Island Stream Invertebrate Survey (ISIS) Final Report

Prepared for the Vashon-Maury Groundwater Protection Committee
by: Bianca Perla, PhD
Vashon Nature Center, LLC
23509 Landers Rd SW Vashon, WA 98070
206.463.9443, bianca.vnc@gmail.com
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Abstract

While physical water quality parameters indicate clean water in Vashon streams, benthic invertebrate metrics assign Vashon streams only very poor to fair ecological condition. This report describes results of an examination of data from the previous seven years of benthic invertebrate monitoring on Vashon. Hypotheses are discussed for why streams are scoring so low. These hypotheses vary from island isolation effects, to cumulative impacts of land-use, to dominating impacts like sedimentation. Different plans of action are recommended to test some of these hypotheses. Next steps include: more statistical analysis of existing data, field tests using targeted sampling sites to examine certain impacts, and continuation of a set of long-term monitoring sites that will help establish clearer pictures of trends in priority streams. The proposed projects are designed to build on and work within the context of existing conservation and research efforts on the island (i.e. ongoing stream restoration efforts, salmon surveys, water quality measurements, existing King County benthic invertebrate sampling). The plans of action also suggest appropriate avenues to involve community members and school students in helping to jointly solve the mystery of low scoring streams.

Acknowledgements

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Introduction

In former benthic invertebrate (BI) sampling efforts (2005-2012) island streams scored surprisingly low on the Benthic Index of Biotic Integrity (B-IBI) indicating that local stream health could be more jeopardized than previously thought. In response, the Vashon-Maury Island Groundwater Protection Committee (GWPC) initiated an exploration of existing data to come up with hypotheses about why streams are scoring low and to develop a plan of action involving the local community in solving this mystery.

This report gives an overview of stream conditions and trends in stream invertebrate communities sampled between 2005 and 2012. Some preliminary hypotheses are proposed for why streams are scoring low. In addition, next steps are proposed with accompanying estimates of cost for further investigating these hypotheses. Special attention is given to ways in which this plan of action compliments and builds on existing monitoring and conservation efforts. In addition various options are suggested for engaging local residents, and for community outreach.

Background:

Why Benthic Invertebrate Monitoring?

Benthic Macro-invertebrates are animals that live in the stream bed and can be seen with the naked eye. Insects, crustaceans, worms, snails, and clams are all benthic macro-invertebrates. They are connected to many other species and ecosystem functions. They are prey to fish, birds and each other. They are pivotal in decomposition of living matter in streams as well as

(photo courtesy: Jeff Adams and the Xerces Society)

nutrient cycling. Because of their placement in the stream bed and their many connections to all parts of the stream ecosystem, benthic invertebrates are sensitive to many different stream impacts. They are also easily collected making them excellent candidates to sample for monitoring stream health.

History of Benthic Invertebrate collection and other Stream Studies on Vashon

The earliest quantitative monitoring of stream health using macro-invertebrates was conducted by King County Roads division between 1999 and 2005. This program used volunteers to help collect invertebrates and samples were sent to a professional lab for identification. The data is on file at King County offices but has not been entered into the Puget Sound Stream Benthos site so it was not analyzed for this report.

Between 2005 and 2012 King County Department of Natural Resources and Parks collected samples for two separate programs: Vashon (2005-ongoing, 3 sites); and Regulatory Effectiveness (2008-2012, 3 sites, see figure 1). In addition, King County Roads division continued sampling their 8 sites from 2006 until 2011 (figure 1). Currently, only the 3 sites from the DNRP Vashon project are planned to continue (see figure 1). These sites are on Shinglemill Creek, Judd Creek, and Christensen Creek.

In addition to Benthic invertebrate collection, King County has an on-going water quality program that tests for dissolved oxygen, temperature, ph, conductivity, total organic carbon, dissolved organic carbon, total suspended solids, turbidity, alkalinity, total and dissolved nutrients (NO2, NO3, P), fecal coliform plus E. coli for Shinglemill, Judd, Fisher, and Mileta creeks. In 2013, two sites will continue, one on Shinglemill and one on Judd Creek.

In 2007 heavy metals were tested on the above-mentioned creeks as well. Heavy metals tested were: Al, An, As, Ba, Br, B, Cd, Ca, Cr,Co, Cu, Fe, hardness, Li, Mn, Mg, Hg, Mb, K, Se, Na, S, Th, Sn, Ti, Vn, Pb, Ag, Zn.

During this same period restoration projects have been initiated on both Shinglemill and Judd Creeks. King County Roads replaced culverts in 3 key salmon bearing sections of Judd Creek and under Cedarhurst Road in lower Shinglemill Creek. In addition, about 1.5 miles of Judd Creek is now undergoing riparian restoration by Vashon-Maury Island Land Trust and independent private land owners. Land Trust restoration started with fencing cattle out of a section of Judd creek in 2007 and has now expanded to removal of invasive species and planting of natives in riparian buffer areas. Additional restoration has happened through King Conservation District programs for at least two other land owners in Judd Creek.

Along Shinglemill Creek in the Needle Creek drainage, the Vashon-Maury Island Land Trust has conducted some native plantings as well as a large log jam restoration project in 2007-2008 in an attempt to stop the considerable erosion along that arm of Shinglemill creek.

Below Table 1 outlines previous studies and restoration projects in Vashon streams.

Project	Date	Streams	Organization
Benthic Invertebrate Sampling	1999-2011	McCormick, Shinglemill, Gorsuch, Ellis, Judd, Fisher, Tahlequah	King County Roads. 2006-2011 data available on Puget Sound Stream Benthos website.
Benthic Invertebrate Sampling	2005-ongoing	Judd, Shinglemill, Christensen	King County DNRP- Vashon project
Benthic Invertebrate Sampling	2008-2012	Judd, Fisher, Tahlequah	King County DNRP- Regulatory effectiveness
Vashon Island Stream Typing	2001	37 stream reaches and tributaries	Washington Trout washingtontrout.org/Vashon.shtml
Salmonwatchers	2001-2009	Judd, Shinglemill, Christensen, Fisher	King County
Salmonwatchers	2011-ongoing	Judd, Shinglemill, Fisher, Christensen, Raabs, Mileta	Vashon Nature Center, LLC
Water Quality Testing	2005-ongoing	Shinglemill, Judd, Fisher, Mileta. Only Shinglemill and Judd will be continued.	King County DNRP
Heavy metals Testing	2007	Judd, Shinglemill, Fisher, Mileta	King County DNRP
Paradise Valley Restoration	2007-ongoing	Judd	Vashon-Maury Island Land Trust and private land owners (through King Conservation District)
Culvert replacement	2007-2010	Judd, 216th, 204th, 111th; Shinglemill-Cedarhurst.	King County Roads
Log Restoration and plantings	2007-ongoing	Shinglemill, Needle Creek drainage	Vashon Maury Island Land Trust
Singer Farm Restoration	2007-ongoing	Judd	Vashon-Maury Island Land Trust

Table 1. Major historical and current stream studies and restoration projects on Vashon

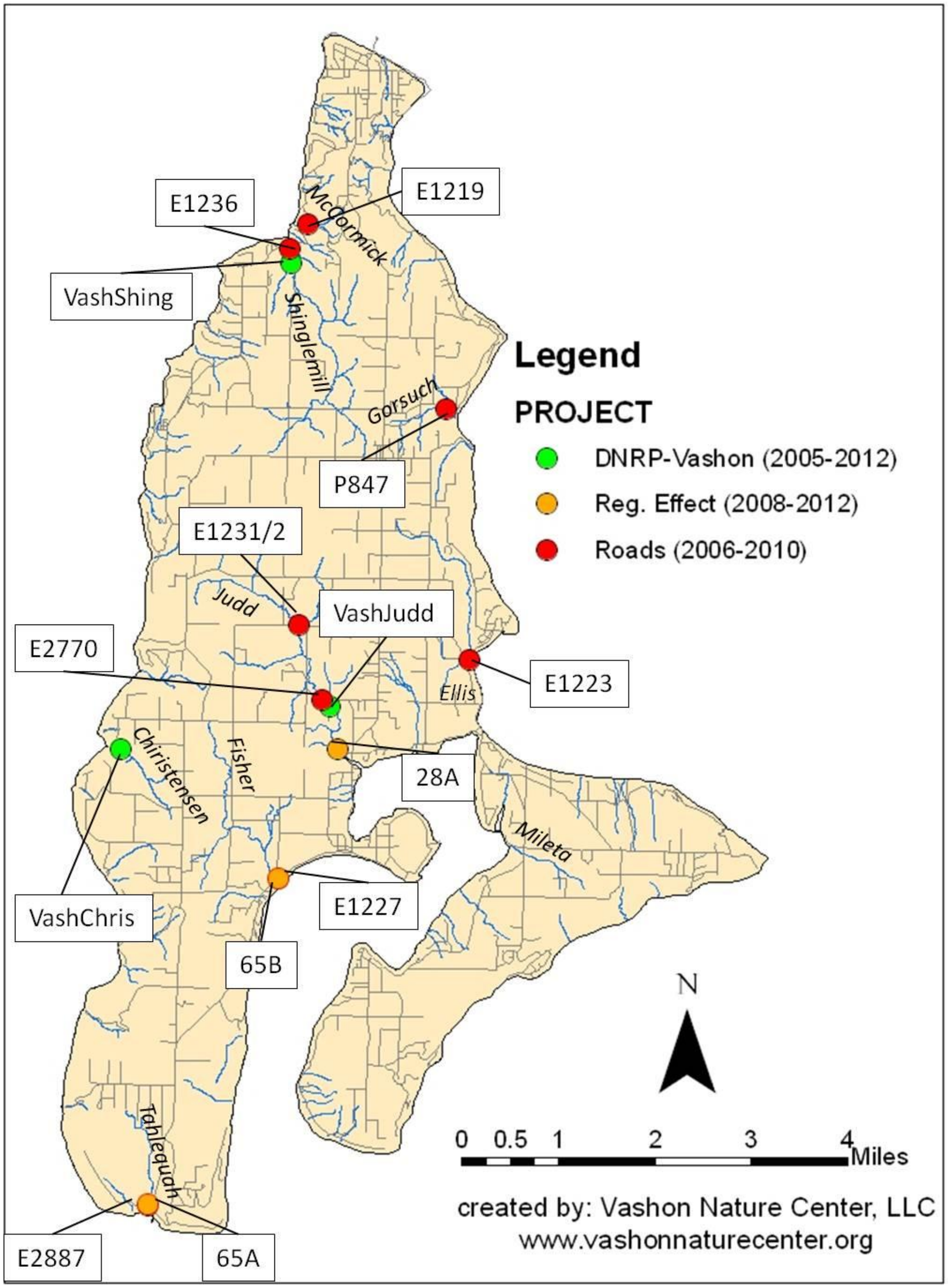

Figure 1. Existing sample sites, sampling years, and responsible King County Departments and programs. Sample site names correspond to the names used to record data in Puget Sound Stream Benthos. Only DNRP sites (green dots) will be continued past 2012. Roads sites (red dots) were stopped in 2010. DNRP regulatory effectiveness sites (orange dots) stop in 2012.

Key Links between Invertebrate Monitoring, Stream studies, and restoration efforts.

- Data from benthic invertebrate sampling can be explored to help form hypotheses for invertebrate decline and to determine direction of long-term trends in B-IBI metrics (see data exploration section below).
- On-going benthic invertebrate monitoring programs are being scaled back from 14 sites to 3 sites which will inhibit ability to track trends on more than 3 sites in the future. It is recommended that a long-term monitoring program through GWPC pick up some of these sites (see long-term monitoring section below).
- There is existing data for some of these sites going back to 1999. Analyzing this data could increase accuracy in the direction of long-term trends by doubling the time available for comparison.
- Comparing water quality measures with B-IBI metrics may yield hypotheses for invertebrate decline.
- Salmon watching programs can be used in conjunction with benthic invertebrate monitoring as another indicator of the biological health of streams. The presence of salmon benefits invertebrates and vice versa. B-IBI sampling could be used to monitor the success of salmon habitat restoration projects.

Data exploration and hypotheses: Why do streams score low?

Of eight streams tested 2005-2012, three had average overall B-IBI scores of very poor to poor. Five had average scores of poor to fair (Figure 2). With the exception of 2 Judd sites, streams are not improving through time. They either exhibit unchanging low scores or decreasing scores (Table 2). Possible explanations for low scores can be divided into two main categories: 1) misrepresentative metrics and sampling; and/or 2) influence of real impacts.

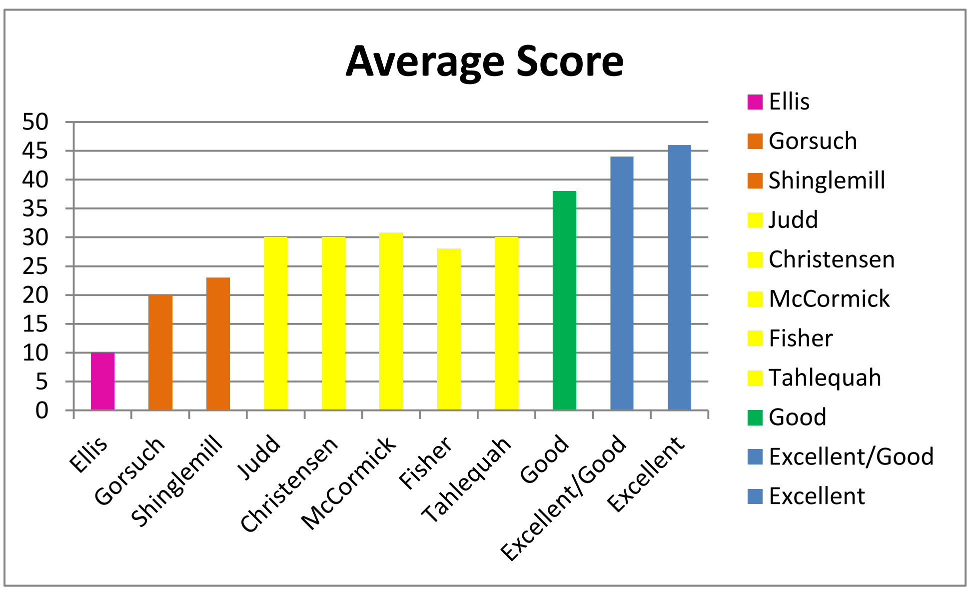

Figure 2. B-IBI scores averaged for each creek from 2005-2012. We have no creeks in good or excellent condition.

Stream and site	Trend	R^2_{adj}	p value	years	Notes/other sites
Ellis	steady	n/a	n/a	2006-2010	Score=10 all years
Gorsuch	steady	.33	1	2006-2010	
Shinglemill VashShing	decreasing	.45	.063, (t-test p=.006*)	2005-2011	T-test comparing 1st 4 sample years 2005-2008 and last 3 years 2009-2011 shows a significant decrease. Site E1236 decrease until 2010.
Judd 28A	increasing	.852	.046 *	2008-2011	E2770 also increasing but not significant, remaining 2 sites steady.
Christensen	steady	.047	.43	2005-2011	
McCormick	steady	.56	.09	2006-2010	Decrease but not significant
Fisher E1227	steady	.241	.23	2006-2010	site 65B also steady
Tahlequah E2887	decreasing	.856	.014*	2006-2010	Site 65A decreasing 2008-2011

*= p value is statistically significant (95% confidence level)

Table 2. Trends in B-IBI scores for data collected between 2005-2011. Linear regression of scores against year was used to determine statistic significance of trends. In addition, when enough years were available, t-tests were used to compare first 4 years with second 3-4 years to test for a significant change between time blocks. Ellis, Gorsuch, Christensen, and Fisher show no change in scores through time. Tahlequah and Shinglemill have statistically significant decreases. McCormick shows a decreasing trend but it is not statistically significant. Judd Creek has 1 site increasing in health, 1 site with an upward trend (but not statistically significant) and 2 sites holding steady with fair ratings.

Representativeness: Are B-IBI metrics and sample sites representative of actual stream health?

The Puget Sound lowlands B-IBI metrics are calibrated to reference sites in mainland areas of the Puget Sound. Because Vashon streams are isolated island streams it is possible that they naturally have lower levels of invertebrate biodiversity than mainland streams (MacArthur and Wilson 2001). In addition, island streams are more groundwater influenced than mainland streams (which have snowmelt components to their hydrology). This could result in different community assemblages seen at Vashon sites compared to mainland reference sites. These natural factors of isolation and groundwater influence could result in lower B-IBI scores making island streams look more impacted then they actually are.

If Puget Sound lowland B-IBI scores are not completely representative of island streams then the best use of B-IBI metrics may be to compare island streams with each other and to establish trends in scores overtime rather than concentrating on actual score values.

Another issue of representativeness is choice of sample site. Sample sites located in areas where local impacts are high could reflect local conditions rather than watershed conditions. Through visits to sample sites along the creeks it was determined that 4 of the 14 sample sites have potentially strong local impacts that could result in B-IBI scores that are not representative of overall watershed conditions. In addition, in Judd Creek, slightly shifting sample site locations could greatly increase the clarity of interpretation for long-term trends by keeping the long-term monitoring site low in the watershed to capture the overall picture, and strategically placing upper sites at locations directly downstream of existing restoration efforts to isolate restoration influence. Alternative sites were identified when possible (Table 3, Figure 3).

To test whether existing sample sites are experiencing local impacts that swamp information about watershed condition, B-IBI sample results of original sites and alternative sites can be taken in the same season. And, comparisons can be made using both qualitative and quantitative analyses of invertebrate community assemblages.

Stream site	Local impacts	Alternative stream site
Ellis E1223	Saltwater influence	None identified. Very low to intermittent flow above E1223.
Christensen (VashChris)	Lawn, cleared area, significant alder, ornamentals, ponds	On file VNC
Fisher 65B, E1227	High invasive species compared to rest of watershed (blackberry, alder, ivy) old road bed by stream, footbridge across stream	On file VNC
VashJudd	High position in watershed for integrating the condition of the entire watershed (misses 2 major tributaries). Hard to access, permission to access isn't guaranteed in the long-term.	KCDNR site 28A
New Judd sites	To isolate effects of restoration happening upstream of the 216th road crossing either of the alternative sites listed would be adequate. The Land Trust site would be best bet for long-term access.	Land Trust parcels
Shinglemill E1236	Below Cedarhurst road. Culvert and road impacts	Existing VashShing site is sufficient

Table 3. Alternative sites identified for existing sample sites that have local impacts that may outweigh overall watershed condition. For locations refer to Figure 3 (new sites in maroon).

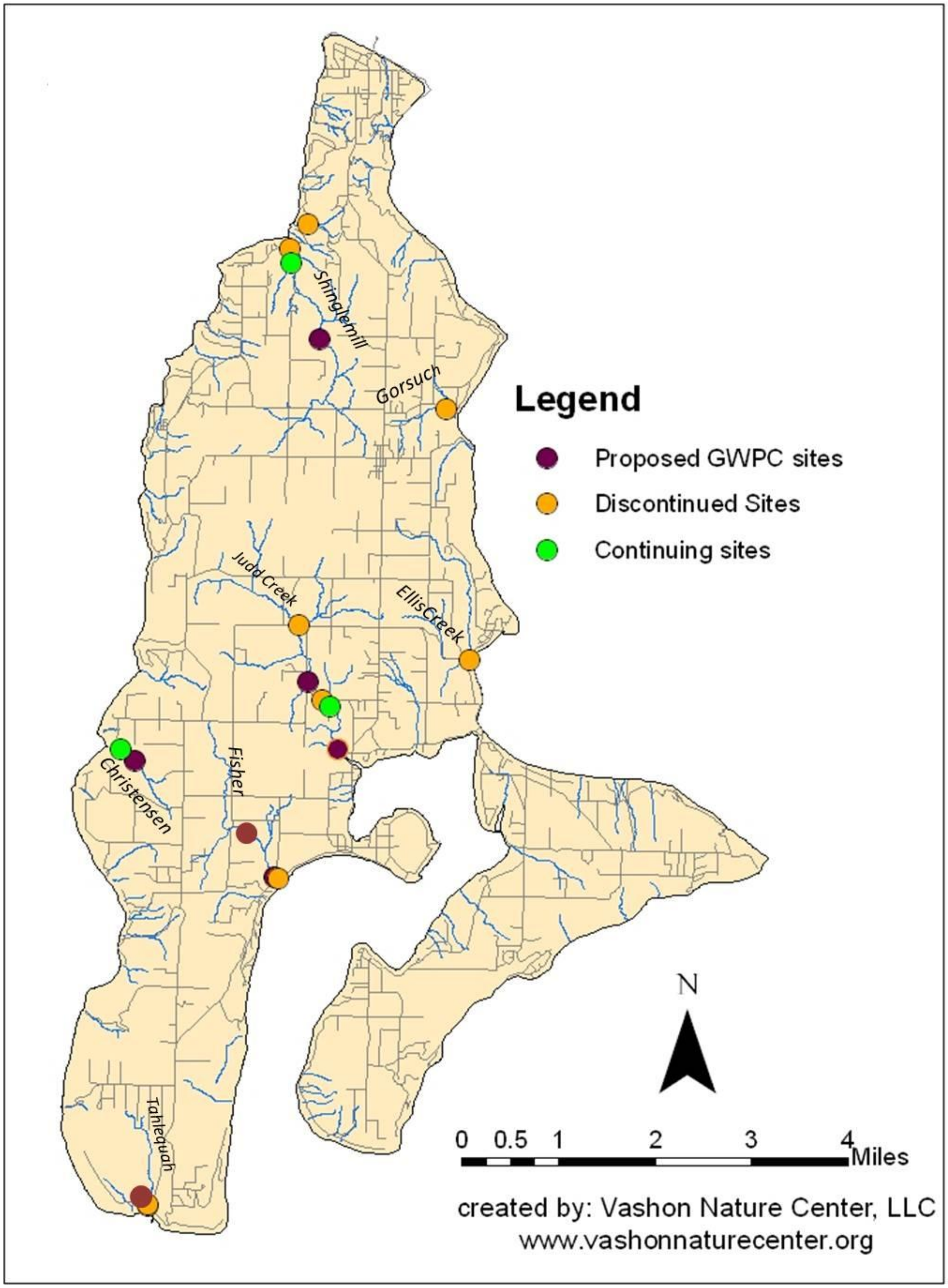

Figure 3. Proposed benthic invertebrate sampling sites along with current and discontinued sites. For site labels of existing sites see Figure 1. Tahlequah site is not a new site but is recommended that GWPC pick this discontinued site up in a long-term monitoring program.

Real Impact Hypotheses:

Besides the possibility that overall B-IBI metrics and sample sites are not representative of actual island watershed conditions, it is possible that low scores in these creeks are attributable to actual impacts (i.e. urbanization, agriculture, pollution). An exploratory look at the data combined with preliminary statistical analysis reveals various possible impact hypotheses. In addition to the analysis included in this report, two other multi-variate analyses (an ordination analysis of invertebrate community assemblages, water quality, and spatial factors by Eric Dinger Aquatic Ecologist NPS; and a stressor analysis by Oregon Department of Environmental Quality technicians) are in process and results will be forwarded to the Groundwater Protection Committee upon their completion.

Stepwise multiple regression analysis of B-IBI metrics against a variety of spatial and land-use variables indicate that watershed geology and land-use explain significant variation in invertebrate community composition (Table 4). The complete list of land-use variables put into the regression analysis is: percent of watershed that is: forested, has old forest conditions (harvested before 1992), urban, or agriculture; percent of riparian buffer that is: forested, old forest, urban, or agriculture; road density of watershed, road crossings per stream km, population density (of watershed), site elevation, watershed area, maximum slope, mean slope, maximum precipitation, stream length.

B-IBI metric	Explanatory variables	R^2_{adj}	P value
Overall score	% urban area in watershed (-), %urban in buffer (-), elevation (+)	.792	.0005
Ephemeroptera richness	Maximum precipitation (-), maximum slope (-)	.768	.001
Plecoptera richness	% urban area in watershed (-), %urban in buffer (-)	.646	.002
Trichoptera richness	%urban in buffer (-), maximum slope (-), %old forest in buffer(+)	.572	.006
Clinger richness	%old forest in watershed (+), %urban in buffer (-), maximum slope (-)	.351	.033
Long-lived richness	Average slope (-), watershed population density (-), %urban in buffer (-)	.511	.011
Percent tolerant	Population density (+)	.442	.008

Table 4. Relationships between B-IBI metrics and spatial and land-use variables. Stepwise multiple regression analysis of IBI metric averages across 2005-2012 with land-use variables, n=14. (-) indicates a negative correlation, (+) indicates a positive correlation. $p<.05$ indicates a statistically significant result. Explanatory variables listed are those that were not eliminated in stepwise regression analysis (thus they are the variables that together significantly explain the most variation in the corresponding IBI metrics). Richness =number of different species/forms. R^2_{adj} is a measure of the strength of correlation (slope of the line) in a linear model (1 being perfect correlation, zero being no correlation).

Of all the spatial variables tested, the amount of urban area, old forest in the watershed, and old forest in the riparian buffer; as well as maximum slope, maximum precipitation, elevation, and population density had the most influence over B-IBI metrics. Surprisingly, no B-IBI metrics were significantly related to road densities, stream crossings, or agricultural area (Table 4).

Land Cover

Stepwise multiple regression analysis revealed significant correlation between many B-IBI metrics and urban influence (% urban area in watershed, % urban area in buffer, population density). In addition, 3 physical characteristics of streams also influenced B-IBI variables- maximum slope, elevation, and maximum precipitation. Old forest was the only land cover variable positively related to B-IBI metrics. Watersheds with more older forest and more older forest in the riparian buffer had higher clinger taxa richness and higher Trichoptera taxa richness than watersheds with less older forest.

The urban influence on stream health metrics is surprising because Vashon streams have relatively low percentages of urban area (% urban in watershed range: 1.5-17.1; % urban in buffer range: 0-14). However, recent research on a national level corroborates these results by finding that streams exhibit signs of degradation even at the earliest stages of urban development (Coles et al. 2012- define early stages as 20% urban area).

As most watersheds had under 6% urban area, the urban area regressions were largely driven by the difference between low urban watersheds and the two watersheds (Gorsuch and Ellis) with urban areas greater than 10%. While it would have been ideal to have more points with more than 6% urban area for this regression, it is good that reality provides few of these cases to test on the island (Beall Creek or Ellisport Creek might be further options) because:

Significant declines in overall B-IBI scores occur between 1.5% and 17% urban area with scores shifting from fair to the lowest possible category--very poor.

The apparent sensitivity of island streams to urban influence brings up interesting questions: Are island streams for some reason more sensitive to urban development than mainland streams? Does this sensitivity have anything to do with the combined effects of urbanization with previous land uses (logging and agriculture)? Does isolation due to marine waters make it more difficult for invertebrates to re-colonize? Does this make island streams less resilient to large disturbances than mainland streams in terms of their ability to recover lost taxa?

Other metrics besides overall B-IBI score were also influenced by percent urban area including: Trichoptera richness, Plecoptera richness, Long-lived richness, and clinger richness (Table 4).

Steep slopes were negatively correlated to clinger taxa richness. Clingers are sensitive to sedimentation. Thus, this likely indicates that watersheds with steeper slopes are more at risk for impacts due to erosion. Maximum precipitation, the other physical variable significantly correlated to B-IBI metrics, is discussed below (see section on run-off and other pollution).

Percentage of old forest in the watershed and in the riparian buffer was the single most important land-use variable that positively influenced B-IBI metrics.

Clinger taxa richness was positively related to percent of old forest in the riparian buffer. Clinger taxa are sensitive to high flows and sedimentation, thus older forest conditions in the riparian buffer are important to clinger taxa for buffering both high flows and effects of erosion. In addition, Trichoptera (caddisfly) taxa richness increased significantly with area of older forest (Table 4). As the variety of habitats in the stream increase, caddisfly variety tends to increase. Thus, it makes sense that Trichoptera richness was related to older forest area because in more mature forests more varieties of habitat are present.

<u>Sediment</u>

Preliminary exploration of data reveals fewer clingers and Plecoptera in some creeks suggesting erosion impact. Invertebrates called clingers cling to stream substrates. When sediments enter a stream channel they deposit a thin film over surfaces making it hard for clingers to hold on in high water events. Plecoptera species are sensitive to sedimentation for similar reasons. Shinglemill and Fisher may be experiencing erosion impacts. They have fewer sediment sensitive species and show slight declines in these taxa overtime (Figure 4 a,b).

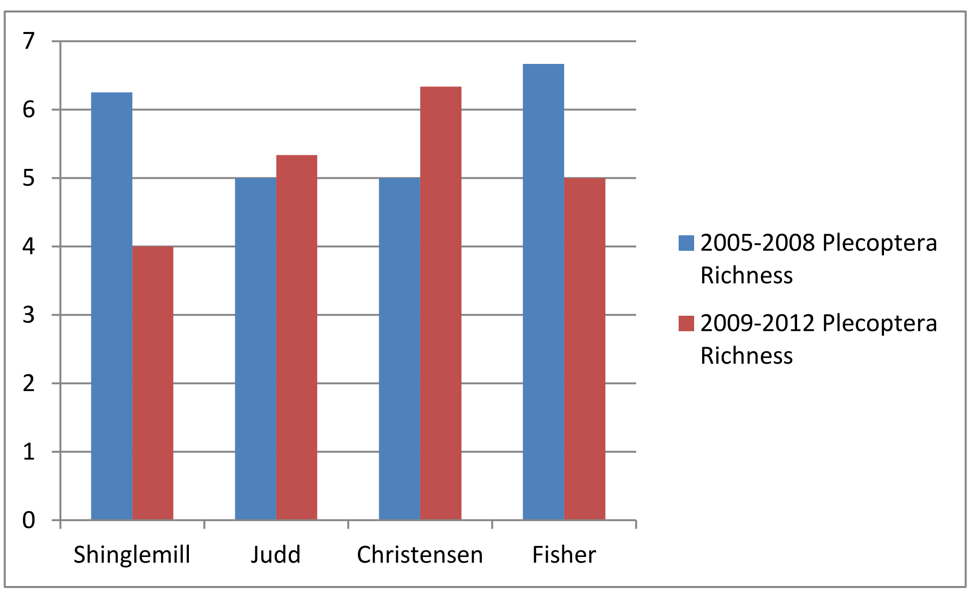

Figure 4 a. Plecoptera taxa richness in similar sized streams for first 4 years of data (blue) and last 4 years (red). Shinglemill and Fisher creeks have the lowest levels of Plecoptera taxa richness and are the only creeks with a downward trend (Fisher trend is statistically significant).

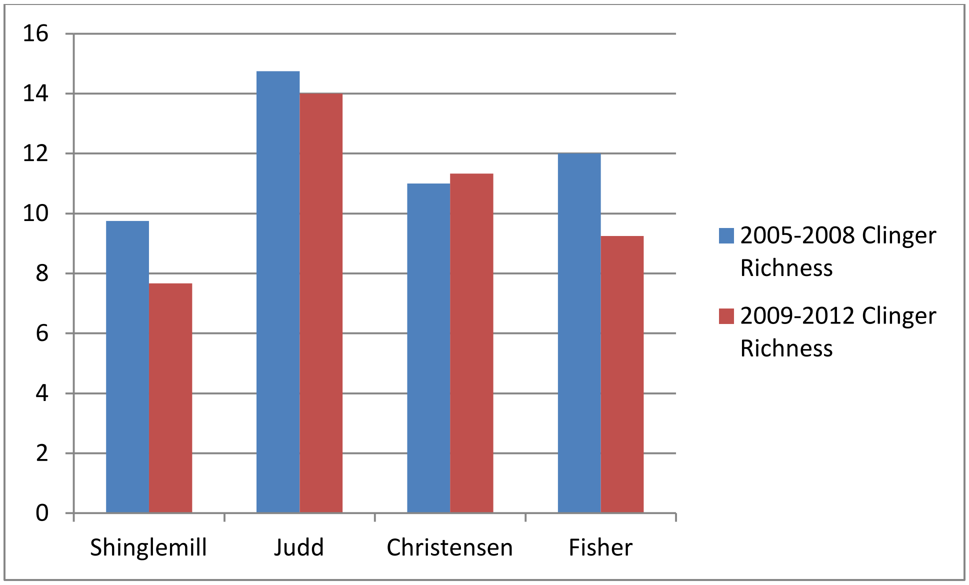

Figure 4b. Clinger richness comparison between first 4 and last 4 years of data collection. Shinglemill and Fisher creeks have lower Clinger richness than other similar sized creeks on Vashon. And both metrics seem to be declining through time (only Fisher declines are statistically significant at the $p<.05$ level).

Run-off or other pollution

As a whole, all island creeks have low Ephemeroptera richness when compared to the Puget Sound lowland reference sites used to calculated B-IBI. In addition, island creeks tend to have slightly fewer Ephemeroptera taxa than similar scoring creeks on the Kitsap peninsula. One explanation for this could be an island effect. Perhaps it is just difficult for mayflies to fly across the marine environment to Vashon. However, there is no compelling reason why Ephemeroptera species would have a harder time doing this than other macro-invertebrates.

Some Ephemeroptera species are particularly sensitive to chemical and heavy metal pollution. It is interesting that Ephemeroptera richness was most significantly correlated with maximum precipitation in watersheds (along with maximum slope, negative relationship, R^2_{adj}=.768, p=.001, n=14, Table 4). Perhaps pollution from run-off in high rain events is causing some disturbance to mayfly species or perhaps mayfly species are just being washed out in high flows.

In Judd Creek, where most metrics are either stable through time or increasing, Ephemeroptera richness is experiencing a decline in 3 of the 4 study sites (sites 28A, VashJudd, E1231: R^2_{adj}=.67, p=.029, n=16). When Plecoptera and Trichoptera richness holds steady while Ephemeroptera richness declines, it is a classic sign that a stream could be experiencing effects of pollution (PSSB 2012).

Potential sources of pollution in this watershed include legacy effects from garbage that was buried on Vashon in the municipal waste yard (within Judd Creek watershed), or another location that used to be a car junkyard where large amounts of cars and car parts are now buried. However, a cursory look at heavy metal data collected in 2007 (King County) shows no outstanding levels of heavy metals in Judd Creek compared to other island creeks. In addition, heavy metal concentrations in island streams did not appear to be elevated when compared to other streams in King County.

Recent restoration efforts on Judd Creek have fenced cattle out of the stream which suggests an alternative hypothesis for declining mayfly richness. Perhaps mayflies were artificially high in Judd creek due to nitrification from livestock, and they are now returning to normal island levels rather than declining due to pollution. However, in the two statistically declining sites in Judd Creek Ephemeroptera richness in Judd Creek is dropping from an average of 3.8 to 2.1. The island-wide average for all streams in all years is 3.6 (with a range: 0 in Ellis to 5.4 in Tahlequah).

Fewer salmon

Another alternative hypothesis for declining mayfly richness (which could also be a reason for low aquatic invertebrate levels as a whole) is that they are tied to drops in salmon numbers. Invertebrate richness and abundance has been shown to increase significantly when salmon carcasses are added to streams and the effect is most strong for mayfly species (Wipfli et al. 1998).

We have very little solid data on salmon numbers in Judd Creek. However, what data we do have from Salmonwatcher counts shows that numbers of salmon observed decreased from 135 in 2004 to 4 in 2008 (since volunteer numbers also decreased these observations standardized for effort become 3 fish/survey in 2004 to 0.2 fish/survey conducted in 2008; data from-- King County SW 2004). While this is a highly speculative hypothesis at this stage, it might be something worth tracking. Salmon returns observed by Salmonwatchers in 2012 were in the hundreds again. It will be interesting to see how mayfly populations respond in 2013. If a salmon carcass enrichment project is ever conducted in Judd Creek it is highly recommended that invertebrate community metrics are taken and tracked to further investigate this hypothesis.

In summary, reasons for low Ephemeroptera richness island-wide, and recent declines in Judd Creek, remain a mystery. It is recommended that a qualitative analysis of possible impacts be requested of labs that identify invertebrates in future samples taken on island streams. Looking at particular species or their absence within the Ephemeroptera order may provide additional clues than overall taxa richness metrics used here. In addition, chironomid midges are sensitive to some heavy metals so a qualitative analysis might also pull in these species in a wider look at pollution possibilities in island streams.

Effects of historical land-use

It is highly probable that legacies of historical land use have heavily influenced the low levels of invertebrates we see in streams today. The island was extensively logged various times from late 1890's to mid-1900. In some areas of the island logging was followed by extensive agriculture. These land-uses caused tremendous changes in stream hydrology and habitat complexity that biotic communities are likely still dealing with today. The increased run-off, sedimentation, and flashiness of streams and the simplification of stream environments starting with these land-use changes, was likely akin to pressing the reset button for aquatic invertebrate communities (Maloney et al. 2008). This coupled with the isolation of the island from other invertebrate populations could potentially have a huge influence on present day invertebrate populations. It would be interesting to use B-IBI sampling to track the effect of stream restoration efforts on both Shinglemill and Judd Creek through time to see how successful they are at rebuilding pre-logging conditions and richer invertebrate assemblages.

Judd Creek late 1890's. Note the deep pool --something rare in island streams today. Photo from: Old Vashon Stories and Pictures on facebook, credit: Sherman.

Summary of hypotheses and key points:

- Overall B-IBI scores for island streams range from fair to very poor.
- Puget Sound lowland reference sites used to create B-IBI may have higher taxa richness than isolated island streams which could underestimate the health of island streams.

- Some existing sample sites contain local impacts more extreme than watershed wide conditions which could also return scores that underestimate overall watershed health.
- Declining trends indicate that real impacts are affecting island streams: with the possible exception of a Judd Creek site, all stream sites are either stable or declining in condition overtime.
- Island streams appear particularly sensitive to urbanization. Urban metrics significantly influenced a variety of B-IBI metrics even though the amounts of urban area in watersheds are minimal (Table 4).
- Percent of the watershed with older forest conditions (harvested before 1992) was significantly positively related to invertebrate groups that do well in complex habitats and with low amounts of sediment (Trichoptera, Plecoptera, clingers).
- Ephemeroptera (mayfly) taxa richness is low island-wide in comparison to similar scoring mainland streams.
- Mayfly richness was most closely related to slope and precipitation maximums which may indicate that pollution of surface water flows could be a factor or perhaps mayflies are being washed out in high water events.
- There are three alternative hypotheses for declining mayfly taxa richness in Judd Creek.
    1. Mayfly taxa richness is declining due to polluted surface water run-off.
    2. Mayfly taxa richness was artificially elevated due to heavy livestock presence in the riparian areas and it is now declining back to natural levels due to restoration efforts that have removed livestock from much of the stream corridor.
    3. Mayfly taxa richness is low because salmon numbers are low. This could also be a wider hypothesis encompassing reasons for low invertebrate diversity in island streams as a whole.
- Taxa living in steep streams may be getting washed out in high water events. Maximum and average slope was negatively correlated with clinger richness, Plecoptera richness, and richness of long-lived taxa.
- Fisher and Shinglemill appear most affected by sediment impacts.
- A qualitative analysis of the array of individual species in future samples (conducted by a qualified lab technician familiar with requirements of each species) could help to verify or discount some of the above hypotheses generated from statistical correlations.

Next Steps

Next steps for this project can be divided into four major categories: data entry and analysis, community outreach about results, citizen science projects, and long-term monitoring. Each of these categories is expanded below. In addition, a table is included that breaks out next steps for each stream (Table 5). In the following section a plan of action for 2013 is presented that focuses on a subset of these activities with proposed budgets.

Data entry and analysis:

1. Data taken at King County Roads sites (1999-2005) should be entered into the Puget Sound Stream Benthos site. This would double the period of time in which to compare samples and enable more confidence in long-term trends. Total cost for data entry is estimated at $600 (see budget Appendix A).
2. Incorporation of any findings from on-going multi-variate analyses will be passed along to the GWPC and should be reviewed for new information.
3. When professional labs perform ID on samples in the future it is recommended that they be asked to include a qualitative analysis of stream stressors along with identification. Lab technicians can give a detailed analysis based on individual species that will reveal much more about possible stressors than the general statistical analysis based on IBI summary metrics conducted here. The total cost for this is: $200/sample (see budget Appendix A).
4. A literature review on urban effects remediation techniques could be timely considering the strong influence that percent urban area seems to have on a variety of different B-IBI metrics. In addition, a field reconnaissance of more urban influenced island streams (like Ellisport creek and Beall creek) could determine whether these have enough summer flow for sampling. If this is the case, an urban stream citizen science project could sample streams to increase the pool of data for streams draining the more urban areas of the island. Or a citizen science sampling project could also be run in conjunction with any future restoration efforts in these streams using BI monitoring to monitor restoration success.

Community Outreach:

Key outreach points at this stage include:

1. The results of this report highlighting trends, hypotheses, and new mysteries.
2. Outreach on effects of urbanization and storm water run-off considering the influence that even small amounts of urban area seem to have on island streams.

3. Outreach to residents of the Judd Creek watershed where a variety of landowners have independently restored sections of this stream (Figure 7). Recognition of landowners in Judd Creek through a public presentation or neighborhood meeting could affirm their efforts.

Stream	**Questions/Hypotheses**	**Steps**
Shinglemill	How much are sediments from known erosion locations affecting invertebrates in Shinglemill? What is the effect of restoration on Shinglemill creek in the long-term?	Test BI's above and below the confluence of Needle Creek tributary to judge sedimentation impact. Simultaneously analyze stream bed for particle size and % fine sediment. Follow trends at VashShing through time to see if sedimentation impacts lessen with Needle Creek restoration.
Judd	Is pollution affecting stream health? What is the direct and watershed wide effect of restoration on Judd Creek? Are salmon numbers tied to mayfly richness and abundance?	Request qualitative lab analysis of future Judd Creek samples to further investigate impacts. Look at the results of ORDOE stressor analysis. Move VashJudd site to former 28A site for long-term monitoring of entire watershed condition. Sample north of 216th to isolate effects of upstream restoration efforts (see figure 5) Monitor mayfly richness and abundance in long-term samples from Judd Creek. Do mayflies increase following years with more abundant salmon counts? If salmon carcass restoration projects are started do mayfly numbers increase?
Christensen	Is the existing long-term site representative of watershed condition? Are mayflies increasing through time and does this indicate nutrient enrichment?	Simultaneously test the existing site and the alternative site in the same season and request that the lab analysis include a qualitative report on differences. Monitor mayfly richness in annual samples. If a statistical increase occurs strategic sampling of the creek sequentially eliminating tributaries could point to possible sources.
Fisher	Is the existing long-term site representative of watershed condition? Is sedimentation becoming a	Simultaneously test the existing site and the alternative site in the same season and request that the lab analysis include a qualitative report on differences. Continue to monitor long-term trends in

	problem in Fisher overtime?	Plecoptera, and clingers. Sample stream bed for sediment.
Tahlequah	What are the trends in different invertebrate populations? At this point trends are not clear so it is hard to hypothesize what may be impacting this creek.	Continue sampling on a bi-annual basis. Request a qualitative lab analysis on invertebrate samples to uncover possible stressors. Look at results of Oregon DOE stressor analysis.
Gorsuch and Ellis	What can we do about urban influences affecting our streams? Do urban remediation techniques result in increases in stream health?	Community outreach on urban sensitivity, identify urban remediation techniques, implement urban remediation where possible. Because scores are so low and steady in both of these creeks further monitoring is not currently recommended as no changes are likely to occur. However, if restoration efforts are started, IBI should be used to monitor the effects of the restoration.
All streams	Are there other urban streams to test that are big enough to be appropriate for B-IBI? And could we expect to learn anything new from testing them? What are long-term trends in creek condition? Why are Ephemeroptera levels low in island creeks compared to other rural mainland creeks?	Topic for discussion and field reconnaissance. Incorporate data from previous sampling efforts 1999-2005 to test for long-term trends. Continue monitoring existing creeks twice every 5 years. Look at results of Oregon DOE stressor analysis. Request qualitative analysis of future samples by labs. Track salmon populations.

Table 5. The questions and hypotheses that arise from exploring existing data are too many to tackle in one year. For the purpose of record questions/hypotheses and subsequent steps to answering them are outlined in this table so they may be considered in subsequent years.

Community involvement in stream assessment:

The conditions on Vashon are perfect for community involvement in stream assessment. Not only are there existing volunteers and landowners already invested in activities directly related to IBI (salmon watchers, landowners with water quality monitoring sites); McMurray middle school, Vashon high school, and the Vashon Wilderness Program are interested in student involvement in B-IBI studies. In addition, we have an exceptional asset in having a strong group of at least four excited and willing expert volunteers that have considerable experience with BI sampling and identification (see Appendix C-contacts). Volunteer interest in benthic invertebrate monitoring has been strong. Currently 20 volunteers are signed up. This number continues to climb as more people find out about the project. For example, after the GWPC Report card was published VNC has gotten 3 more volunteer offers and 1 landowner offering to host a monitoring site.

The potential for unique, very good quality and successful community projects cannot be overstated. Below three possible projects are explored. The long-term monitoring option below also involves community members in field sampling.

Shinglemill Invertebrate Project (SIP)

The Shinglemill Invertebrate Project provides an opportunity to test one hypothesis about stream conditions in a way that involves local community members and 6th-12th grade students. Since existing data indicate a possible effect of sediments in Shinglemill, this project will attempt to isolate location of sediment impacts.

The hypothesis tested would be: *Invertebrate samples taken upstream of the Needle creek confluence will contain more sediment sensitive species than samples taken downstream of the confluence because sediments are primarily originating from the Needle Creek tributary.*

This project would use volunteers to test 2 sites on Shinglemill creek in September 2013, one above and one below the Needle Creek tributary. Field volunteers would collect BI samples and take data on physical aspects of the stream including measures of how much sediment is present in the stream bed at each site (see Appendix B for protocol).

The invertebrate samples would then be taken to McMurray middle school science class where, along with 4 expert volunteers, students would sort and qualitatively identify differences between samples. Sorted samples could then be taken home by expert volunteers for further identification and more quantitative comparison if needed. Research on using untrained volunteers to identify invertebrates shows that volunteers are able to sort specimens to family as accurately as expert taxonomists (Fore et al. 2001).

High school science teachers expressed interest in presenting this project to high school students as a public service project. Interested high school students could be involved in all aspects of the project from start to end including: collecting samples in the field; sorting samples with McMurray students; finishing the ID and quantitative analysis of differences with expert volunteers; and presenting the results to the Groundwater Protection Committee.

Information from this project will help GWPC identify locations and impact of major sediment sources. It will also inform Land Trust restoration efforts along Shinglemill Creek. This gives a real life context to the students' work. Since restoration has recently begun in the Needle Creek drainage there is also opportunity to visit these sites again in later years and repeat these measurements with another group of students. This could give schools ownership and investment in periodically tracking these sites through time to look for differences.

Judd Restoration Field Project:

As mentioned in the community outreach section, there is much potential for significant restoration success along at least a 2 mile stretch of Judd Creek (Figure 5). Talking with landowners in the area there is interest in B-IBI and salmon monitoring. There is also considerable interest in conducting a salmon habitat restoration project involving students, willing land owners (estimate about 4), and the Land Trust.

There is extensive opportunity for community involvement and collaboration on many scales. Next steps include (listed in order of increasing involvement and complexity of overall project):

1. Involving landowners as volunteers to take long-term monitoring BI samples along Judd Creek (see long-term monitoring section).
2. Working with the Land Trust and interested land owners to restore native riparian vegetation (planting), and habitat complexity (log jams) and monitoring results with BI sampling.
3. Enhancing the riparian environment through dropping salmon carcasses along the creek and monitoring changes with BI samples and salmon counts. (Side note: some land owners have expressed excitement for this. In addition, Vashon Wilderness Program students are interested in using their tracking abilities to monitor carcasses that are dropped and keep track of how they are cycled through the system.)

This same stretch of Judd is the heaviest for coho salmon use so counts of salmon and salmon redds can be used in conjunction with BI sampling to monitor the effects of restoration efforts overtime. It is recommended that these possibilities be explored further by starting discussions with the Land Trust, and private landowners about pursuing a joint restoration and BI monitoring effort in Judd Creek that involves local residents and schools.

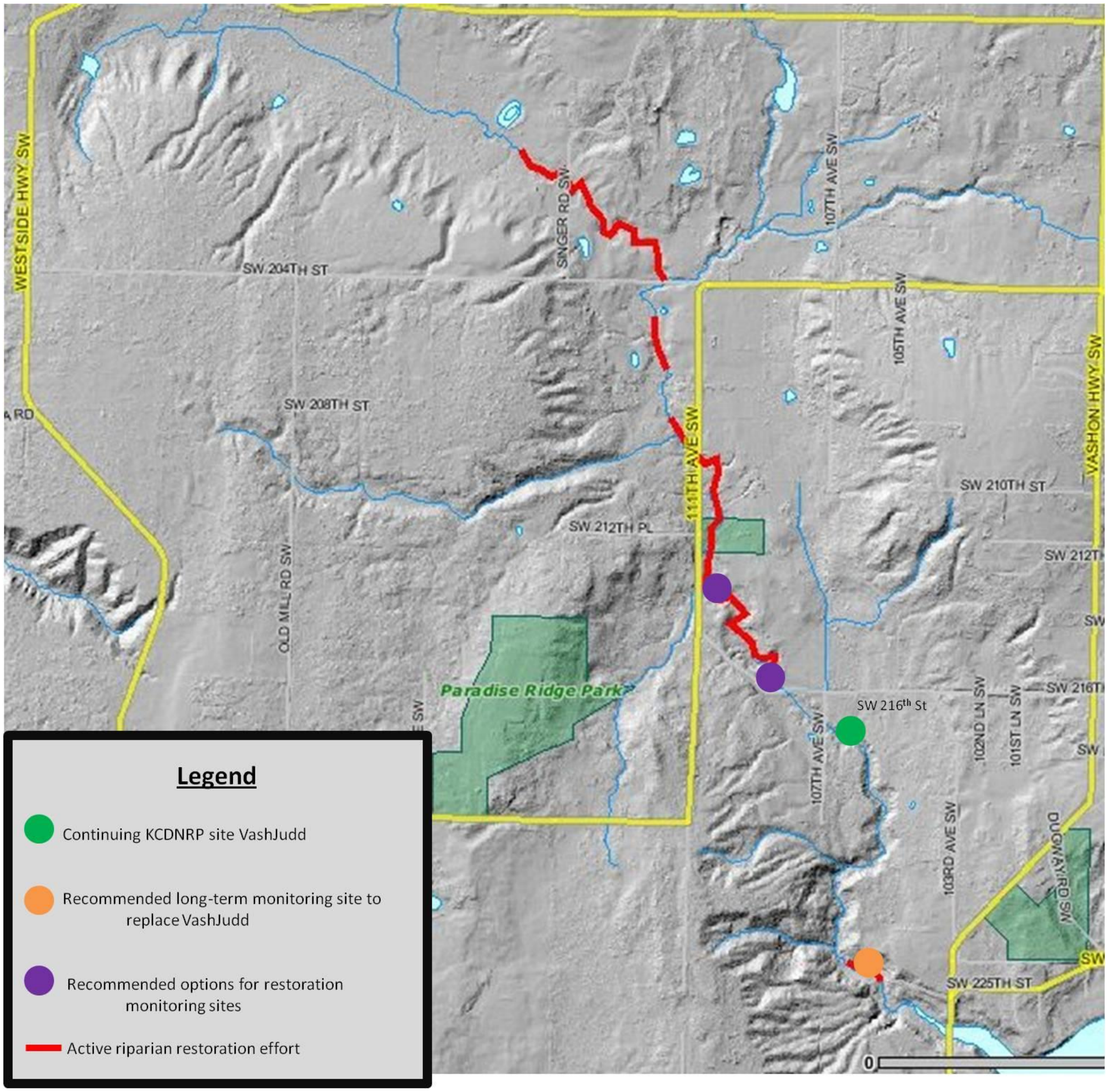

Figure 5. Paradise Valley section of Judd Creek where independent restoration efforts are taking place. This 2 mile stretch runs from just above SW 204th St to the culvert under SW 216th St with a small additional section at the mouth. Purple dots represent 2 alternatives for restoration monitoring sample sites. The green dot is the current VashJudd monitoring site. It is recommended that this be moved to the orange dot location to more fully capture the condition of the entire watershed (currently VashJudd misses 2 major perennial western tributaries).

Urban Influences Project

Preliminary findings suggest a heavy influence of urban area in watershed and riparian buffers. However, this trend is largely driven by 2 data points. This trend could be looked into further by:

1. Reconnaissance of watersheds with 10% or more urban area to determine if flows are large enough in late summer to conduct B-IBI.
2. If suitable sites can be found volunteers could sample them.
3. Conduct a literature review on urban impact remediation techniques.
4. Identify techniques appropriate for island streams.
5. Start restoration and have volunteers monitor results with B-IBI.

To determine if this project is even feasible it is recommended that a reconnaissance of potential watersheds be undertaken as a first step.

Of the three above projects, only the Shinglemill Invertebrate Project is far enough along to be launched in its entirety next year as a community science project. The first step in the Judd Creek Restoration monitoring can also be launched as part of the long-term monitoring project described below. It is recommended that more scoping be done for subsequent steps in the Judd Creek Restoration project and for the Urban Influences project for consideration in subsequent years.

Long-term monitoring

Currently, there are enough willing volunteers signed up on the Vashon Nature Center Invertebrate Volunteer list to sufficiently run a volunteer based long-term monitoring program. The number of interested volunteers could currently cover 6 streams per year (2-3 volunteers/stream). However, to account for volunteer attrition and stay within budget capacity for GWPC, it is recommended that 3 streams per year be sampled using volunteers to collect samples. These samples would then be shipped to professional labs for identification.

In prioritizing effort for a long-term monitoring program the first sites recommended for discontinued monitoring would be: McCormick, Ellis Creek, and Gorsuch. In the case of Ellis and Gorsuch, the 2005-2011 time period sufficiently and without question established that these creeks are in poor condition and staying there. For this reason it is not expected that anything new would be learned from long-term monitoring at these sites unless restoration programs were started or there was reason to believe conditions were going to start changing. McCormick is a slightly smaller stream than what B-IBI protocol is ideally designed for.

It is recommended that the following creeks continue to be monitored at least twice in the next five years: Shinglemill, Judd, Christensen, and Tahlequah (see Table 6 for a sample monitoring schedule that includes the Shinglemill Invertebrate Project along with a long-term monitoring program).

Stream	ID	2012	2013	2014	2015	2016	2017	Taxonomic resolution	PSSB
Shingle	Vashshing	DNRP	DNRP	DNRP	DNRP	DNRP	DNRP	lowest	Yes
Shingle	Westside Water		GWPC					Family	No
Shingle	Needle Creek		GWPC					Family	No
Judd	VashJudd	DNRP	DNRP					lowest	Yes
Judd	LandTrust/other			GWPC		GWPC		lowest	Yes
Judd	28A	DNRP		DNRP	DNRP	DNRP	DNRP	lowest	Yes
Christn	VashChris	DNRP	DNRP	DNRP	DNRP	DNRP	DNRP	lowest	Yes
Christn	Alternate site			GWPC		GWPC		lowest	Yes
Fisher	65B	DNRP			GWPC		GWPC	lowest	Yes
Fisher	LT Dean				GWPC		GWPC	lowest	Yes
Tahle	65A	DNRP			GWPC		GWPC	lowest	Yes

Table 6. Five year sampling schedule for Vashon B-IBI (2012 included for perspective). This shows the role of GWPC monitoring in context of the existing on-going monitoring done by KCDNRP. All GWPC samples will be collected according to Washington Department of Ecology standard operating procedures. With the exception of Shinglemill Invertebrate Project , all samples will be lab analyzed following WADOE SOP to lowest taxonomic level, and entered into the larger Puget Sound Stream Benthos database. With this schedule all above streams will be sampled within the twice in 5 years time frame as recommended by Washington Department of Ecology.

<u>*Sample site locations*</u>

It is recommended that GWPC work with King County DNRP to shift sites in Judd Creek for a more optimum long-term monitoring configuration. Specifically, it is recommended that site 28A at the mouth of Judd Creek be picked up by KCDNRP Vashon program as the long-term monitoring site in place of VashShing. 28A is lower in the watershed and captures a more complete picture of overall watershed condition than the VashJudd site upstream. In addition, it is recommended that an upstream sample site be located just upstream of SW 216th on Land Trust land. This new location would be immediately downstream of the restoration stretch (See Figure 5) and therefore it could be used to more clearly isolate the effects of restoration over time. The new site location may also be more secure in terms of access permission over the years. A long-term monitoring site upstream of the 216th culvert could be used to track restoration success in the Judd Creek Restoration Project described above.

For Fisher and Christensen creeks existing (or former) long-term monitoring sites should be sampled at the same time as alternative sites to test hypotheses concerning local impacts of these sample sites.

<u>Long-term monitoring Protocol</u>

Washington Department of Ecology recommends sampling each stream twice every 5 years. It is recommended that all samples collected for long-term monitoring sites follow the 8 square foot sample size and protocol outlined in the Washington State Department of Ecology Standard Operating Procedures (WADOE 2012-Appendix B). In addition, samples should be lab analyzed according to the level prescribed in the taxonomic procedures outlined in these same operating procedures. These samples are then entered into the Puget Sound Stream Benthos database and contribute to a wider body of knowledge about stream conditions throughout the region. This is useful in connecting island efforts to the larger benthic monitoring community.

In addition to collecting invertebrate samples it is recommended that certain field measurements of stream characteristics be taken along with photos of the sample sites. One example of a standard field measurements data sheet (from Jeff Adams, Xerces Society) is included in Appendix B. This data sheet has been adopted in many different ongoing BI sampling efforts throughout Oregon and Washington states.

Long-term monitoring is especially important on Vashon Island because overall B-IBI scores might not be well calibrated to island streams. Therefore, monitoring trends becomes a more important way of understanding the level of impact that island streams are experiencing. Past King County sampling efforts have gifted Vashon with a robust long-term data set.

There are many benefits in continuing this long-term monitoring: more years would give a better sense of trends in creeks that are showing slight but not statistically significant declines in metrics; it may be possible to pick up any rapid or catastrophic changes if we have a longer term variation in sites upon which to judge spikes and dips; it creates a relationship between volunteers and streams that they repeatedly return to which fosters a culture of stewardship for island streams.

Recommended Steps for 2013

There are clearly many ways in which this project can proceed. Below 3 different options are outlined based on the estimated capacity of the GWPC in the first year.

2013 Option 1-- Shinglemill Invertebrate Project (SIP)

2013 Option 2—Research and Outreach

Research--Tie up loose ends of data analysis by incorporating results of multi-variate tests, entering 1999-2005 data into PSSB and analyzing for longer term trends, literature review of urban remediation techniques, field reconnaissance of streams for urban impacts project (step 1 for urban influence project).

Outreach--a general newspaper article and on-line publication communicating results of this report and above mentioned research. Neighborhood meeting for Judd Creek watershed (Step 1 for Judd Creek Restoration Project).

2013 Option 3: Long-term monitoring program, 3 sites/year.

2013 Option 4: Long-term monitoring program (LTM) and Shinglemill Invertebrate Project (SIP)

The advantages of starting both LTM and SIP in 2013 include: combination of efforts reduces costs, combining projects will engage more volunteers, less interruption in data flow for sample sites (see Table 7 below).

Stream	ID	2012	2013	2014	2015	2016	2017	Taxonomic resolution	PSSB
Shingle	Vashshing	DNRP	DNRP	DNRP	DNRP	DNRP	DNRP	lowest	Yes
Shingle	Westside Water		GWPC					Family	No
Shingle	Needle Creek		GWPC					Family	No
Judd	VashJudd	DNRP						lowest	Yes
Judd	LandTrust		GWPC		GWPC		GWPC	lowest	Yes
Judd	28A	DNRP	DNRP	DNRP	DNRP	DNRP	DNRP	lowest	Yes
Christn	VashChris	DNRP	DNRP	DNRP	DNRP	DNRP	DNRP	lowest	Yes
Christn	Alternate site		GWPC		GWPC			lowest	Yes
Fisher	65B	DNRP		GWPC		GWPC		lowest	Yes
Fisher	LT Dean			GWPC		GWPC		lowest	Yes
Tahle	65A	DNRP	GWPC		GWPC		GWPC	lowest	Yes

Table 7. Benthic Inverebrate sampling schedule for Option 4

Summary

Island streams have generally poor biological health. The cause of this is not known. In this report both qualitative exploration and statistical analysis of existing data are used to uncover various hypotheses for impacts to island streams.

There is a good window of opportunity in the next 5 years to study aquatic invertebrates on Vashon and to make some traction in solving this mystery. Data has been collected for a long enough time that preliminary trends are starting to show in existing data. There is great excitement and willingness from landowners, schools, local residents and experts to help with a BI sampling project. The GWPC Environmental Report Card has just been published which galvanizes the community around a common language and knowledge about island sustainability of which aquatic invertebrates are a part. And lastly, there are a variety of concurrent efforts that a BI sampling program can be linked to including on-going riparian restoration projects, a salmon watcher program, and interest in applied environmental science opportunities by local schools.

With some work, there is potential to connect with other island efforts to integrate BI sampling with restoration projects and watershed conservation that could have regional implications in watershed management. However, even a small grassroots program would be beneficial not only in increasing knowledge of what is going on with island streams, but also in contributing to a multi-generational culture of stewardship concerning island streams, of which the benefits are many and far reaching.

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APPENDICES

Appendix A: Protocol

Benthic Invertebrates

Sampling protocol for all streams and projects will follow Washington State Department of Ecology standard operating procedures for combining 8- 1ft2 samples from 4 different riffles (2 samples/riffle) on a stream reach.

Benthic invertebrate identification should also follow those outlined in the standard operating procedures by identifying invertebrates to genus level at least (including Chironomids) and to species when possible.

Detailed standard operating procedures for sampling and identification are available here:

https://fortress.wa.gov/ecy/publications/publications/0103028.pdf

Physical Characteristics Sampled in the Field

In addition to benthic invertebrate sampling a variety of field measurements should be taken at each stream sample site. The following data sheet from the Xerces Society could be used as one option. Alternatively, King County field data sheets could also be used for consistency in all island monitoring efforts. King County data sheets have the same information on them as this sample sheet however in a slightly different configuration.

Shinglemill Invertebrate Project

Additional sediment quantification will be conducted for the Shinglemill Invertebrate Project. The following publication discusses a variety of protocols for assessing the effects of deposited fine sediment:

http://www.cawthron.org.nz/coastal-freshwater-resources/downloads/sediment-assessment-methods.pdf

Macroinvertebrate Monitoring Field Form

Site Information

Site Name ______________________________ Site ID # __________

Team leader ______________ Members: ______________________

Access OK ☐ yes Landowner ______________ Call first ☐ ______ - __________

ODFW OK ☐ yes Stream gradient (map or clinometer): ______%

☐ location NOT sampled - Reason: ______________________

Date Sampled: _____/_____/_______ Temp _______(C or F) Time (military/24 hour): _______

Latitude/Longitude from map or GPS (decimal degrees):
Lat. (North) ______________ Long. (West) ______________

Location verified by (✔) ☐ GPS ☐ Location ☐ Signs ☐ Roads ☐ Topo map ☐ other _________

(first collect any desired chemistry data; next, macroinvertebrate samples; then, gather habitat data below)

REACH Habitat Information

Initial average wetted width (4 widths near X-spot; feet and tenths) (___+___+___+___)/4 = _______

Reach: 40X ave. wetted (500' min/1000' max) _______

Distance btwn transects: 2X wetted (min 25'/max 50') ___

Time/Date Imprinted Photos

Bottom of reach upstream time # _______

Midpoint D/S time # _______

Midpoint U/S time # _______

Top of reach downstream time # _______

Transect Wetted Widths

Transect #	Wet margin to wet margin (feet and tenths)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	

Transect Wollman Pebble Count

Substrate		Tally	Total	comment
Bedrock smooth	**>car**			
Bedrock rough	**>car**			
Concrete/asphalt				
Large Boulder	**yardstick - car**			
Small Boulder	**basketball - yardstick**			
Cobble	**tennis ball - basketball**			
Coarse Gravel	**marble - tennis ball**			
Fine Gravel	**ladybug - marble**			
Sand	**gritty - ladybug**			
Silt/Clay/Muck	**slick, not gritty**			
hardpan	**consolidated fines**			
Wood	**any size**			
Other	**(please comment)**			

Human Use & Influence

	NOT PRESENT	LEFT ONLY	RGHT ONLY	BOTH BANKS	ON BANK	WITHIN 30 ft	> 30 ft	
Riprap/wall/dike/revetment	☐	☐	☐	☐	☐	☐	☐	________
Industrial	☐	☐	☐	☐	☐	☐	☐	________
Pavement/cleared lot	☐	☐	☐	☐	☐	☐	☐	________
Roads/railroads	☐	☐	☐	☐	☐	☐	☐	________
Rural residential	☐	☐	☐	☐	☐	☐	☐	________
Urban residential	☐	☐	☐	☐	☐	☐	☐	________
Parks/lawn/informal recreation	☐	☐	☐	☐	☐	☐	☐	________
Row crops	☐	☐	☐	☐	☐	☐	☐	________
Pasture/range/Hay field	☐	☐	☐	☐	☐	☐	☐	________
Mining/sand & gravel	☐	☐	☐	☐	☐	☐	☐	________
Logging operation last 5 year	☐	☐	☐	☐	☐	☐	☐	________
Forest/woodland	☐	☐	☐	☐	☐	☐	☐	________
Other________________	☐	☐	☐	☐	☐	☐	☐	________

Biological Information

Fish observations		Aquatic wildlife		Other wildlife	
species	quantity & size	species	comment	species	comment

Visual Riparian Estimates

OWEB Canopy Cover:
☐ low under 40%
☐ medium 40–70%
☐ high over 70%

Vegetation type: D C M B G No veg

Tree Size: R S M L No forest

Stand Density: Dense Sparse No forest

Definitions for Riparian Estimates
D = deciduous
C = coniferous
M = mixed
B = brush
G = grass
No veg = bare ground or rock
R = revegetation (<4" average diameter)
S = small diameter (4-12")
M = medium diameter (12-24")
L = large diameter (>24")
No forest = no forest cover
Dense = trees spaced closely together / canopy closed
Sparse = trees spaced far apart / canopy open

Macroinvertebrate Sample Information

of Kicks composited ☐ 8 @ 1 ft² ☐ other________
Collected by ______________________________

Field duplicate collected: ☐ yes ☐ no

Number of riffles sampled: ________

Typical substrate in riffles:

Dominant size ____________________

Secondary size ____________________

Jars _______ # Field duplicate jars ________

Other Notes and Comments:

Appendix B: Contacts, Resources, Volunteers, Partners

Name	Description	Organization	email	phone
Citizen volunteers	citizen volunteer interest	Vashon Nature Center list	on file VNC	on file VNC
Ann Marie Pierce	Education and Outreach Specialist	Thurston County Stream Team	pearcea@co.thurston.wa.us	360-754-3355
Expert volunteers	Help with ID and sampling protocol	Vashon Nature Center list	on file VNC	on file VNC
David Dunn	Administrator of Centennial Grant Program	Washington Department of Ecology	jnej461@ecy.wa.gov	360-407-6566
David Robinson	BI fieldwork Vashon	King County	David.robinson@kingcounty.gov	
Doug Osterman	WRIA 9 Salmon recovery	King County	doug.osterman@kingcounty.gov	206-296-8069
Eric Ferguson	Hydrologist	King County	eric.ferguson@kingcounty.gov	206-263-6512
Gay Roselle	science teacher--school interest	McMurray Middle School	groselle@vashonsd.org	
Greg Rabourn	Basin steward and GWPC coordinator	King County	greg.rabourn@kingcounty.gov	206-296-1923
Jayme Gordon	Stream Team Coordinator	Pierce County Conservation District	JaymeG@piercecountycd.org	253-845-2973
Jo Wilhelm	Ecologist coordinates B-IBI sampling for KCDNR	King County DNR	Jo.Wilhelm@kingcounty.gov	206-263-6556
Mindy Allen	Owner -Invert ID lab	Aquatic Entomology Lab	allenspardise@msn.com	360-427-5325
Pamn Aspiri	administrator--college courses	Vashon College	pamn.aspiri@vashoncollege.org	
Patrick Edwards	Project Coordinator Cascades-Coast k-12	Portland State University	www.pdx.edu/soe-gk12	503-725-8303
Robert Wisseman	Senior Scientist- Invert ID	Aquatic Biology Associates	bobwisseman@mac.com	541-752-1568
Susan Braley	Water Quality Program	Washington Department of Ecology	Susan.Braley@ecy.wa.gov	360-407-6414
Stacey Hinden	Director	Vashon Wilderness Program	stacey@vashonwildernessprogram.org	206-651-5715
Susie Kalhorn	Environmental Education and Outreach Specialist	Vashon	burnhorn@gmail.com	
Tom Devries	science teacher--school interest	Vashon High School	tomdevrie@aol.com	
Trish Howard	environmental educator curriculum writer CES	Chautauqua Elementary	trishhoward@gmail.com	206-463-0075
Vashon Audubon Society	interest in riparian health as bird habitat	Vashon Audubon Society	spiers@centurytel.net	
VMI Land Trust	Landowner, stream restoration	Vashon Maury Island Land Trust	tom@vashonlandtrust.org	206-463-2644
Wease Bollman	Rhithron and associates recommended lab for ID	Missoula Montana	contact@rhithron.com	406-721-1977

END