levels and a short summary of the information with comparisons to local rain gages. The report schedule will follow the Jones 2015 Timber Sale operational seasons such as (June 2015 and Sept. 2015) and (June 2016 and Sept. 2016).
-Final reporting: the semiannual reports will be available for the City at any time during the monitoring process; however, a comprehensive report will be provided following the monitoring timeline of February 2015 through May 2016. The final report will compile all semiannual reports and summarize the results of the study to compare turbidity levels at the designated monitoring station pre-timber harvest against post-timber harvest in the watershed.
-Possible investigation: if the turbidity monitoring discovers abnormally high turbidity readings such as from a landslide, AKS will investigate upstream reaches to attempt to determine the cause of the high turbidity outputs. AKS will report the findings to the City and work with the City on potential resolutions if determined appropriate.

MONITORING REIMBURSABLE EXPENSES

AKS anticipates the following reimbursable expenses correlated with the turbidity monitoring services:

- Mileage
- Copies
- Deliveries
- Clerical

ESTIMATE FOR SERVICES

TIMBER SALE ADMINISTRATION	
CONTRACT ADMINISTRATION:	**$40,000**
POST-SALE ADMINISTRATION	
TREE PLANTING ADMINISTRATION:	**$7,000**
TREE SURVIVAL MONITORING:	**$3,000**
BPA COORDINATION:	**$5,000**
REIMBURSABLE EXPENSES:	**$3,000**
TURBIDITY MONITORING	
EQUIPMENT AND MONITORING STATION:	**$9,500**
CONTINUOUS MONITORING AND REPORTING:	**$17,000**
REIMBURSABLE EXPENSES:	**$1,000**
TOTAL ESTIMATED COST (WITHOUT TURBIDITY MONITORING):	**$58,000**
TOTAL ESTIMATED COST (INCLUDING TURBIDITY MONITORING):	**$85,500**

ASSUMPTIONS:

- Contract Administration services assumes that the timber sale will be active during the summers of 2015 and 2016; therefore, an eight month timeframe is assumed necessary to complete the timber sale and that daily inspections are required. Costs will be less if the sale is completed in one summer and fewer inspections are required.
- Public outreach services and meetings are not included in this proposal.
- The tree planting contract is to be prepared by AKS with review by the City Attorney.
- The post sale administration does not include the cost to purchase the tree seedlings.
- Tree survival monitoring is only for the first three years following planting. Additional monitoring may be necessary depending on the condition of the planted trees. Additional monitoring services can be determined at that time.
- BPA Coordination efforts do not include analyzing full impacts of the transmission lines or access roads within the Watershed. These impacts (loss of timber production, seedling loss, etc.) can be evaluated at a later time upon the City's request with additional contract scope.
- Turbidity monitoring estimates are only for one monitoring station for the described monitoring cycle of February 2015 through May 2017. Continued monitoring beyond the initial monitoring cycle can be determined at a later date.
- AKS will attempt to set up the monitoring station in a secure area that will not be damaged by high stream flows, debris, vandalism, etc. In the event that the equipment is damaged due to factors outside of AKS' control, the City of Camas will be responsible for the cost of replacement equipment.
- The estimate does not include possible permitting fees associated with the Turbidity Monitoring.

BASIS OF FEE AND BILLING:

In consideration for performing said services, the Client agrees to compensate AKS on an hourly basis at our standard rates. Invoices will be issued monthly for work performed the previous month.

EXCLUSIONS:

Services not specifically included.

Fees or bonds required by affected governmental bodies for review, filing, and submission of plans, drawings, and plats are not included in the estimate. Title company fees are not included.

See attached "General Provisions".

____
AKS Engineering & Forestry Vancouver, LLC

Date 01-26-15

AKS Engineering & Forestry Vancouver, LLC
9600 NE 126th Avenue, Suite 2520
Vancouver, WA 99682

____
Mayor Scott Higgins

Date _______________________________

City of Camas
PO Box 1055
Camas, WA 98607

GENERAL PROVISIONS

1. **REIMBURSABLE EXPENSES**: Reimbursable expenses of AKS Engineering & Forestry, LLC (AKS) shall be those expenses incurred directly for the project, including but not limited to transportation costs, meals, lodging, computer services, printing, permit fees, and binding charges. Reimbursement for these expenses shall be on the basis of actual costs (if incurred through an outside vendor) or at AKS' current cost rates.
2. **OUTSIDE SERVICES**: Any technical or professional services furnished by an outside consultant or contractor will be billed at cost.
3. **AKS' FEES AND FEE ESTIMATES:** Unless otherwise agreed in writing, charges for all AKS' services will be billed in accordance with AKS' rate schedule in effect at the time the services are performed. Any estimate provided by AKS will be provided on the basis of experience and judgment, but AKS cannot warrant that actual time and expenses will not vary from these fee estimates.
4. **PAYMENT TO AKS**: Monthly invoices will be issued by AKS for all work performed under the terms of this Agreement. Invoices are due and payable on receipt. All amounts more than 30 days past due will be subject to finance charges. Finance charges are computed at a periodic rate of 1.5% per month (which is an annual percentage rate of 18%), unless another rate is mandated by law, in which case the finance charge shall equal the maximum interest rate allowed by law. Client agrees that, if it disputes any portion of an invoice, Client must notify AKS of such dispute in writing within 30 days of the invoice date, which notice must set forth the disputed amount and the reason for such dispute. Client hereby waives any right to dispute an invoice more than 30 days after an invoice's date.
5. **FAILURE TO PAY**: Client acknowledges that failure to timely pay any amount hereunder is a material breach of this Agreement, and that AKS may, in its sole discretion, suspend service and all other obligations under this contract and/or under any other contract between AKS and Client (and/or between AKS and any other client subject to control by Client or any of Client's principals) in the case of any late payment, and that if any payment is not timely made, AKS may further withhold plans, documents, and information (whether such documents and/or information was prepared under this contract, another contract between AKS and Client, or a contract between AKS and another client subject to control by Client or one of Client's principal's). AKS may claim a lien for all materials, labor, and services furnished if any amount due hereunder is not timely paid. In addition to the principal amount due hereunder, and any Finance Charges that accrue hereunder, Client agrees to pay AKS all collection costs that AKS incurs, regardless of whether or not litigation is initiated, including but not limited to reasonable attorney's fees, court costs, and charges for AKS staff time (at AKS' regular rates). If AKS suspends work as a result of Client's non-payment, AKS may require an additional "start up fee" to re-start work hereunder, even if Client cures all past defaults.
6. **GOVERNMENT CHANGES**: If AKS, pursuant to this Agreement, produces a work product and/or performs field work that complies with the ordinances, policies and procedures of governmental agencies, and any such governmental agency changes its ordinances, policies, procedures or requirements after the date of this Agreement, any additional office or field work thereby required shall be paid for by Client as extra work.
7. **ADDITIONAL SERVICES**: Client agrees that if services not specified in this Agreement are provided, or if Client requests services not specified here-in, Client agrees to timely pay for all such services as extra work at AKS's standard rates (if not otherwise specified).
8. **CONSTRUCTION COST ESTIMATES**: Any construction cost estimates provided by AKS will be on a basis of experience and judgment, but since AKS has no control over market conditions or bidding procedures, AKS cannot warrant that bids or actual construction costs will not vary from these cost estimates.
9. **PROFESSIONAL STANDARDS**: AKS shall only be responsible, to the level of competency and the standards of care, skill, and diligence maintained by professionals providing similar services in AKS' local community at the time that AKS provides services under this Agreement. **AKS makes no other warranty, expressed or implied.**
10. **TERMINATION-** Either Client or AKS may terminate this Agreement by giving 30 days written notice to the other party. In such event, Client shall immediately pay AKS in full for all work previously authorized and performed prior to effective date of termination.
11. **LIMITATION OF LIABILITY: Client hereby waives all claims against AKS and releases AKS from any claim, demand, loss, or liability that Client may now or hereafter have against AKS arising out of or in connection with this Agreement or the services provided hereunder (whether in tort, contract or otherwise), provided that any such claim, demand, loss or liability has not resulted from AKS' gross negligence or willful misconduct. In no case shall AKS's liability to the Client for any cause or combination of causes, in the aggregate, exceed the amount of the fee actually paid to AKS under this Agreement. In no event shall AKS be liable for any indirect or consequential damages of any kind.**
12. **LEGAL EXPENSES**: In the event either party hereto must seek legal counsel for the purpose of enforcing or otherwise interpreting the terms of this Agreement, whether or not legal action is initiated, the losing party shall pay the prevailing party all fees, costs, and expenses incurred including reasonable attorneys' fees and expert witness fees, including any fees and costs incurred on appeal.
13. **ENFORCEABILITY**: In case any one or more of the provisions contained in this Agreement shall be held illegal, the enforceability of the remaining provisions contained herein shall not be impaired.
14. **AUTHORIZATION TO PROCEED:** Any request by Client for AKS to proceed with work shall constitute an express acceptance of all terms to this Agreement, including these General Provisions.
15. **TRANSFERABILITY OF AGREEMENT**: This Agreement is between Client and AKS and is not transferable without the written consent of the other party.
16. **ACCESS TO SITE**: Unless otherwise stated, Client warrants that AKS will have access to the site, to the same degree as Client, for activities necessary to perform services. Client represents that it has unrestricted access to the site.
17. **OWNERSHIP OF DOCUMENTS**: It is understood and agreed that the calculations, drawings, and specifications prepared pursuant to this Agreement ("Work Product"), whether in hard copy or machine-reader form, are instruments of professional service intended for one-time use by Client only for this project only. Work Product is and shall remain the property of AKS. Client shall not obtain the right to use the Work Product, even for one-time use unless all amounts due under this Agreement are paid in full. If Client is in possession of any Work Product and has not paid any amount due hereunder, AKS may demand return of the Work Product, and may specifically enforce Client's obligation to return such Work Product.
18. **INSURANCE**: AKS is covered by a general liability insurance policy and a professional liability policy, which policies shall each provide for at least $1,000,000 coverage per occurrence. If Client requires additional coverage in excess of that amount, and if procurable, AKS will obtain additional insurance to the level Client requests at Client's sole expense.
19. **INDEMNITY**: Client hereby agrees to defend AKS and hold AKS harmless from any claim, demand, loss or liability, including reasonable attorneys' fees, that results from for any loss, damage or liability arising from any acts by the Client, its agents, staff, and/or other consultants or agents that act at the direction of Client.
20. **WORK OF OTHERS**: Client agrees that AKS shall not be responsible or liable for any work performed or services provided by any entity other than AKS and/or any person that is not a direct employee of AKS. Client acknowledges that AKS may assist Client with the coordination of other contractors and/or design professional and/or consultants, and/or that AKS will make arrangements for the provision of services by others; and Client further acknowledges that such coordination and/or other such efforts does not make AKS liable for the services provided by others. Client understands and expressly acknowledges that AKS does not provide Geo-technical engineering, Traffic engineering, structural engineering, wetland delineation, and electrical engineering, services. Client expressly acknowledges that AKS does not assume responsibility for determining, supervising, implementing or controlling the means, methods, technique, sequencing or procedures of construction, or monitoring, evaluating or reporting job conditions that relate to health, safety or welfare.
21. **ALL TERMS MATERIAL:** All provisions herein are material to AKS's agreement to provide services, and were expressly negotiated by the parties.
22. **VENUE:** Any litigation initiated in connection with this Agreement shall take place in Clark County, Washington, unless such case involves a lien claim that must be litigated elsewhere as a matter of law, in which case all issues related to this Agreement may be litigated in the same forum as the lien claim. All claims of any nature that relate to this Agreement shall be subject to Washington law, unless such claims relate to the foreclosure of a lien and are, as a matter of law, subject to the laws of another state, in which case only the lien claim will be subject to the laws of another state, and all other claims/issues will remain subject to Washington law.
23. **NOTICE OF CLAIMS:** Client shall, and expressly agrees to, provide AKS immediate written notice of any facts that could potentially result in any potential claim against AKS, including but not limited to any dispute, any claimed damages, any perceived failure by AKS, or otherwise. As a condition precedent to any recovery from AKS, Client shall give AKS written notice of any such claim or facts that could result in a claim not later than ten (10) days after the date of the occurrence of the event causing the potential claim. Client's failure to provide such notice, for any reason, shall constitute waiver of such claim.

PREPARED BY:
MINISTER AND GLAESER
SURVEYING, INC.
2200 E. EVERGREEN BLVD.
VANCOUVER, WA. 98661
(360) 694-3313

LAKE HILLS SUBDIVISION

A SUBDIVISION OF A PORTION OF THE
SE 1/4 AND SW 1/4 OF THE SE 1/4
OF SECTION 28 AND THE NE 1/4 AND THE NW 1/4
OF THE NE 1/4 OF SECTION 33
T. 2 N., R. 3 E., W.M.
CITY OF CAMAS
CLARK COUNTY, WASHINGTON

JOB NO: 06-586 JANUARY 7, 2015

NOTES:

1) THIS PLAT IS SUBJECT TO CONDITIONS SET FORTH IN THE CITY OF CAMAS DECISIONS FOR THIS SUBDIVISION (CITY FILE: SUB 12-01 LAKE HILLS)

2) NO BUILDING PERMITS SHALL BE ISSUED UNTIL THIS SUBDIVISION IS GRANTED FINAL ACCEPTANCE IN ACCORDANCE WITH CMC 17.21.070.

3) A HOMEOWNERS ASSOCIATION (HOA) WILL BE REQUIRED FOR THIS DEVELOPMENT. COPIES OF THE C.C.&R'S SHALL BE SUBMITTED AND ON FILE WITH THE CITY OF CAMAS.

4) A RIGHT OF ENTRY IS HEREBY GRANTED TO THE CITY OF CAMAS FOR THE REPAIR AND MAINTENANCE OF THE STEF AND STEP SEWER SYSTEMS.

5) ALL COSTS ASSOCIATED WITH THE INSTALLATION OF THE STEF (LOTS 1-42) AND STEP (LOTS 43-53) SYSTEMS FOR INDIVIDUAL LOTS WILL BE THE RESPONSIBILITY OF SAID INDIVIDUAL LOT OWNERS.

6) NO FURTHER SHORT PLATTING OR SUBDIVIDING WILL BE PERMITTED ONCE THE FINAL PLAT HAS BEEN RECORDED.

7) THE LOTS IN THIS SUBDIVISION ARE SUBJECT TO TRAFFIC IMPACT FEES, SCHOOL IMPACT FEES, AND PARK/OPEN SPACE IMPACT FEES. EACH NEW DWELLING WILL BE SUBJECT TO THE PAYMENT OF APPROPRIATE IMPACT FEES AT THE TIME OF BUILDING PERMIT ISSUANCE.

8) AUTOMATIC FIRE SPRINKLER SYSTEMS DESIGNED AND INSTALLED IN ACCORDANCE WITH NFPA 13D ARE REQUIRED IN ALL DWELLINGS.

9) IN THE EVENT THAT ANY ITEM OF ARCHAEOLOGICAL INTEREST IS UNCOVERED DURING THE COURSE OF A PERMITTED GROUND DISTURBING ACTION OR ACTIVITY, ALL GROUND DISTURBING ACTIVITY SHALL IMMEDIATELY CEASE AND THE APPLICANT SHALL NOTIFY THE PUBLIC WORKS DEPARTMENT AND DAHP.

10) MAXIMUM BUILDING LOT COVERAGE IS 35%.

11) TRACT "A" IS DEDICATED TO THE H.O.A. AS A STORMWATER FACILITY TO BE MAINTAINED BY THE H.O.A.

12) TRACT "B" IS DEDICATED TO THE H.O.A. AS NATURAL OPEN SPACE AND SHALL REMAIN IN ITS NATURAL STATE UNLESS OTHERWISE APPROVED BY THE CITY COUNCIL.

13) TRACT "C" IS DEDICATED TO THE H.O.A. AS A LANDSCAPE AREA TO BE MAINTAINED BY THE H.O.A.

14) TRACT "D" IS DEDICATED TO THE H.O.A. AS A PRIVATE ACCESS ROAD TO BE MAINTAINED BY THE H.O.A. THE CITY OF CAMAS IS GRANTED A SEWER AND UTILITY EASEMENT OVER TRACT "D".

15) YARD SETBACKS ARE AS FOLLOWS:
SIDE AND CORNER REAR YARD: 5 FEET
SIDE YARD FLANKING A STREET: 20 FEET
REAR YARD: 25 FEET
MINIMUM FRONTAGE ON A CUL-DE-SAC OR CURVE: 30 FEET
FRONT YARD LOTS 43-48: PROVIDED ON SHEET 4 OF THIS PLAT
FRONT YARD ALL OTHER LOTS: 20 FEET

DEED REFERENCE:

GRANTOR: ARTHUR PICULELL
GRANTEE: MARTIN C. PEETS ETAL
AF NO. 5064067 D
DATE: 04-11-2014

SURVEY REFERENCES:

1) LDC SURVEY BOOK 54 PAGE 153
2) LACAMAS WOODS BOOK 311 PAGE 017
3) FOREST GLEN BOOK 311 PAGE 389
4) LACAMAS SHORES PHASE 6D BOOK "J" PAGE 559
5) LACAMAS SHORES PHASE 6B BOOK "J" PAGE 157
6) LACAMAS SHORES PHASE 2 BOOK "H" PAGE 417
7) COONEY SURVEY BOOK 49 PAGE 186
8) RENTON SURVEY BOOK 55 PAGE 130
9) SPOSITO SHORT PLAT BOOK 2 PAGE 424
10) FOREST HILLS BOOK "H" PAGE 898

MINISTER AND GLAESER SURVEYING, INC. MAKES NO WARRANTIES AS TO MATTERS OF UNWRITTEN TITLE SUCH AS ADVERSE POSSESSION, ACQUIESCENCE, ESTOPPEL, ETC.

A FIELD TRAVERSE WAS PERFORMED USING A THREE SECOND TOTAL STATION. THE FIELD TRAVERSE MET THE MINIMUM STANDARDS FOR SURVEYS AS DESIGNATED IN WAC 332-130-090. ALL CORNERS NOTED AS FOUND WERE VISITED IN JUNE 2014.

PERIMETER DESCRIPTION:

A PARCEL OF LAND LOCATED IN A PORTION OF THE SOUTHEAST QUARTER AND THE SOUTHWEST QUARTER OF THE SOUTHEAST QUARTER OF SECTION 28 AND THE NORTHEAST QUARTER AND THE NORTHWEST QUARTER OF THE NORTHEAST QUARTER OF SECTION 33, TOWNSHIP 2 NORTH, RANGE 3 EAST, WILLAMETTE MERIDIAN, CITY OF CAMAS, CLARK COUNTY, WASHINGTON, DESCRIBED AS FOLLOWS;

BEGINNING AT THE NORTHWEST CORNER OF THE NORTHEAST QUARTER OF SAID SECTION 33,

THENCE SOUTH 88°28'30" EAST, ALONG THE NORTH LINE OF SAID NORTHWEST QUARTER AND THE SOUTH LINE OF "LACAMAS WOODS" ACCORDING TO THAT CERTAIN PLAT RECORDED IN BOOK 311 OF PLAT AT PAGE 017 RECORDS OF CLARK COUNTY WASHINGTON, FOR A DISTANCE OF 340.00 FEET, TO THE SOUTHEAST CORNER OF LOT 7 OF SAID PLAT, SAID POINT BEING THE TRUE POINT OF BEGINNING;

THENCE NORTH 01°25'26" EAST, ALONG THE EAST LINE OF LOTS 7 AND 8 OF SAID "LACAMAS WOODS" PLAT, FOR A DISTANCE OF 62.08 FEET, TO AN EXISTING ROCK WALL;

THENCE NORTH 16°16'42" EAST, ALONG SAID ROCK WALL, 7.55 FEET;

THENCE NORTH 28°42'49" EAST, ALONG SAID ROCK WALL, 3.73 FEET TO THE SOUTH LINE OF SAID LOT 8;

THENCE SOUTH 88°32'47" EAST, ALONG THE SOUTH LINE OF SAID LOT 8, FOR A DISTANCE OF 74.38 FEET, TO THE SOUTHEAST CORNER OF SAID 'LACAMAS WOODS" PLAT AND THE SOUTHWEST CORNER OF "FOREST GLEN' ACCORDING TO THAT CERTAIN PLAT RECORDED IN BOOK 311 AT PAGE 389 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE SOUTH 88°56'31" EAST, ALONG THE SOUTH LINE OF SAID "FOREST GLEN" PLAT, FOR A DISTANCE OF 160.17 FEET;

THENCE SOUTH 88°57'30" EAST, ALONG THE SOUTH LINE OF SAID "FOREST GLEN" PLAT, FOR A DISTANCE OF 171.16 FEET;

THENCE SOUTH 88°52'42" EAST, ALONG THE SOUTH LINE OF SAID "FOREST GLEN" PLAT, FOR A DISTANCE OF 108.49 FEET, TO THE SOUTHEAST CORNER THEREOF AND THE SOUTHWEST CORNER OF "LACAMAS SHORES PHASE 6D" ACCORDING TO THE PLAT THEREOF RECORDED IN BOOK "J" OF PLATS AT PAGE 559 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE SOUTH 89°00'00" EAST, ALONG THE SOUTH LINE OF SAID "LACAMAS SHORES PHASE 6D", FOR A DISTANCE OF 292.41 FEET, TO THE SOUTHEAST CORNER THEREOF AND THE SOUTHWEST CORNER OF TRACT "A" OF "LACAMAS SHORES PHASE 6B" ACCORDING TO THE PLAT THEREOF RECORDED IN BOOK "J' OF PLATS AT PAGE 157 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE SOUTH 88°55'22" EAST, ALONG THE SOUTH LINE OF SAID TRACT "A", FOR A DISTANCE OF 240.79 FEET;

THENCE SOUTH 01°21'31" WEST, ALONG THE WEST LINE OF LOTS 32, 33 AND 34 OF SAID "LACAMAS SHORES PHASE 6B" PLAT AND THE WEST LINE OF LOT 15 OF "LACAMAS SHORES PHASE 2" ACCORDING TO THAT CERTAIN PLAT RECORDED IN BOOK "H" OF PLAT AT PAGE 417, RECORDS OF CLARK COUNTY, WASHINGTON, FOR A DISTANCE OF 496.01 FEET, TO THE NORTHEAST CORNER OF THAT CERTAIN TRACT OF LAND CONVEYED TO THE CITY OF CAMAS BY DEED RECORDED UNDER AUDITORS FILE NUMBER 499448 D, RECORDS OF CLARK COUNTY WASHINGTON;

THENCE ALONG SAID CITY OF CAMAS BOUNDARY LINE THE FOLLOWING COURSE AND DISTANCES:

THENCE NORTH 89°59'00" WEST, 64.35 FEET;

THENCE NORTH 47°14'47" WEST, 41.21 FEET;

THENCE SOUTH 56°45'13" WEST, 138.86 FEET;

THENCE NORTH 82°29'37" WEST, 88.35 FEET;

THENCE SOUTH 68°01'13" WEST, 176.70 FEET;

THENCE NORTH 64°13'04" WEST, 125.01 FEET;

THENCE NORTH 72°22'03" WEST, 106.70 FEET;

THENCE SOUTH 00°00'01" WEST, 179.32 FEET;

THENCE SOUTH 43°48'44" EAST, 113.48 FEET;

THENCE SOUTH 23°06'03" EAST, 68.84 FEET;

THENCE SOUTH 53°56'50" EAST, 485.69 FEET;

THENCE SOUTH 00°01'16" EAST, 57.16 FEET, TO A 5/8" IRON ROD WITH YELLOW PLASTIC CAP INSCRIBED LDC DESIGN GROUP, HELD FOR THE NORTHWEST CORNER OF THE BAFUS TRACT, AS SHOWN IN THAT CERTAIN RECORDED SURVEY BOOK 54 OF SURVEY AT PAGE 153 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE LEAVING SAID CITY OF CAMAS PROPERTY LINE, SOUTH 00°00'45" EAST, ALONG THE WEST LINE OF SAID BAFUS TRACT, 124.73 FEET, TO THE NORTHERLY RIGHT-OF-WAY LINE OF NW LAKE ROAD;

THENCE ALONG SAID NORTHERLY RIGHT-OF-WAY LINE, THE FOLLOWING COURSES AND DISTANCES:

THENCE NORTH 58°02'48" WEST, 158.51 FEET;

THENCE ALONG THE ARC OF A 2834.79 FOOT RADIUS CURVE TO THE RIGHT, FOR AN ARC DISTANCE OF 50.44 FEET, THROUGH A CENTRAL ANGLE OF 01°01'10", THE LONG CHORD OF WHICH BEARS NORTH 57°32'13" WEST, FOR A CHORD DISTANCE OF 50.44 FEET, TO AN ANGLE POINT IN THE RIGHT-OF-WAY AS DEDICATED TO THE CITY OF CAMAS PER AUDITORS FILE NUMBER 3986755 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE NORTH 27°37'56" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 12.90 FEET;

THENCE NORTH 57°37'56" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 7.16 FEET;

THENCE NORTH 87°37'56" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 12.00 FEET;

THENCE ALONG THE ARC OF A 2834.79 FOOT RADIUS NON-TANGENT CURVE TO THE RIGHT, FOR AN ARC DISTANCE OF 344.50 FEET, THROUGH A CENTRAL ANGLE OF 06°57'46", THE LONG CHORD OF WHICH BEARS NORTH 52°57'54" WEST, FOR A CHORD DISTANCE OF 344.29 FEET, TO AN ANGLE POINT IN THE RIGHT-OF-WAY AS DEDICATED TO THE CITY OF CAMAS PER AUDITORS FILE NUMBER 3653507 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE NORTH 18°45'28" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 10.97 FEET;

THENCE NORTH 48°45'28" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 7.16 FEET;

THENCE NORTH 78°45'28" WEST, ALONG SAID CITY OF CAMAS RIGHT-OF-WAY, FOR A DISTANCE OF 11.39 FEET;

THENCE ALONG THE ARC OF A 2834.79 FOOT RADIUS NON-TANGENT CURVE TO THE RIGHT, FOR AN ARC DISTANCE OF 282.05 FEET, THROUGH A CENTRAL ANGLE OF 05°42'02", THE LONG CHORD OF WHICH BEARS NORTH 46°05'50" WEST, FOR A CHORD DISTANCE OF 281.93 FEET, TO THE POINT OF TANGENT;

THENCE NORTH 43°14'48" WEST, ALONG SAID NW LAKE ROAD RIGHT-OF-WAY, FOR A DISTANCE OF 437.17 FEET, TO THAT CERTAIN BOUNDARY LINE AGREEMENT BETWEEN SARAH L. DEDMORE AND LAKE HILLS LLC, BY DEED RECORDED UNDER AUDITORS FILE NUMBER 5088566 RECORDS OF CLARK COUNTY WASHINGTON;

THENCE NORTH 19°24'01" EAST, ALONG THE EAST LINE OF SAID BOUNDARY LINE AGREEMENT, FOR A DISTANCE OF 409.18 FEET, TO THE TRUE POINT OF BEGINNING;

CONTAINING: 18.30 ACRES OF LAND, MORE OR LESS.

TOGETHER WITH AND SUBJECT TO: EASEMENTS, RESERVATIONS, COVENANTS AND RESTRICTIONS APPARENT OR OF RECORD.

BASIS OF BEARING: NAD 83/91, WASHINGTON STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, US SURVEY FEET.
CONVERGENCE ANGLE: -01°25'13.1890"
COMBINED SCALE FACTOR: 1.00004316
(AT NW CORNER OF SECTION 33) PER RENTON SURVEY BOOK 55 PAGE 130

80 40 0 80 120 160
SCALE 1 INCH = 80 FEET

CITY OF CAMAS MAYOR:

APPROVED: ____________________
CITY OF CAMAS MAYOR DATE

CITY OF CAMAS FINANCE DIRECTOR:

THERE ARE NO DELINQUENT SPECIAL ASSESSMENTS AND ALL SPECIAL ASSESSMENTS ON ANY OF THE PROPERTY THAT IS DEDICATED AS STREETS, ALLEYS OR FOR OTHER PUBLIC USE ARE PAID IN FULL AT THE DATE OF CERTIFICATION.

ATTESTED BY: ____________________
CITY OF CAMAS FINANCE DIRECTOR DATE

CITY OF CAMAS COMMUNITY DEVELOPMENT DEPARTMENT:

APPROVED: ____________________
CITY OF CAMAS COMMUNITY DEVELOPMENT DIRECTOR, OR DESIGNEE DATE

CITY OF CAMAS ENGINEER:

A) ALL IMPROVEMENTS HAVE BEEN INSTALLED IN ACCORDANCE WITH THE REQUIREMENTS OF THIS TITLE AND WITH THE PRELIMINARY PLAT APPROVAL;

B) ALL IMPROVEMENTS MEET CURRENT PUBLIC WORKS DRAWING STANDARDS FOR ROAD, UTILITY AND DRAINAGE CONSTRUCTION PLANS;

C) ORIGINAL AND REPRODUCIBLE MYLAR OR ELECTRONIC RECORDS IN A FORMAT APPROVED BY THE PUBLIC WORKS DIRECTOR OR DESIGNEE AND CERTIFIED BY THE DESIGNING ENGINEER AS BEING "AS CONSTRUCTED" HAVE BEEN SUBMITTED FOR CITY RECORDS.

APPROVED: ____________________
CITY OF CAMAS ENGINEER DATE

FIRE CHIEF:

APPROVED: ____________________
FIRE CHIEF, OR DESIGNEE DATE

CLARK COUNTY ASSESSOR:

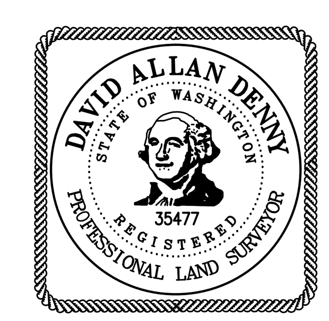
THIS PLAT MEETS THE REQUIREMENTS OF R.C.W 58.17.170, LAWS OF WASHINGTON, TO BE KNOWN AS LAKE HILLS SUBDIVISION,
PLAT NO.__________ IN THE COUNTY OF CLARK, STATE OF WASHINGTON.

____
COUNTY ASSESSOR DATE

CLARK COUNTY AUDITOR:

FILED FOR RECORD THIS______DAY OF __________, 2014
IN BOOK __________OF PLATS, AT PAGE ________
AT THE REQUEST OF LAKE HILLS, LLC
AUDITOR'S RECEIVING NO. ____________________

DEPUTY/COUNTY AUDITOR



SURVEYOR'S CERTIFICATE:

I HEREBY CERTIFY THAT THIS PLAT AS SHOWN IS A TRUE RETURN FROM THE FIELD AND THAT THE DELINEATION IS CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

____
DAVID A DENNY, PROFESSIONAL LAND SURVEYOR DATE
PLS NO. 35477

UTILITY AND SIDEWALK EASEMENT:

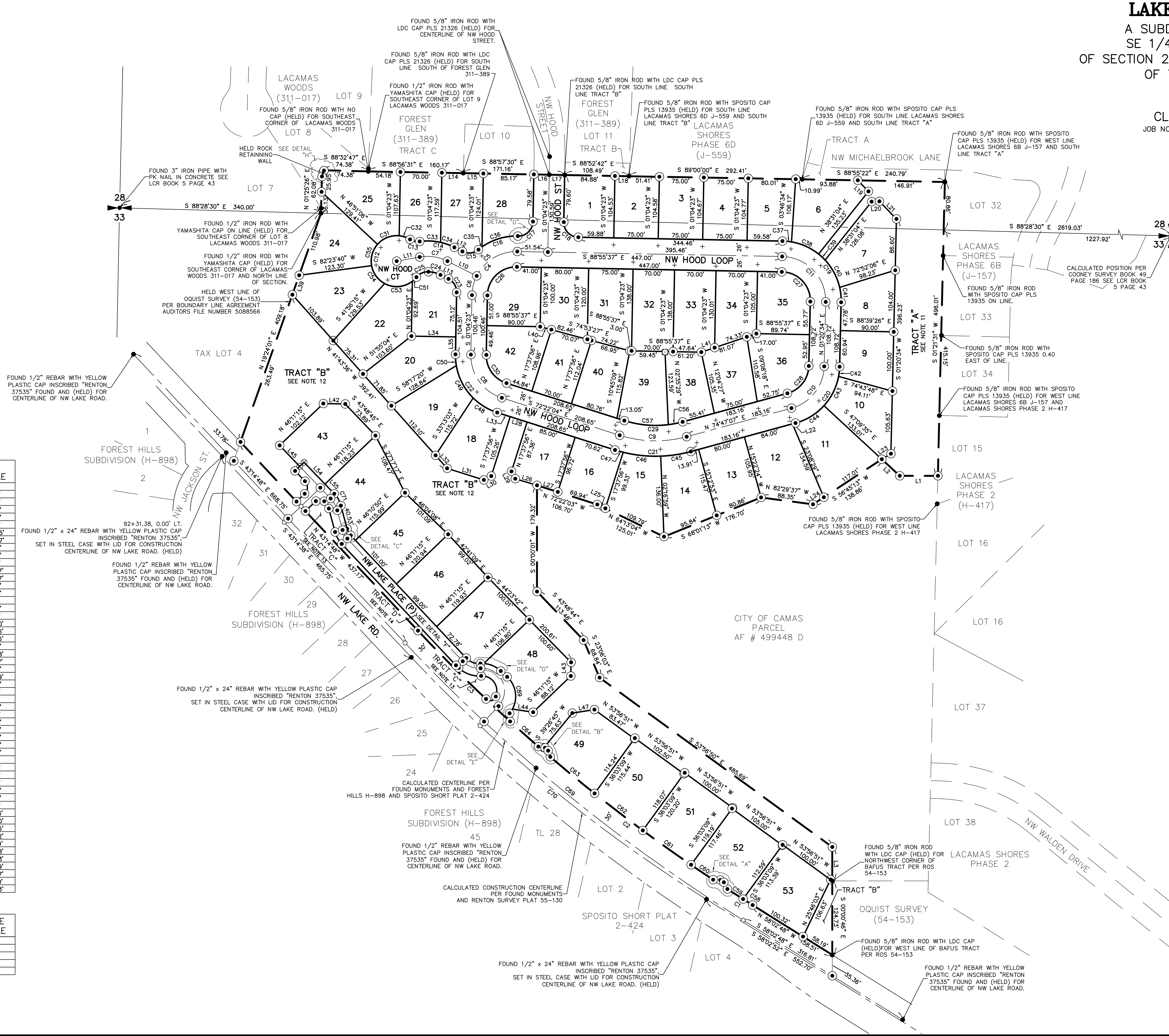
AN EASEMENT IS HEREBY RESERVED UNDER AND UPON THE EXTERIOR SIX (6) FEET AT THE FRONT BOUNDARY LINES OF ALL LOTS FOR THE INSTALLATION, CONSTRUCTING, RENEWING, OPERATING AND MAINTAINING ELECTRIC, TELEPHONE, TV CABLE, WATER AND SANITARY SEWER SERVICES. ALSO A SIDEWALK EASEMENT AS NECESSARY TO COMPLY WITH ADA SLOPE REQUIREMENTS UPON THE EXTERIOR SIX (6) FEET ALONG THE FRONT BOUNDARY LINES OF ALL LOTS ADJACENT TO PUBLIC STREETS.

PREPARED BY:
MINISTER AND GLAESER
SURVEYING, INC.
2200 E. EVERGREEN BLVD.
VANCOUVER, WA. 98661
(360) 694-3313

LAKE HILLS SUBDIVISION

A SUBDIVISION OF A PORTION OF THE
SE 1/4 AND SW 1/4 OF THE SE 1/4
OF SECTION 28 AND THE NE 1/4 AND THE NW 1/4
OF THE NE 1/4 OF SECTION 33
T. 2 N., R. 3 E., W.M.
CITY OF CAMAS
CLARK COUNTY, WASHINGTON

JOB NO: 06-586 JANUARY 7, 2015



LOT SQUARE FOOTAGE TABLE	
LOT	S.F.
1	8741.27'
2	7840.17'
3	7847.09'
4	7853.84'
5	8133.03'
6	10709.55'
7	10946.37'
8	8035.09'
9	8003.02'
10	9610.76'
11	11469.27'
12	11642.47'
13	8874.32'
14	9783.84'
15	9589.11'
16	8239.53'
17	8188.36'
18	10091.20'
19	10018.46'
20	10794.16'
21	7637.92'
22	11846.78'
23	11047.17'
24	9708.90'
25	11705.69'
26	8007.77'
27	8936.71'
28	9141.22'
29	8484.74'
30	8799.81'
31	9702.49'
32	9660.00'
33	9569.98'
34	8224.88'
35	8927.72'
36	9645.11'
37	8366.17'
38	8041.85'
39	9016.99'
40	8390.08'
41	7734.84'
42	9087.18'
43	11972.13'
44	11943.30'
45	11965.76'
46	11922.72'
47	11961.99'
48	11989.08'
49	11999.43'
50	11999.29'
51	11998.97'
52	11999.10'
53	11997.73'

TRACT SQUARE FOOTAGE TABLE	
TRACT	S.F.
A	44,078'
B	116,392'
C	5,164'
D	13,361'

LEGEND:

○	INDICATES CALCULATED POSITION
●	INDICATES FOUND MONUMENT AS NOTED
◉	INDICATES 1/2" x 24" REBAR WITH YELLOW PLASTIC CAP INSCRIBED "D.DENNY 35477" SET.
⊗	INDICATES ROCK NAIL WITH BRASS WASHER "PLS 35477" SET.
⊡	INDICATES 1.00' WITNESS CORNER SET S'02°35'29"E FROM CALCULATED POSITION, 1/2" x 24" REBAR WITH YELLOW PLASTIC CAP INSCRIBED "D.DENNY 35477" SET.
+	INDICATES ROCK NAIL WITH BRASS WASHER INSCRIBED "35477" SET AT THE EXTENSION OF LOT LINE IN THE CURB FOR THE PURPOSE OF LINE NOT DISTANCE

BASIS OF BEARING: NAD 83/91, WASHINGTON STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, US SURVEY FEET.
CONVERGENCE ANGLE: -01°25'13.1890"
COMBINED SCALE FACTOR: 1.00004316
(AT NW CORNER OF SECTION 33) PER RENTON SURVEY BOOK 55 PAGE 130

80 40 0 80 120 160
SCALE 1 INCH = 80 FEET

DAVID ALLAN DENNY
STATE OF WASHINGTON
35477
REGISTERED
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CLARK COUNTY, WASHINGTON

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LOT SQUARE FOOTAGE TABLE

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48	11989.08'
49	11999.43'
50	11999.29'
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52	11999.10'
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TRACT SQUARE FOOTAGE TABLE

TRACT	S.F.
A	44,078'
B	116,392'
C	5,164'
D	13,361'

LINE TABLE

LINE	LENGTH	BEARING
L1	64.35	N89°59'00"W
L2	41.21	N47°14'47"W
L3	57.16	S00°01'16"E
L4	12.90	N27°37'56"W
L5	7.16	N57°37'56"W
L6	12.00	N87°37'56"W
L7	10.97	N18°45'28"W
L8	7.16	N48°45'28"W
L9	11.39	N78°45'28"W
L10	55.41	S63°13'10"E
L11	39.35	N79°57'02"E
L12	15.20	N63°13'10"W
L13	15.13	S63°13'10"E
L14	35.99	S88°56'31"E
L15	34.01	S88°57'30"E
L16	26.00	S88°57'30"E
L17	26.00	S88°57'30"E
L18	23.59	S88°52'42"E
L19	25.91	S43°55'37"E
L20	13.18	N87°17'43"E
L21	41.33	S43°55'37"E
L22	5.25	S74°47'07"W
L23	17.97	N58°43'12"E
L24	21.85	S56°45'13"W
L25	15.22	N64°13'04"W
L26	38.30	N73°14'00"W
L27	36.76	S72°22'03"E
L28	30.00	S72°22'04"E
L29	14.05	N27°22'04"W
L30	14.14	S62°37'56"W
L31	65.01	N72°22'04"W
L32	29.27	N41°43'36"W
L33	23.03	S72°22'04"E
L34	75.00	N88°55'37"W
L35	29.39	S01°04'23"W
L39	34.71	N19°24'01"E
L40	19.66	S74°53'27"E
L41	23.74	N71°24'38"E
L42	36.93	S88°48'45"E
L43	23.16	S01°06'01"W
L44	35.39	N81°19'30"W
L45	49.00	N43°48'45"W
L46	10.00	S46°11'15"W
L47	37.72	N81°03'09"E
L48	1.91	S78°45'28"E
L49	14.59	N46°55'02"W
L50	2.32	S17°18'20"W
L51	6.46	S46°32'20"E
L52	3.18	S43°48'45"E
L53	11.00	N46°11'15"E
L54	51.00	S43°48'45"E
L55	22.67	S43°48'45"E
L56	84.33	S46°11'15"W
L57	45.18	S46°11'15"W
L58	30.00	S46°11'15"W
L59	9.15	S46°11'15"W
L60	45.47	S43°03'16"W
L61	5.64	S43°03'16"W
L62	30.00	S43°03'16"W
L63	9.83	S43°03'16"W

CURVE TABLE

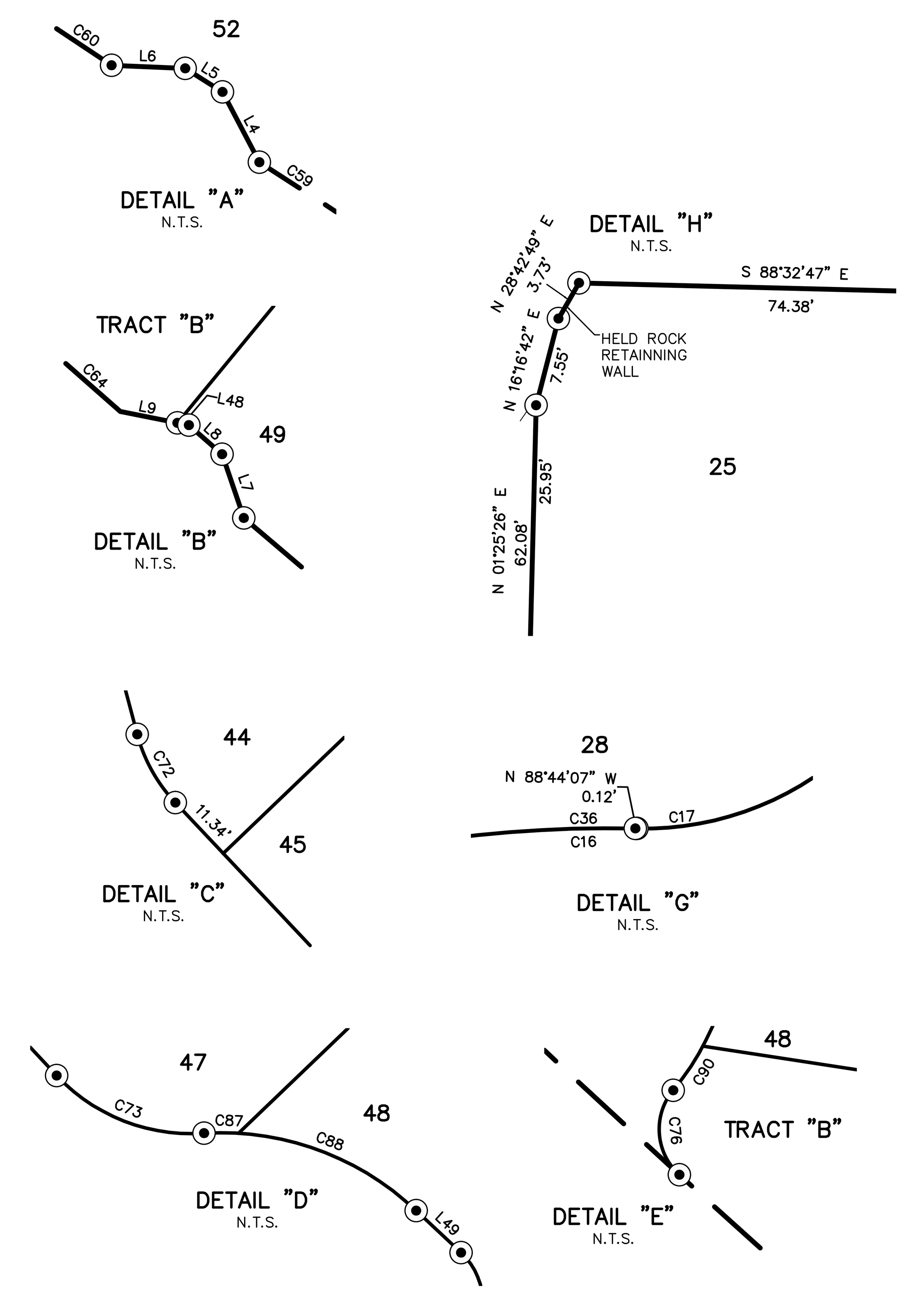
CURVE	RADIUS	DELTA	ARC DIST.	CHORD BEARING	CHORD DIST.
C1	2834.79	1°01'10"	50.44	S57°32'13"E	50.44
C2	2834.79	6°57'46"	344.50	S52°57'54"E	344.29
C3	2834.79	5°42'02"	282.05	S46°05'50"E	281.93
C4	75.00	90°00'00"	117.81	S46°04'23"W	106.07
C5	75.00	64°17'33"	84.16	S58°55'36"W	79.81
C6	75.00	25°42'27"	33.65	S13°55'36"W	33.37
C7	75.00	36°49'48"	48.21	N81°38'04"W	47.38
C8	75.00	73°26'27"	96.13	S35°38'51"E	89.69
C9	200.00	32°50'49"	114.66	S88°47'29"E	113.09
C10	75.00	73°26'33"	96.14	N38°03'50"E	89.69
C11	75.00	90°16'11"	118.16	N43°47'32"W	106.32
C12	43.00	262°18'27"	196.86	S09°37'31"E	64.75
C13	25.00	38°57'03"	17.00	S77°56'49"E	16.67
C14	101.00	34°12'11"	60.29	N80°19'15"W	59.40
C15	25.00	66°07'26"	28.85	N83°43'07"E	27.28
C16	101.00	40°36'29"	71.58	S70°57'39"W	70.09
C17	25.00	90°11'30"	39.35	N46°10'08"E	35.41
C18	25.00	90°00'00"	39.27	S43°55'37"E	35.36
C19	101.00	90°16'11"	159.13	N43°47'32"W	143.17
C20	101.00	73°26'33"	129.46	N38°03'50"E	120.78
C21	226.00	32°50'49"	129.56	S88°47'29"E	127.80
C22	101.00	73°26'27"	129.46	S35°38'51"E	120.78
C23	25.00	64°17'33"	28.05	N31°04'24"W	26.60
C24	49.00	24°45'49"	21.18	N75°36'05"W	21.01
C25	25.00	52°47'45"	23.04	S65°37'08"W	22.23
C26	49.00	90°00'00"	76.97	S46°04'23"W	69.30
C27	49.00	90°16'11"	77.20	N43°47'32"W	69.46
C28	49.00	73°26'33"	62.81	N38°03'50"E	58.60
C29	174.00	32°50'49"	99.75	S88°47'29"E	98.39
C30	49.00	73°26'27"	62.81	S35°38'51"E	58.60
C31	43.00	54°31'41"	40.92	S68°28'04"W	39.40
C32	43.00	25°47'48"	19.36	N71°22'11"W	19.20
C33	101.00	20°09'17"	35.53	N87°20'42"W	35.35
C34	101.00	14°02'53"	24.76	N70°14'37"W	24.70
C35	101.00	4°13'57"	7.46	S52°46'23"W	7.46
C36	101.00	36°22'32"	64.12	S73°04'37"W	63.05
C37	101.00	8°46'57"	15.48	N84°32'09"W	15.47
C38	101.00	28°39'44"	50.53	N65°48'48"W	50.00
C39	101.00	8°32'27"	15.06	N47°12'43"W	15.04
C40	101.00	29°53'52"	52.70	N27°59'33"W	52.11
C41	101.00	14°23'11"	25.36	N05°51'02"W	25.29
C42	101.00	9°20'55"	16.48	N06°01'01"E	16.46
C43	101.00	31°38'12"	55.77	N26°30'34"E	55.06
C44	101.00	32°27'26"	57.22	N58°33'24"E	56.45
C45	226.00	12°59'51"	51.27	N81°17'02"E	51.16
C46	226.00	16°12'06"	63.91	S84°06'59"E	63.69
C47	226.00	3°38'52"	14.39	S74°11'30"E	14.39
C48	101.00	27°08'41"	47.85	S58°47'44"E	47.40
C49	101.00	35°27'59"	62.52	S27°29'24"E	61.53
C50	101.00	10°49'47"	19.09	S04°20'31"E	19.06
C51	43.00	12°44'58"	9.57	N45°35'44"E	9.55
C53	43.00	66°15'51"	49.73	N85°06'09"E	47.01
C54	43.00	51°31'03"	38.66	S36°00'24"E	37.37
C55	43.00	51°27'06"	38.61	S15°28'40"W	37.33
C56	174.00	8°07'09"	24.66	N78°50'41"E	24.64
C57	174.00	24°43'40"	75.09	S84°43'54"E	74.51
C58	2834.79	0°23'05"	19.03	S57°51'16"E	19.03
C59	2834.79	0°38'06"	31.41	S57°20'41"E	31.41
C60	2834.79	0°54'32"	44.97	S55°59'31"E	44.97
C61	2834.79	2°01'17"	100.01	S54°31'37"E	100.01
C62	2834.79	2°04'21"	102.54	S52°28'48"E	102.53
C63	2834.79	1°57'36"	96.98	S50°27'49"E	96.97
C64	2834.79	1°17'17"	63.73	S48°18'12"E	63.73

CURVE TABLE

CURVE	RADIUS	DELTA	ARC DIST.	CHORD BEARING	CHORD DIST.
C65	46.00	28°51'24"	23.17	N29°23'03"W	22.92
C66	34.00	28°18'33"	16.80	S29°06'38"E	16.63
C67	38.00	50°25'30"	33.44	S68°28'39"E	32.37
C68	38.00	136°44'40"	90.69	N25°19'04"W	70.65
C69	2864.79	14°48'00"	740.00	S50°38'48"E	737.94
C70	2500.00	14°48'13"	645.93	S50°38'45"E	644.14
C71	46.00	28°51'24"	23.17	N29°23'03"W	22.92
C72	26.00	28°18'33"	12.85	S29°06'38"E	12.72
C73	30.01	50°48'49"	26.61	S68°40'28"E	25.75
C74	46.00	47°01'03"	37.75	N69°55'16"W	36.70
C75	45.00	86°14'07"	67.73	N03°47'59"W	61.51
C76	10.00	86°58'38"	15.18	S04°10'14"E	13.76
C77	2834.79	0°38'49"	32.01	S47°20'09"E	32.01
C78	2834.79	0°28'34"	23.55	S46°46'27"E	23.55
C79	10.00	116°09'30"	20.27	N75°23'05"E	16.98
C80	25.00	110°44'08"	48.32	N38°03'44"W	41.14
C81	51.00	46°30'46"	41.40	S70°10'25"E	40.27
C82	47.00	28°18'33"	23.22	S29°06'38"E	22.99
C83	23.00	28°51'24"	11.58	N29°23'03"W	11.46
C84	10.00	90°00'00"	15.71	N88°48'45"W	14.14
C85	15.00	90°00'00"	23.56	N01°11'15"E	21.21
C86	2834.79	3°17'22"	162.75	S44°53'29"E	162.73
C87	46.00	6°57'11"	5.58	N89°57'12"W	5.58
C88	46.00	40°03'52"	32.17	N66°26'41"W	31.51
C89	45.00	75°13'36"	59.08	N09°18'14"W	54.93
C90	45.00	11°00'31"	8.65	N33°48'49"E	8.63
C91	2864.79	3°45'53"	188.24	S45°07'45"E	188.21

LAND INVENTORY:

A)	TOTAL ACREAGE	18.30 AC
B)	TOTAL DEVELOPED ACREAGE	15.63 AC
C)	TOTAL LOT AREA	11.93 AC
D)	TOTAL INFRASTRUCTURE ACREAGE	3.58 AC
E)	TOTAL TRACT AREA	3.10 AC
F)	TOTAL ACREAGE OF CRITICAL AREAS	NONE
G)	TOTAL ACREAGE OF RECREATIONAL OPEN SPACES	2.67 AC



LEGEND:

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⊡	INDICATES 1.00' WITNESS CORNER SET S°0235'29"E FROM CALCULATED POSITION, 1/2" x 24" REBAR WITH YELLOW PLASTIC CAP INSCRIBED "D.DENNY 35477" SET.
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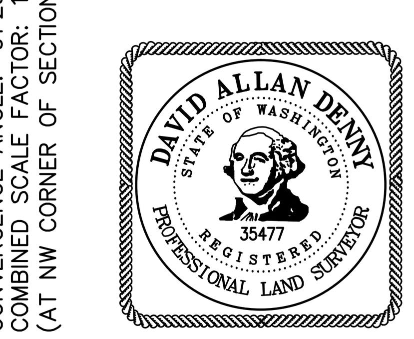

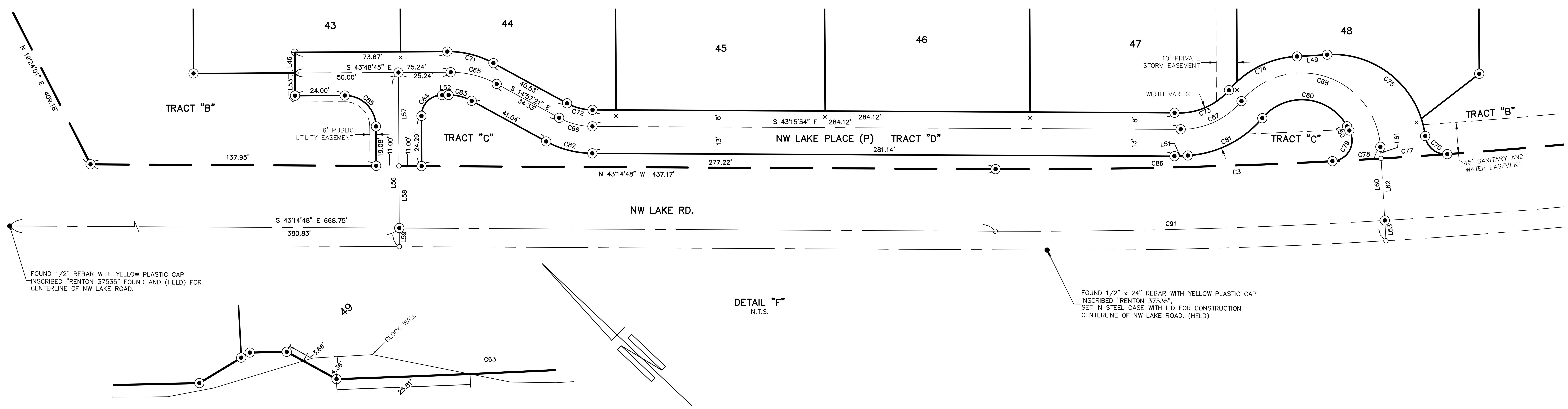

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YARD SETBACKS ARE AS FOLLOWS:
SIDE AND CORNER REAR YARD: 5 FEET
SIDE YARD FLANKING A STREET: 20 FEET
REAR YARD: 25 FEET
MINIMUM FRONTAGE ON A CUL-DE-SAC OR CURVE: 30 FEET
FRONT YARD LOTS 43-48: PROVIDED ON THIS SHEET
FRONT YARD ALL OTHER LOTS: 20 FEET

BASIS OF BEARING: NAD 83/91, WASHINGTON STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, US SURVEY FEET.
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CLARK COUNTY, WASHINGTON

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LINE TABLE		
LINE	BEARING	DISTANCE
L64	S 46°46'09" E	3.15'
L65	S 84°31'28" E	37.96'
L66	S 70°34'11" E	6.14'
L67	S 32°45'24" E	12.60'
L68	N 05°41'30" E	8.09'
L69	N 10°57'28" W	9.73'
L70	S 77°38'06" E	9.97'
L71	N 15°55'49" E	5.08'
L72	S 89°16'49" E	6.28'
L73	N 34°05'04" W	18.85'
L74	S 68°26'54" E	15.89'
L75	N 04°14'40" E	10.62'
L76	N 49°56'44" W	8.44'
L77	N 34°26'20" W	31.44'
L78	N 62°41'59" W	11.49'
L79	N 37°39'21" W	17.95'
L80	N 34°35'43" W	16.01'
L81	N 44°46'51" W	20.16'
L82	N 56°19'29" W	32.96'
L83	N 24°00'10" W	23.76'
L84	N 24°43'15" W	25.78'
L85	N 25°33'08" W	18.27'
L86	N 33°23'02" W	6.40'

LINE TABLE		
LINE	BEARING	DISTANCE
L87	N 18°49'14" W	6.21'
L88	N 63°57'51" W	8.06'
L89	N 32°51'59" W	9.26'
L90	N 22°15'54" W	34.13'
L91	N 79°13'10" E	9.81'
L92	S 61°16'46" E	4.42'
L93	S 68°00'58" E	7.81'
L94	S 51°35'32" E	9.27'
L95	S 61°20'17" E	27.51'
L96	S 89°03'06" E	5.68'
L97	N 25°39'29" W	21.96'
L98	N 36°47'01" W	16.49'
L99	N 30°15'14" W	9.33'
L100	N 34°39'40" E	6.01'
L101	N 28°22'12" E	7.13'
L102	N 02°54'57" E	9.83'
L103	N 06°59'33" E	7.18'
L104	N 53°31'30" E	3.34'
L105	N 65°07'08" E	10.62'
L106	N 16°43'58" E	3.74'
L107	N 06°33'03" E	13.73'
L108	N 16°41'30" E	10.45'

CURVE TABLE					
CURVE	RADIUS	DELTA	ARC DIST.	CHORD BEARING	CHORD DIST.
C92	5.66'	129°02'37"	12.74'	S 87°36'56" E	10.22'
C93	6.97'	60°39'38"	7.38'	S 57°41'21" W	7.04'
C94	11.90'	94°55'49"	19.72'	N 61°32'28" E	17.54'
C95	11.76'	88°27'33"	18.16'	S 51°03'03" W	16.41'
C96	4.73'	125°03'07"	10.32'	N 37°45'59" E	8.39'
C97	4.59'	149°24'38"	11.97'	S 37°33'57" W	8.85'
C98	6.68'	103°03'11"	12.02'	N 72°07'19" E	10.46'
C99	25.45'	59°58'26"	26.64'	N 24°32'40" W	25.44'
C100	28.24'	28°41'55"	14.14'	N 36°13'33" W	14.00'
C101	31.50'	17°45'53"	9.77'	S 46°48'53" E	9.73'
C102	56.84'	10°21'06"	10.27'	S 35°02'34" E	10.26'
C103	39.55'	27°46'31"	19.17'	S 75°20'24" E	18.99'
C104	12.46'	58°46'18"	12.78'	N 22°35'13" W	12.22'
C105	44.16'	16°34'37"	12.78'	S 07°23'48" E	12.73'
C106	12.56'	32°53'01"	7.21'	N 46°47'48" W	7.11'
C107	6.52'	42°22'20"	4.82'	S 47°39'57" E	4.71'
C108	16.84'	90°34'38"	26.62'	S 24°49'31" W	23.93'
C109	14.21'	38°01'39"	9.43'	N 77°33'35" W	9.26'
C110	11.40'	35°04'01"	6.97'	S 65°30'50" E	6.87'
C111	6.17'	96°13'07"	10.36'	N 19°16'04" E	9.19'
C112	10.52'	43°06'07"	7.91'	S 12°18'40" E	7.72'
C113	100.66'	4°56'08"	8.67'	N 13°21'12" E	8.67'
C114	9.71'	43°37'11"	7.40'	S 31°28'28" W	7.22'
C115	12.69'	43°43'46"	9.68'	N 45°45'33" E	9.45'
C116	45.00'	10°05'28"	7.93'	N 33°21'17" E	7.92'

BASIS OF BEARING: NAD 83/91, WASHINGTON STATE PLANE
COORDINATE SYSTEM, SOUTH ZONE, US SURVEY FEET.
CONVERGENCE ANGLE: -01°25'13.1890"
COMBINED SCALE FACTOR: 1.00004316
(AT NW CORNER OF SECTION 33) PER RENTON SURVEY BOOK 55 PAGE 130

30 15 0 30 45 60
SCALE 1 INCH = 30 FEET

DAVID ALLAN DENNY
STATE OF WASHINGTON
35477
REGISTERED
PROFESSIONAL LAND SURVEYOR

DWG FILE: 06586.DWG DRAWN BY: NG PROJ MGR: DAD

Camas Vision Statement (Revised Draft)

Your voice, Your vision, Your future

The Camas 2035 Vision was developed to guide the goals and policies of the Camas Comprehensive Plan. The Vision is written in the present tense, as if we are describing Camas as it exists in 2035. Some aspects of the vision can be found in Camas today, while others represent aspirations for the future.

Introduction

In the year 2035, residents of Camas continue to appreciate their safe, diverse and welcoming community. Those that were raised in Camas will return for family wage jobs, and to ultimately retire here. Camas maintains its small town character while accommodating future residents. Camas is well known for its excellent schools, thriving businesses and ready access to metropolitan amenities and natural features. A vibrant downtown and community events bring neighbors together and are enjoyed by all.

Vital, Stable and Livable Neighborhoods

Camas is a well planned and connected city where residents enjoy pedestrian and bicycle paths between neighborhoods and to downtown. Historic structures are maintained and rehabilitated to accommodate new homes and businesses. There is a wide variety and range of housing for all ages and income levels. Quality public facilities, services and utilities contribute to a high quality of life.

Diversified Economy

The economy has grown to attract a variety of businesses that offer stable employment opportunities and family wage jobs in the medical and high-tech fields. Camas is a gateway to nature and recreational opportunities, leading to a robust tourism industry. Professional office and industrial uses will typify western Camas, with retail businesses supporting the large campus firms. The north shore area will fulfill the employment and retail needs of the growing population on the east side, and reduce trips outside of the city. Downtown Camas retains its historic atmosphere as a walkable, attractive place to shop, dine and gather. Housing within the city's core contributes to a town center that supports local businesses.

Public Services

Camas continues to have an excellent school system, an asset that draws families to the community. Students and their families enjoy the city's parks, trails, community centers and other recreational opportunities. The library continues its vital role as a place of learning. Residents value well-funded police, fire and emergency response services. Proficient government agencies maintain existing city assets and coordinate future development.

Natural Environment

Camas appreciates and remains good stewards of its natural environment. A vegetated corridor provides habitat and safe passage for wildlife from Green Mountain to the Columbia River. Lacamas Lake is treasured as a unique and pristine resource. City policies preserve trees and natural areas.

Summary of Public Outreach

January 6, 2014

As a community, we are preparing an update of the Camas Comprehensive Plan that directs our city's long-term growth and development. The 2004 Plan helped lead the way for the neighborhoods, schools, parks and downtown that we enjoy today. Camas 2035 is a citywide process to envision our desired future 20 years from now and identify the policies and actions needed to get us there. The Camas 2035 outreach process is designed to meet the following objectives:

- Create a vision that preserves what Camas residents value most about Camas today, while planning for future generations.
- Ensure early and continuous public engagement through a variety of outreach methods.
- Build community support for the 2035 Vision and the subsequent comprehensive plan update.

Over the past six months, under the guidance of the Vision Steering Committee, hundreds of community members have participated in two rounds of Camas 2035 outreach activities. The purpose of the first round was to identify Camas' strengths and understand what residents value about Camas today. Outreach activities included:

- Online questionnaire completed by 417 community members.
- Conversations with key stakeholder groups, including the Camas Youth Advisory Committee (CYAC), Port of Camas/Washougal, Camas Parent Teacher Organization Leaders, Helen Baller Parent Teacher Association and Camas/Washougal Economic Development Association.
- Vision kick-off at Camas Days where community members recorded what they love most about Camas.

The purpose of the second round was to validate the draft vision statement and identify actions needed to achieve the vision. Outreach efforts were targeted to segments of the population that did not show strong participation in the first round, including the southeast quadrant of the city, seniors and youth. A second questionnaire distributed online and in paper form was completed by 177 people.

The following is a summary report of community outreach results. A detailed compilation of comments received throughout the process is available upon request.

ROUND ONE (July – November 2014)

Questionnaire

Who Responded?

While responses are fairly well distributed over various demographics, it is clear that different tools or targeted outreach are needed to reach the under 18 and 55 and older cohorts. Approximately 71% of questionnaire respondents fall between the ages of 35 and 54, significantly higher than the percentage of the population they represent. While it is unlikely that pre-high school youth would respond to this questionnaire, an overall response rate of 1.0% for those 18 and younger leaves room for improvement. Likewise, while rates of internet use are lower for people 65 and older, targeted efforts to reach seniors should be employed.

Age Group	Response %	2010 Census
18 or younger	1.0%	33.3%*
19 to 34	8.4%	13.9%**
35 to 44	39.8%	17.3%
45 to 54	31.6%	15.9%
55 to 64	15.3%	10.9%
65 and older	3.9%	8.7%

*Census cohort 19 and younger. **Census cohort 20 to 34

While the majority of respondents are longer-term residents of Camas, more than 41% moved here within the last 10 years. Approximately 8% of respondents work, but do not live in Camas.

Years Lived in Camas	Response
1 or less	6.8%
2 to 5	18.0%
6 to 10	16.7%
More than 10	48.5%
I work in Camas	8.3%
I am a visitor to Camas	1.7%

Responses have come in from all areas of the city. The highest percentage of responses came from NW Brady Road and NW 18th Ave., NW 38th and NW Parker St., and NW Lake Road and Sierra St. The southeast portion of the City is likely underrepresented so targeted outreach efforts should be employed.

Closest Intersection to Residence	Response
NW Brady Road and NW 18th Ave.	17.7%
NW Lake Road and Sierra St.	14.8%
NW 38th and NW Parker St.	14.0%
NW Fargo St and NW Logan	8.6%
NE 3rd Ave. and NE Adams	8.1%
NW 18th and Division St	6.7%
NE Everett and 43rd Ave.	6.7%
Leadbetter Road and 232nd Ave.	4.4%
NW Lake Road and NW Friberg-Strunk St.	2.0%
SE 2nd and SE Whitney	2.0%
Not sure/Not applicable	15.0%

What did they say?

What do you love/value most about Camas?

The excellent schools and “small town feel” are most often cited as what people value about Camas. Another important feature is the ready access to nature, such as open spaces, parks, trails, the Columbia River and Lacamas Lake. Residents value their neighbors and the broader community and see Camas as a safe, livable place to raise a family. Camasonians also appreciate the Camas downtown, as well as its proximity to Portland.

What are the City's two greatest strengths/assets?

Responses regarding Camas greatest strengths or assets are similar to the responses above. Camas schools are the overwhelming choice as the City's greatest strength, followed by trails, parks, open spaces and nature. The Camas community, downtown, people, and businesses all contribute to an outstanding quality of life.

The following "word clouds" help illustrate responses regarding what people value about Camas and the City's greatest assets.

What we value

Greatest strengths/assets

Rate the importance of goals and aspirations identified in the 2004 Comprehensive Plan.
Camas residents strongly support comprehensive plan goals that promote the City's "small town" atmosphere and vital, stable and livable neighborhoods. The Camas downtown, recreational opportunities and preserving the City's natural assets also receive strong support. Camasonians support quality public facilities, a vibrant and diverse economy and robust public participation in land use decisions. Receiving less support are providing a variety of housing types to meet the needs of the community and providing "a safe, balanced and efficient transportation system that supports industrial, commercial and residential uses."

Goal	Average
Camas' "small town" atmosphere.	3.68
Vital, stable and livable neighborhoods	3.64
Downtown as a unique and special place to visit, shop and live	3.64
Optimal active and passive recreational opportunities for present and future residents	3.61
Preservation, restoration and improvement of the natural environment	3.60
Public facilities, services and utilities to ensure the quality of life for current and future community members	3.42
A strong, vibrant and diverse economy	3.38
Early and continuous public participation for all community members in the development of land use plans and regulations	3.35
A variety of housing opportunities to meet the needs of all members of the community	2.86
A safe, balanced and efficient transportation system that supports industrial, commercial and residential uses	2.77

Highest possible score is 4.0.

What should the City do to make Camas an even better place to live or visit in the future?

Camasonians would like to see new recreational amenities, such as an indoor pool and community center, as well as more parks and trails. New businesses and employment opportunities, and investment in city infrastructure also are important. Camas residents would like to develop or renovate underutilized properties, while preserving those structures with historic value. Less important to residents are pursuing additional entertainment options, cultural activities, gathering places or retail services.

Priority	Responses		
	#1 Action	#2 Action	#3 Action
Add new recreational amenities (indoor pool, community center, tennis courts)	72	51	36
Recruit new businesses for more employment opportunities	66	51	42
Invest in infrastructure (roads and bridges, municipal buildings, water and sewer)	57	46	43
Add more parks and trails	59	46	30
Renovate/develop underutilized properties	19	34	54
Preserve historic structures and features	22	31	32
Promote cultural and social activities (theater, public art, music in the park)	20	26	47
Create a public gathering space (plaza or square)	21	31	19
Pursue additional retail services	14	27	19
Pursue additional entertainment options	5	9	19

In what ways are you most likely to participate in the Camas 2035 Vision process?

Going forward, Camas residents are prefer to participate in the 2035 process by completing online questionnaires and staying informed via email or local newspapers. Residents are less likely to participate through groups of which they are a member, social media or public meetings. Most Camasonians prefer not to give public testimony.

Activity	Response
Complete online questionnaires	77.1%
Stay informed by email	60.3%
Read articles in the Camas Washougal Post Record or The Columbian	51.7%
Participate through groups of which I am a member (e.g., school, church, civic organization)	38.0%
Follow the vision Facebook page	32.0%
Attend public meetings	30.3%
Comment on the vision website	28.0%
Give testimony at public hearings	8.6%

Community Conversations

The following is a summary of key comments made during community conversations.

Port of Camas Washougal
Camas' strengths include its location relative to SR 14 and easy access to I-5 and I-205, the School District and sports programs, proximity to rural areas and downtown Portland, and access to recreational and shopping opportunities. The City should continue to be good stewards of the environment while seeking opportunities to ease the development process. More shopping opportunities are needed within Camas to reduce travel.

Camas Parent Teacher Organization Leaders
Camas greatest assets are its schools, sense of community, proximity to Portland and natural areas/views and recreational opportunities. The City should protect trees and open spaces, close the income disparity, update and maintain park facilities and encourage more professional services and specialists.

Camas/Washougal Economic Development Association
Camas' schools, quality of life, parks/trails and housing are its greatest assets. Camas and Washougal are seeking more development-ready sites, such as the Steigerwald Commerce Center, Camas Meadows and North Dwyer Creek Business Park as environmental constraints are present across much of the city in the form of floodplains and steep slopes. The City should seek opportunities to add a variety of housing options to meet the needs of all of its residents.

Hellen Baller Parent Teacher Association
Camas' greatest strengths are its schools, green space and small businesses. The City does an excellent job of providing planning, police and infrastructure services. The mill is another important element of the community. In the future, more transportation and housing options are desired along with recreational opportunities and a community center. Specific goods and services also are needed, such as a bakery, book store and café for parents with young kids.

Camas Youth Advisory Committee (CYAC)
CYAC members believe one of Camas' primary assets is Camas High School, which brings the community together. Downtown is a central gathering place with sufficient retail to serve the community and other amenities, such as the farmers market, library and theater. Students value the city's parks, trails and recreational opportunities as well as easy access to natural features like mountains and beaches. CYAC members also appreciate the nice people and residential neighborhoods that are Camas. Students are concerned about population growth and want to see Camas High School, downtown and a new community center as central gathering places. They are interested in preserving the sense of community and safety Camas enjoys today. CYAC members believe transportation and environmental measures are needed to address traffic congestion and pollution. They anticipate a more diverse population and want to ensure that community members are not divided by socio-economic differences.

ROUND TWO (December 2014 – January 2015)

Questionnaire

Who Responded?

As in the first round, we saw very few survey responses from residents age 34 and younger and none from those under 18. Low turnout may be due in part to the survey being conducted at a time when school was not in session. Targeted efforts to reach seniors were successful as responses from those 65 and older make up 16.6% of the responses, four times the share of round one.

Age Group	Response %	Round One Response %
18 or younger	0.0%	1.0%
19 to 34	8.0%	8.4%
35 to 44	30.7%	39.8%
45 to 54	30.7%	31.6%
55 to 64	14.1%	15.3%
65 and older	16.6%	3.9%

*Census cohort 19 and younger. **Census cohort 20 to 34

As in the first survey, more than 56% of respondents have lived in Camas for more than 10 years, while approximately 41% have lived here fewer than 10 years.

Years Lived in Camas	Response
1 or less	4.0%
2 to 5	18.0%
6 to 10	20.0%
More than 10	55.3%
I work in Camas	2.0%
I am a visitor to Camas	0.7%

Vision Validation

Introduction

In the year 2035, residents of Camas continue to appreciate their community as a safe, welcoming and livable place for people of all ages. Camas maintains its small town character while accommodating current and future residents. Excellent schools, a vibrant downtown and ready access to metropolitan amenities, parks, trails, open space, the Columbia River and Lacamas Lake are enjoyed by all. The Camas Farmer's Market, First Fridays, Camas Days and other community events bring neighbors together.

97.1% of respondents support or strongly support the introduction to the vision statement.

	Responses	Response %
Do not support	2	1.2%
Somewhat support	3	1.8%
Support	36	21.1%
Strongly support	130	76.0%
Total	171	100.0%

Vital, Stable and Livable Neighborhoods

Camas is a well planned and connected city where residents enjoy pedestrian and bicycle paths between neighborhoods and to downtown. Historic structures are maintained and rehabilitated to accommodate new homes and businesses. There is a wide variety and range of affordable housing for all ages and income levels. Quality public facilities, services and utilities contribute to a high quality of life. Residents enjoy a variety of social and cultural activities to celebrate the city, its history and its people.

91.7% of respondents support or strongly support the statement on vital, stable and livable neighborhoods.

	Responses	Response %
Do not support	5	2.9%
Somewhat support	9	5.3%
Support	58	34.1%
Strongly support	98	57.6%
Total	170	100.0%

Diversified Economy

Downtown Camas retains its main street atmosphere as a walkable, attractive place to shop, with local businesses and low vacancy rates. The economy has grown to attract manufacturing and high tech companies offering stable employment opportunities and family wage jobs. Camas is a gateway to nature and recreational opportunities, leading to a robust tourism industry.

93.0% of respondents support or strongly support the statement on a diversified economy.

	Responses	Response %
Do not support	5	2.9%
Somewhat support	7	4.1%
Support	53	31.2%
Strongly support	105	61.8%
Total	170	100.0%

Public Services

Camas continues to have an excellent school system, an asset that draws young families to the community. Students and their families enjoy the city's parks, trails and recreational opportunities, which are well maintained by city employees and volunteers. The library continues its vital role as a community gathering place. Residents of all ages gather at the community center to socialize and enjoy its many amenities. Citizens value the services of well funded police, fire, planning and parks departments.

95.9% of respondents support or strongly support the statement on public services.

	Responses	Response %
Do not support	2	1.2%
Somewhat support	5	2.9%
Support	29	17.1%
Strongly support	134	78.8%
Total	170	100.0%

Natural Environment

A wildlife corridor enhances the trail system throughout the city and connects to the Columbia River. Lacamas Lake is treasured as a unique resource for recreation. The parks and trails are well maintained and handicap accessible. City policies protect trees and open spaces.

97.4% of respondents support or strongly support the statement on the natural environment.

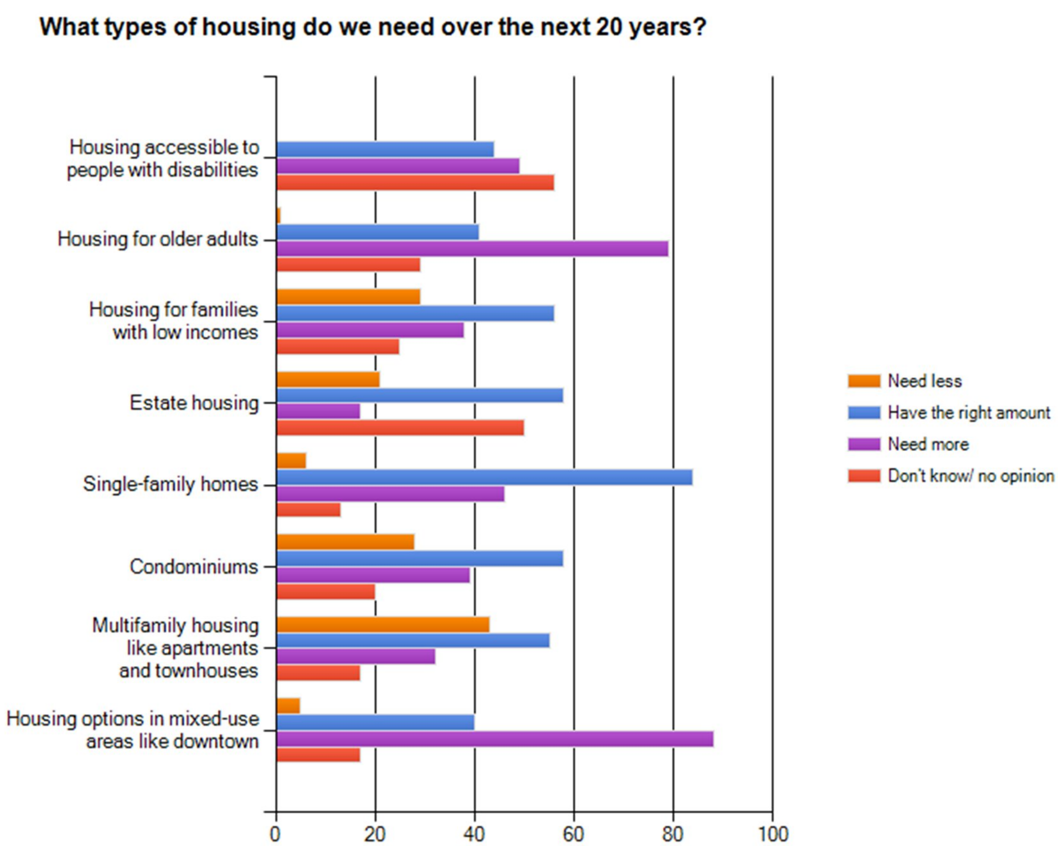
	Responses	Response %
Do not support	2	1.3%
Somewhat support	2	1.3%
Support	19	12.0%
Strongly support	135	85.4%
Total	158	100.0%

Vision Actions

Housing

What types of housing do we need over the next 20 years?

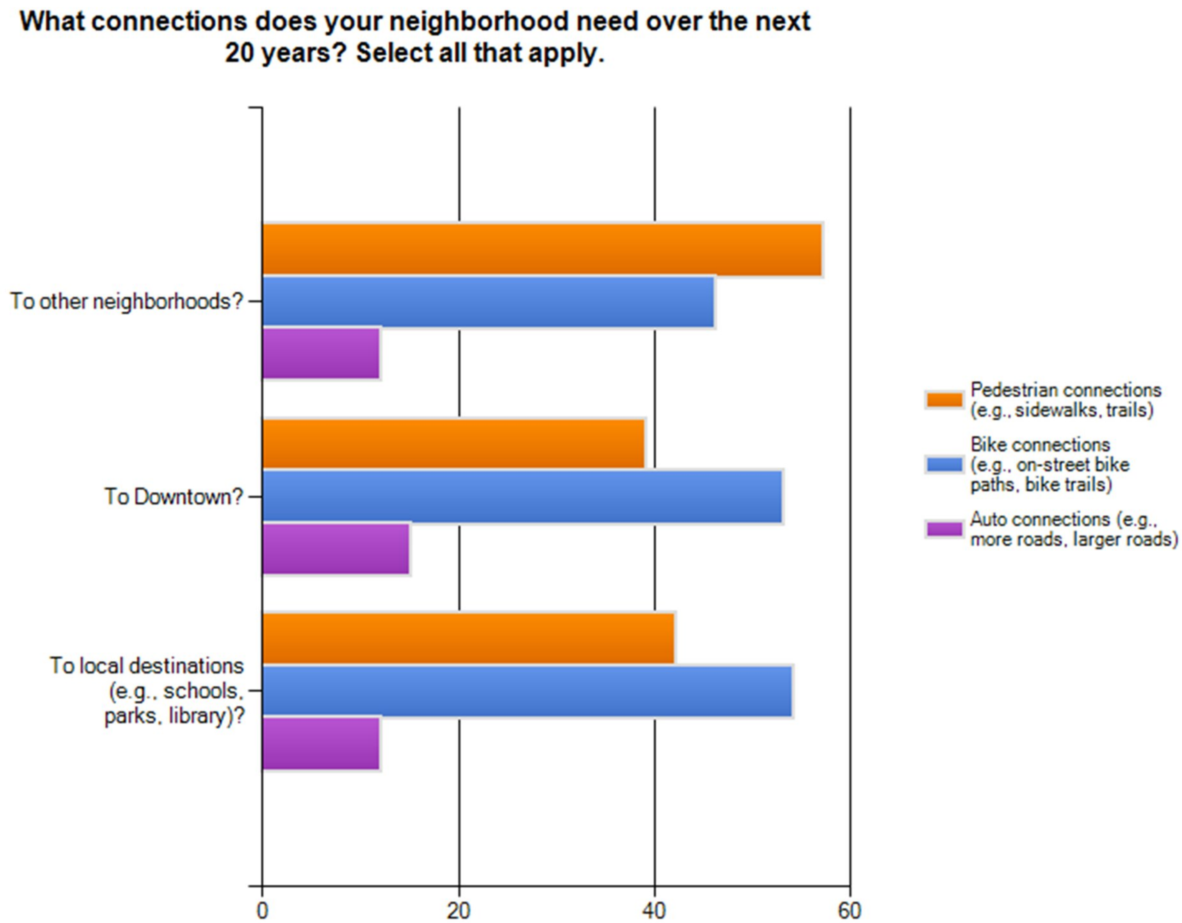
Respondents indicate that housing options in mixed-use areas like downtown are most needed, followed by housing for older adults and people with disabilities. A majority of respondents feel that the city has the right amount of single-family homes, estate housing, condominiums, housing for families with low incomes and multi-family housing.



Connections/Transportation

What connections does your neighborhood need over the next 20 years?

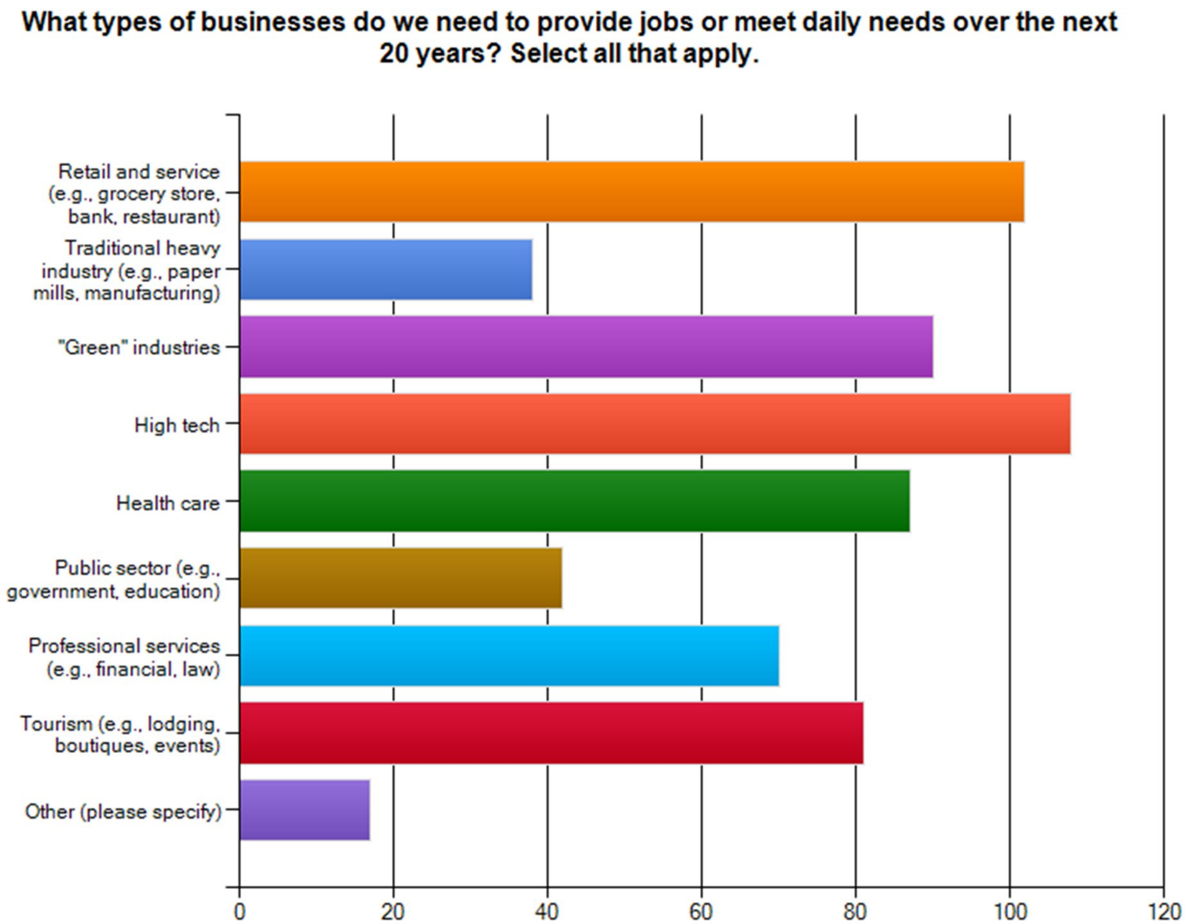
Respondents indicate that better pedestrian and bike connections are needed throughout the city, with a focus on pedestrian connections between neighborhoods and bike connections to downtown and local destinations.



Economy/Jobs

What types of businesses do we need to provide jobs or meet daily needs over the next 20 years?

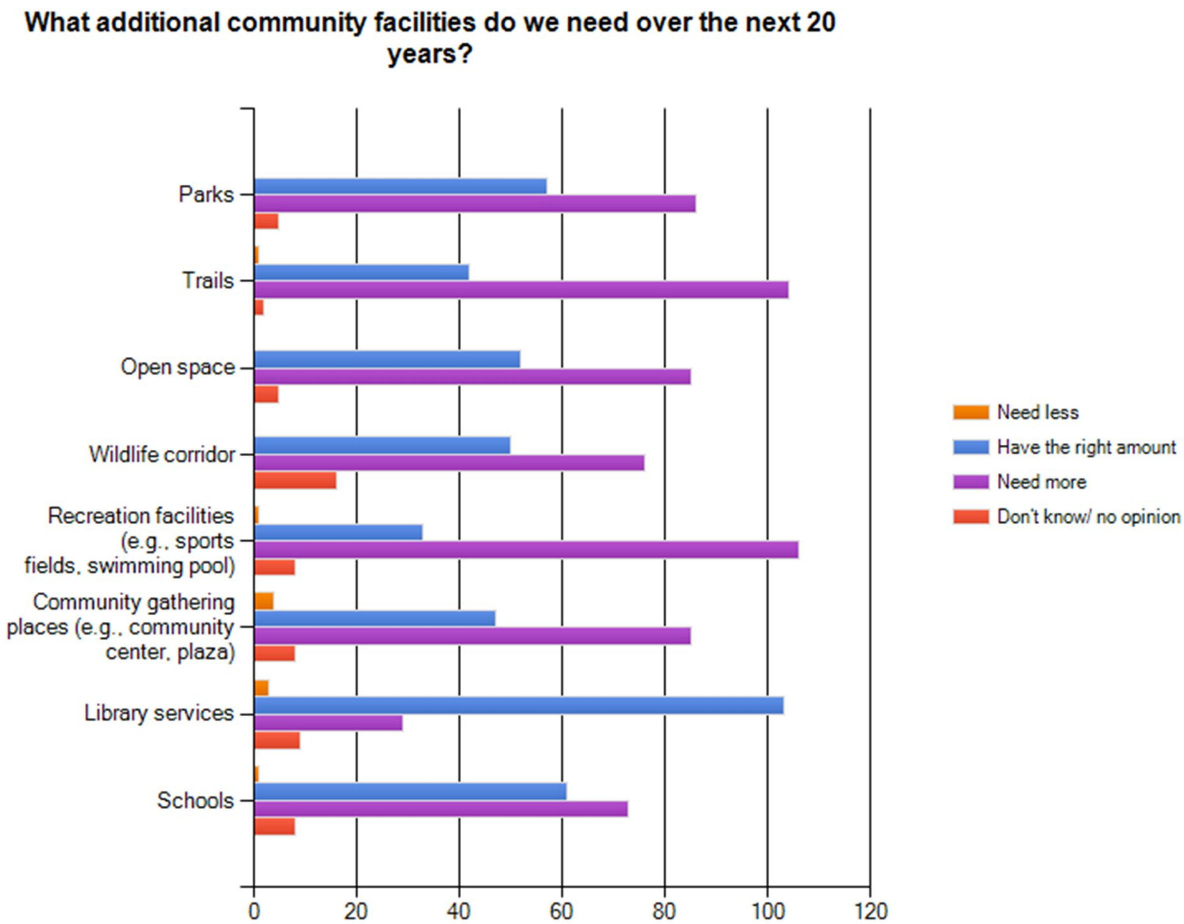
Respondents desire high tech businesses most, followed by retail and service, “green” industries, health care and tourism. Public sector and traditional heavy industry are least desirable.



Community Facilities

<u>What additional community facilities do we need over the next 20 years?</u>

A majority of respondents feel that more is needed of all the services listed with the exception of library services.



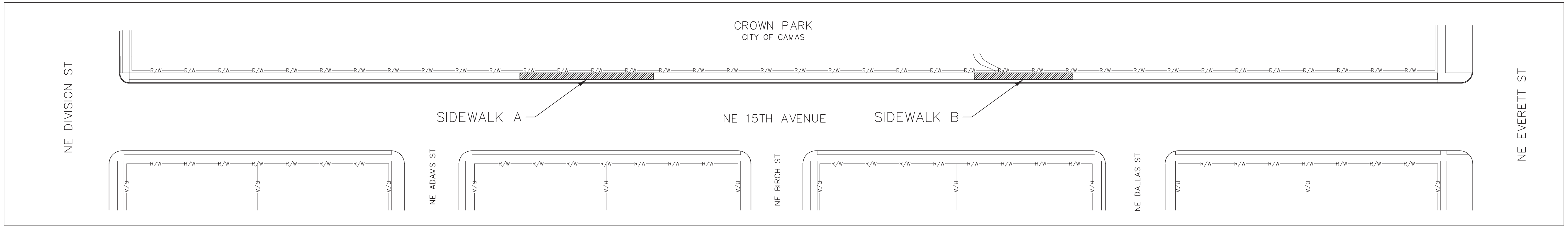
I, Jennifer Gorsuch, Deputy City Clerk, hereby certify that these bid tabulations are correct.

Jennifer Gorsuch — 1/27/15 — Date

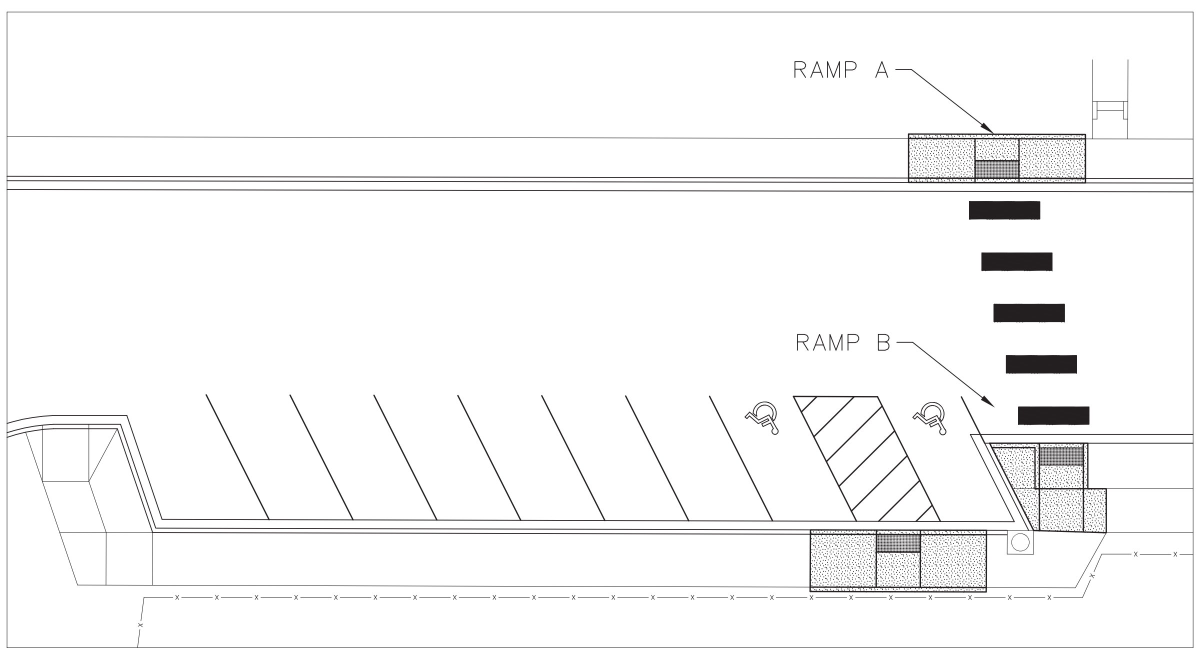
PROJECT NO. S-598 DESCRIPTION: 2015 Camas ADA Ramp Repairs DATE OF BID OPENING: January 27, 2015, at 11AM Entered by: RLS				Engineer's Estimate: $22,152 (plus sales tax)		Schmid & Sons, Inc. PO Box 799 Camas, WA 98607 360.835.3376		McNealy Excavating, Inc. 81 Dubalson Drive Washougal, WA 98671 360.837.1613	
ITEM NO	DESCRIPTION	UNIT	QTY	UNIT PRICE	ENGRG TOTAL	UNIT PRICE	CONTRACT TOTAL	UNIT PRICE	CONTRACT TOTAL
1	Mobilization	LS	1.00	$2,000.00	$2,000.00	$1,200.00	$1,200.00	$2,500.00	$2,500.00
2	Clearing & Grubbing	LS	1.00	$800.00	$800.00	$200.00	$200.00	$800.00	$800.00
3	Removal of Structure and Obstruction	LS	1.00	$2,000.00	$2,000.00	$3,560.00	$3,560.00	$2,500.00	$2,500.00
4	Crushed Surfacing Top Course	TN	16.00	$50.00	$800.00	$56.75	$908.00	$50.00	$800.00
5	Cement Concrete Traffic Curb	LF	51.00	$25.00	$1,275.00	$20.55	$1,048.05	$30.00	$1,530.00
6	Cement Concrete Pedestrian Curb	LF	51.00	$20.00	$1,020.00	$17.95	$915.45	$20.00	$1,020.00
7	Cement Concrete Sidewalk	SY	99.00	$43.00	$4,257.00	$60.00	$5,940.00	$31.00	$3,069.00
8	Cement Concrete Sidewalk Ramp, Type 2	EA	2.00	$1,100.00	$2,200.00	$808.00	$1,616.00	$1,200.00	$2,400.00
9	Cement Concrete Sidewalk Ramp, Type 3	EA	1.00	$1,800.00	$1,800.00	$500.00	$500.00	$1,600.00	$1,600.00
10	Ramp Detectable Warning	SF	30.00	$60.00	$1,800.00	$28.80	$864.00	$35.00	$1,050.00
11	Roadside Restoration	LS	1.00	$200.00	$200.00	$495.00	$495.00	$750.00	$750.00
12	Erosion Control and Water Pollution Control	LS	1.00	$1,500.00	$1,500.00	$235.00	$235.00	$500.00	$500.00
13	Project Temporary Traffic Control	LS	1.00	$500.00	$500.00	$515.00	$515.00	$500.00	$500.00
14	Minor Changes	LS	1.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00
	SUBTOTAL				$22,152.00		$19,996.50		$21,019.00
	8.4% WA STATE SALES TAX				$1,860.77		$1,679.71		$1,765.60
	CONTRACT TOTAL (BASIS OF AWARD)				$24,012.77		$21,676.21		$22,784.60

City of Camas WASHINGTON

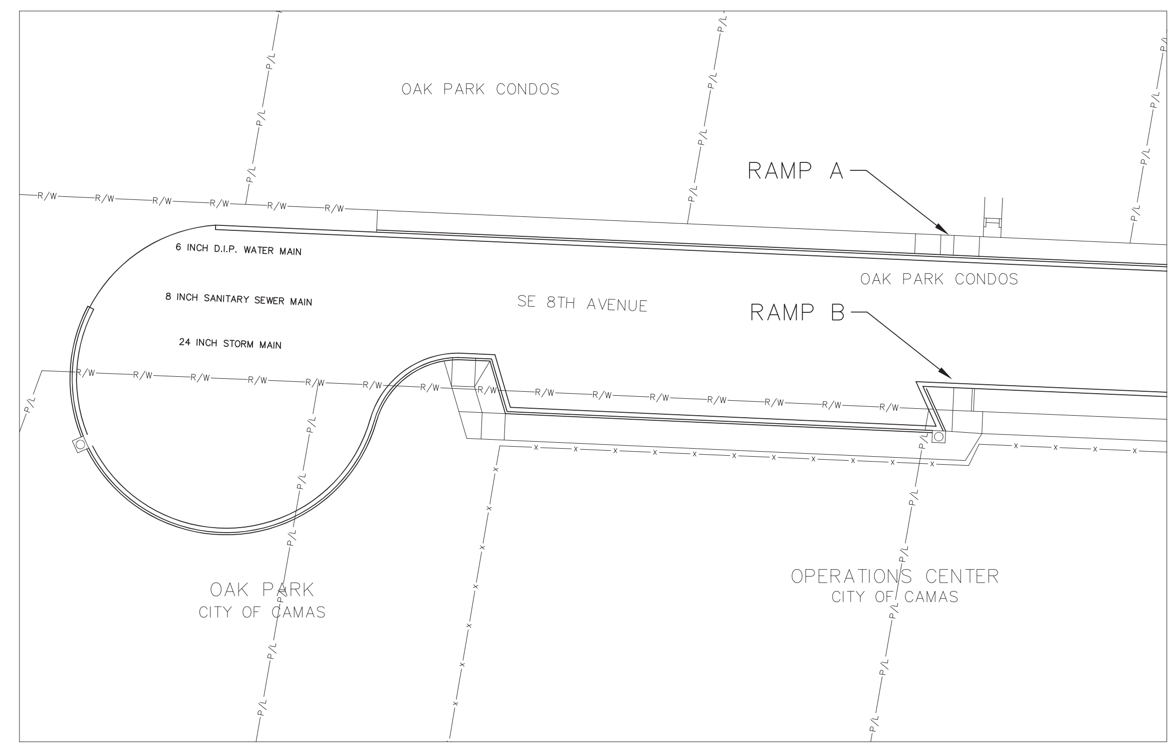
PROJECT NO. S-598 DESCRIPTION: 2015 Camas ADA Ramp Repairs DATE OF BID OPENING: January 27, 2015, at 11AM Entered by: RLS				PD Badertscher Constr LLC 5317 NE 316th Court Camas, WA 98607 360.798.8771		Halme Excavating, Inc. 22514 NE 72nd Avenue Battle Ground, WA 98604 360.687.7399		Haag & Shaw, Inc. 636 SE 3rd Avenue Camas, WA 98607 360.834.2514	
ITEM NO	DESCRIPTION	UNIT	QTY	UNIT PRICE	CONTRACT TOTAL	UNIT PRICE	CONTRACT TOTAL	UNIT PRICE	CONTRACT TOTAL
1	Mobilization	LS	1.00	$1,000.00	$1,000.00	$2,200.00	$2,200.00	$1,000.00	$1,000.00
2	Clearing & Grubbing	LS	1.00	$500.00	$500.00	$1,950.00	$1,950.00	$700.00	$700.00
3	Removal of Structure and Obstruction	LS	1.00	$3,500.00	$3,500.00	$3,200.00	$3,200.00	$4,100.00	$4,100.00
4	Crushed Surfacing Top Course	TN	16.00	$31.25	$500.00	$30.00	$480.00	$200.00	$3,200.00
5	Cement Concrete Traffic Curb	LF	51.00	$30.00	$1,530.00	$21.00	$1,071.00	$32.00	$1,632.00
6	Cement Concrete Pedestrian Curb	LF	51.00	$20.00	$1,020.00	$21.00	$1,071.00	$32.00	$1,632.00
7	Cement Concrete Sidewalk	SY	99.00	$45.45	$4,499.55	$51.00	$5,049.00	$40.50	$4,009.50
8	Cement Concrete Sidewalk Ramp, Type 2	EA	2.00	$1,750.00	$3,500.00	$775.00	$1,550.00	$2,100.00	$4,200.00
9	Cement Concrete Sidewalk Ramp, Type 3	EA	1.00	$1,700.00	$1,700.00	$785.00	$785.00	$2,100.00	$2,100.00
10	Ramp Detectable Warning	SF	30.00	$26.67	$800.10	$27.00	$810.00	$0.00	$0.00
11	Roadside Restoration	LS	1.00	$500.00	$500.00	$500.00	$500.00	$500.00	$500.00
12	Erosion Control and Water Pollution Control	LS	1.00	$500.00	$500.00	$500.00	$500.00	$300.00	$300.00
13	Project Temporary Traffic Control	LS	1.00	$500.00	$500.00	$1,000.00	$1,000.00	$500.00	$500.00
14	Minor Changes	LS	1.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00
	SUBTOTAL				$22,049.65		$22,166.00		$25,873.50
	8.4% WA STATE SALES TAX				$1,852.17		$1,861.94		$2,173.37
	CONTRACT TOTAL (BASIS OF AWARD)				$23,901.82		$24,027.94		$28,046.87



CROWN PARK SIDEWALK
EXISTING CONDITIONS
SCALE: 1" = 40'



MARKING PLAN
SCALE: 1" = 10'



OAK PARK ADA RAMPS
EXISTING CONDITIONS
SCALE: 1" = 20'

CALL
2 BUSINESS DAYS
BEFORE YOU DIG
1-800-424-5555
"it's the law"
A FREE SERVICE
CLARK COUNTY UTILITES COORDINATING COUNCIL

DATES
DESIGN DATE: 12/20/14
AS-BUILT DATE:
SCALES
HORIZONTAL: AS SHOWN
VERTICAL: N/A
CONTACTS
DESIGNED BY: SCD
APPROVED BY: JH
PROJ. ENGR.: SCD

CITY OF CAMAS WASHINGTON
616 NE 4TH AVENUE
CAMAS, WA 98607
PH:(360) 834-3451

COMMUNITY DEVELOPMENT
ENGINEERING DEPARTMENT

2015 ADA RAMP & SIDEWALK
IMPROVEMENTS
PLAN OVERVIEW

CAMAS PROJECT NUMBER
S-598

STATUS
☐ DRAFT
☒ CONSTRUCTION
☐ AS-BUILT

PAGE
1 OF 1

CAMAS DRAWING NUMBER

CAMAS CATALOG NUMBER

CITY OF CAMAS PROJECT NO. S-583, TAP7034-(002), TA-5412 Project Name: NW 18th Ave. Bike & Ped. Trail Link	PAY ESTIMATE: THREE / FINAL PAY PERIOD: December 1, 2014 - December 31, 2014 Original Contract Amount: $214,159.61	Green Construction, Inc. P.O. Box 142 Washougal, WA 98671 (360) 817-9948

ITEM NO.	DESCRIPTION	UNIT	ORIGINAL QUANTITY	UNIT PRICE	CONTRACT TOTAL	QUANTITY PREVIOUS	TOTAL PREVIOUS	QUANTITY THIS EST.	TOTAL THIS EST.	QUANTITY TO DATE	TOTAL TO DATE
Base Bid											
1	Roadway Surveying	LS	1.00	$9,000.00	$9,000.00	1.00	$9,000.00	0.00	$0.00	1.00	$9,000.00
2	SPCC Plan	LS	1.00	$500.00	$500.00	1.00	$500.00	0.00	$0.00	1.00	$500.00
3	Mobilization	LS	1.00	$8,950.00	$8,950.00	1.00	$8,950.00	0.00	$0.00	1.00	$8,950.00
4	Traffic Control Supervisor	LS	1.00	$2,000.00	$2,000.00	1.00	$2,000.00	0.00	$0.00	1.00	$2,000.00
5	Flaggers and Spotters	HR	240.00	$54.00	$12,960.00	328.00	$17,712.00	0.00	$0.00	328.00	$17,712.00
6	Other Traffic Control Labor	HR	8.00	$56.00	$448.00	12.00	$672.00	0.00	$0.00	12.00	$672.00
7	Other Temporary Traffic Control	LS	1.00	$1,000.00	$1,000.00	1.00	$1,000.00	0.00	$0.00	1.00	$1,000.00
8*	Clearing and Grubbing	AC	0.30	$40,000.00	$12,000.00	1.00	$40,000.00	-0.41	($16,400.00)	0.59	$23,600.00
9	Removal of Structures and Obstructions	LS	1.00	$9,850.00	$9,850.00	1.00	$9,850.00	0.00	$0.00	1.00	$9,850.00
10	Sawcutting Asphalt Pavement	LF	175.00	$3.50	$612.50	135.50	$474.25	0.00	$0.00	135.50	$474.25
11	Earthwork	LS	1.00	$17,950.00	$17,950.00	1.00	$17,950.00	0.00	$0.00	1.00	$17,950.00
12	Porous Geotextile Fabric	SY	1525.00	$1.58	$2,409.50	1,595.70	$2,521.21	0.00	$0.00	1595.70	$2,521.21
13	Permeable Ballast	CY	130.00	$48.68	$6,328.40	266.00	$12,948.88	0.00	$0.00	266.00	$12,948.88
14	Crushed Surfacing Top Course	CY	255.00	$52.12	$13,290.60	88.60	$4,617.83	0.00	$0.00	88.60	$4,617.83
15	Porous HMA Cl. 1/2" PG 70-72	TON	225.00	$180.81	$40,682.25	256.70	$46,413.93	0.00	$0.00	256.70	$46,413.93
16	Corrugated Polyethylene Storm Sewer Pipe, 6" Daim.	LF	6.00	$38.10	$228.60	6.00	$228.60	0.00	$0.00	6.00	$228.60
17	Corrugated Polyethylene Storm Sewer Pipe,8" Daim.	LF	8.00	$43.15	$345.20	8.00	$345.20	0.00	$0.00	8.00	$345.20
18	Corrugated Polyethylene Storm Sewer Pipe, 12" Diam.	LF	230.00	$52.42	$12,056.60	226.00	$11,846.92	0.00	$0.00	226.00	$11,846.92
19	Polyvinyl Chloride (PVC) C-900 Storm Sewer Pipe, 12" Daim.	LF	395.00	$42.46	$16,771.70	398.50	$16,920.31	40.00	$1,698.40	438.50	$18,618.71
20	Catch Basin, Type 1	EA	2.00	$2,491.00	$4,982.00	2.00	$4,982.00	0.00	$0.00	2.00	$4,982.00
21	Area Drain, 12" Basin	EA	1.00	$760.00	$760.00	1.00	$760.00	0.00	$0.00	1.00	$760.00
22	30" Basin with Solid Lid	EA	3.00	$2,422.42	$7,267.26	3.00	$7,267.26	0.00	$0.00	3.00	$7,267.26
23	Valve/Meter Box Adjustment	EA	2.00	$300.00	$600.00	5.00	$1,500.00	0.00	$0.00	5.00	$1,500.00
24	ESC Lead	DAY	25.00	$50.00	$1,250.00	36.00	$1,800.00	0.00	$0.00	36.00	$1,800.00
25	Erosion Control	LS	1.00	$4,680.00	$4,680.00	1.00	$4,680.00	0.00	$0.00	1.00	$4,680.00
26	Landscaping	LS	1.00	$7,930.00	$7,930.00	1.00	$7,930.00	0.00	$0.00	1.00	$7,930.00
27	Driveway construction Type HMA w/Earthwork	SY	100.00	$58.49	$5,849.00	85.60	$5,006.74	0.00	$0.00	85.60	$5,006.74
28	Detectable Warning Surface	SF	36.00	$28.00	$1,008.00	0.00	$0.00	60.00	$1,680.00	60.00	$1,680.00
29	Quarry Spalls	CY	250.00	$42.60	$10,650.00	259.50	$11,054.70	0.00	$0.00	259.50	$11,054.70
30	Irrigation System	LS	1.00	$1,800.00	$1,800.00	1.00	$1,800.00	0.00	$0.00	1.00	$1,800.00
C.O. #1	Change Order #1								$6,021.49		$6,021.49
	Street Subtotal				$214,159.61		$250,731.83		($7,000.11)		$243,731.72

	ORIGINAL CONTRACT TOTAL	TOTAL PREVIOUS	**TOTAL THIS EST.**	TOTAL TO DATE
SUBTOTALS	$214,159.61	$250,731.83	**($7,000.11)**	$243,731.72
CHANGE ORDERS TO DATE	$0.00	$0.00	**$0.00**	$0.00
SUBTOTAL	$214,159.61	$250,731.83	**($7,000.11)**	$243,731.72
TOTAL CONTRACT	**$214,159.61**	$250,731.83	**($7,000.11)**	$243,731.72
PREVIOUS RETAINAGE WITHHELD		($12,536.59)		
TOTAL LESS RETAINAGE		**$238,195.24**		
Retainage payment to contractor 12/31/14		$12,536.59		
TOTALS		**$250,731.83**	**($7,000.11)**	**$243,731.72**
**Check from contractor on 1/23/15			$7,000.11	

Account #300-00-594-760-65

TOTAL THIS PAY EST. = **$0.00**

1/27/15
Project Engineer Date

1/27/15
Contractor Date

1-27-15
Project Manager Date

* Over payment of 0.41 Acres was made for bid item #8, Clearing and Grubbing, on Pay Estimate #2.
**The balance of the overpayment has been reimbursed by the contractor on this pay estimate.

Amount: $12,536.59 Sequence Number: 8592586136

Account: 105000006200 Capture Date: 01/09/2015

Bank Number: 123308825 Check Number: 124368

THE FACE OF THIS DOCUMENT HAS A COLORED BACKGROUND ON WHITE PAPER

City of Camas WASHINGTON

616 NE 4TH AVENUE
CAMAS, WASHINGTON 98607
TELEPHONE (360) 834-2462

BANK OF AMERICA
CAMAS BRANCH
CAMAS, WASHINGTON

98-0882
1233

124368

CLAIMS CHECK

Date	Amount
12/31/2014	$12,536.59

Pay: TWELVE THOUSAND FIVE HUNDRED THIRTY-SIX AND 59 / 100

Michael Green Construction Inc
P.O. Box 142
Washougal, WA 98671

FINANCE DIRECTOR

THE BACK OF THIS DOCUMENT CONTAINS AN ARTIFICIAL WATERMARK - HOLD AT AN ANGLE TO VIEW

⑈124368⑈ ⑆123308825⑆ 105000006200⑈

Security features on this check are Tamper Resistant Paper, Micro Print Signature Line, Colored Background on the front and Original Document Security Screen on the back

0063259292

>125108272<
Columbia Bk #1063
2015-01-09
0063259292

ENDORSE CHECK HERE:

PAY TO THE ORDER OF
WEST COAST ...
FOR DEPOSIT ONLY
GREEN CONSTRUCTION, INC.
1120000722

DO NOT SIGN/WRITE/STAMP BELOW THIS LINE
FOR FINANCIAL INSTITUTION USAGE ONLY

Electronic Endorsements:

Date	Sequence	Bank #	Endrs Type	TRN	RRC	Bank Name
01/09/2015	000008545916511	91000019	Undetermined	N		WELLS FARGO BANK, NA
01/09/2015	008592586136	121103886	Pay Bank	N		BANK OF AMERICA, NA
01/09/2015	000000063259292	125108272	Rtn Loc/BOFD	Y		COLUMBIA STATE BK, D

City of Camas
616 NE 4th Avenue
Camas, WA 98607
360-834-2462

Finance Office Hours:
Monday-Friday 9:00 - 5:00 p.m.

Date/Time 01/23/2015 14:42
Receipt No. 00240250
Receipt Date 01/23/2015
suspense
Reimburse #S-5
83 - Green Con
struction 7,000.11

Cash: 0.00
Other: 7,000.11
Check: 7,000.11

Total: 7,000.11
Change: 0.00

Check No: 6116

Green Construction Project # S-583
Customer #: 000000

Cashier: cagonzalez
Station: IS01306