FRESHWATER QUALITY IMPLEMENTATION STRATEGY

Protect and Restore Puget Sound Stream Health

As measured by the Benthic Index of Biotic Integrity

November 2020

Stormwater Strategic Initiative

Washington Department of Ecology
Washington Stormwater Center
Washington Department of Commerce

In collaboration with:
Puget Sound Partnership
Puget Sound Institute
B-IBI Interdisciplinary Team

Acknowledgements

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PUGET SOUND
National Estuary Program

Title: Freshwater Quality Implementation Strategy: Protect and Restore Puget Sound Stream Health as Measured by the Benthic Index of Biotic Integrity

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Summary:

The Benthic Index of Biotic Integrity Freshwater Quality Implementation Strategy describes the interim results needed to make progress towards the Freshwater Quality Vital Sign target. The Implementation Strategy identifies four strategies: Local Capacity Strategy; Watershed Planning Strategy; Education and Incentives Strategy; and Working Lands Strategy.

Suggested citation:

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Table of Contents

List of Tables

List of Figures

Executive Summary

The Puget Sound region has seen tremendous changes since the mid-1800s. Forested basins have been replaced with agricultural and urban developments, which has had far-reaching effects our rivers and streams. Changes in land use have often led to erosive stream-flows, excessive sedimentation, warm water temperatures, removal of streamside vegetation, and contaminated runoff. This Benthic Index of Biotic Integrity (B-IBI) Implementation Strategy outlines a series of actions, approaches, and interim results that are meant to reverse some of those impacts in order to restore and protect streams throughout the Puget Sound.

B-IBI is a measure of stream health based on the abundance and type of stream macroinvertebrates present at a site. Stream macroinvertebrates – the insects, snails, worms, etc. that live in the stream bed - vary in their sensitivity to environmental stressors, and therefore are excellent indicators of stream health. Highly degraded streams tend to support only the most tolerant types of macroinvertebrates and result in low B-IBI scores. Streams that support a diverse group of sensitive macroinvertebrates produce higher scores. B-IBI scores decline predictably along a gradient of land use intensity.

The B-IBI Implementation Strategy focuses on improving regional freshwater quality by achieving two specific targets of the Puget Sound Partnership's Freshwater Quality Vital Sign. These stated B-IBI targets are:

- Protect – Maintain 100 percent of Puget Sound lowland stream drainage areas ranked as "excellent"
- Restore – Improve and restore at least 30 streams ranked as "fair" so that scores improve to "good"

This Implementation Strategy is the work of an Interdisciplinary Team (IDT) of regional experts in science and policy, with extensive experience developing and leading projects for the protection and restoration of Puget Sound streams. The IDT worked through a step-wise process that: 1) identified stressors (environment) and pressures (human), 2) highlighted the causes of the stressors and pressures, 3) identified the barriers that impede us from addressing the stressors and pressures, and 4) identified strategies, approaches, and actions that address the barriers.

The IDT determined that the primary pressure affecting streams is increasing land use intensity focusing on the conversion of forests to agricultural, residential, commercial, and industrial land uses. The key stressors arising from these land use changes are altered hydrology, degraded riparian areas, degraded instream habitat, and degraded water quality.

The Strategies

The IDT identified four broad strategies likely to improve stream condition. These are listed below.

Increased Local Capacity Strategy: The objective of this strategy is to improve funding, staff capacity, and availability of decision support tools for local stormwater management programs.

Many jurisdictions lack the capacity, in terms of personnel and/or expertise, to implement stormwater management programs. This lack of capacity limits local governments from addressing the impacts of stormwater on a local and regional scale. This strategy calls for increased stormwater program funding and

training, and it calls for more effective investment of limited resources. Funding would allow for increased staffing resources, training, and improved stormwater management tools and information resources.

Watershed Planning Strategy: The objective of this strategy is to promote multi-program and cross-jurisdictional planning on a coordinated watershed scale to maximize benefits from protection, mitigation and restoration.

Stream conditions are affected by local and watershed-scale pressures. The overall watershed condition may limit the extent of recovery from local restoration or mitigation activities. As such, restoration and protection activities have a better likelihood of success if implemented in a framework that considers the entire watershed. Watershed-scale planning is one key way of incorporating that framework.

The strategy is intended to protect and restore watershed function and habitat, encouraging the development of political will to support the planning and implementation of restoration and protection activities, and promote investments in recovery including monitoring and evaluation to improve our understanding of how to improve B-IBI scores.

Education and Incentives Strategy: The objective of this strategy is to encourage stormwater retrofits and source control activities that limit pollutants, and to encourage habitat restoration on privately owned properties through focused incentives supported by education.

Past development was built without stormwater controls and there are few regulatory mechanisms that address stormwater runoff from these legacy developments. Major redevelopment of a property generally triggers new stormwater retrofit requirements but the rate of mitigation through this mechanism is slow and stormwater retrofits are generally not required on private properties. The rate of stormwater retrofit and habitat restoration work on private land will likely increase with well-designed education and incentive programs.

This strategy is designed to increase stormwater retrofits and source control with focused incentives like technical assistance, financial assistance, and/or permitting advantages, and to increase the restoration of riparian, in-stream and wetland habitats by leveraging opportunities to coordinate and concentrate existing and planned restoration investments.

Draft Working Lands Strategy: The objective of this strategy is to reduce the risk to forests and agricultural areas of being converted to urban or suburban land uses, and to reduce ongoing impacts of working lands on stream health.

There is ample evidence that impacts on stream quality are commensurate with the extent of development in a given watershed. Therefore, there is benefit in preventing the conversion of working lands to other more intense land uses. The implementation of Best Management Practices (BMPs) on working lands can mitigate adverse impacts.

This working lands strategy is considered draft. The information the IDT received from key stakeholders and implementers indicated that a more comprehensive, integrated, working lands strategy effort is warranted. This strategy requires new regional coordination, stakeholder engagement, and conceptual development.

Moving Forward

The publication of the B-IBI Implementation Strategy is a starting point. It does not identify every project and policy change necessary to achieve the recovery targets. It is intended to create a strategic framework to achieve ambitious goals. The Implementation Strategy should help guide and prioritize regional recovery actions, inform policy decisions, and identify ways to evaluate progress.

This Implementation Strategy must be updated to as new information comes available. A robust research and monitoring program is necessary to better understand the effectiveness of various actions and projects, and to support planning and prioritization. The results and lessons learned from research and monitoring should be considered when the Implementation Strategy is updated and revised. The Implementation Strategy must exist within an adaptive management framework.

Implementation of this strategy will be an ongoing challenge. It will require resources and coordination, political will, difficult conversations, and hard choices. We will need the Puget Sound recovery community, including senior leadership within federal and state agencies, tribes, and other collaborators (the entire Puget Sound Management Conference) to chart the course ahead, and undertake the actions and activities that will lead to Puget Sound recovery. This Implementation Strategy is one example of the collective effort that will help us reach our recovery targets.

1 Introduction and Overview

The Puget Sound region has undergone tremendous change since the mid-1800s. Watersheds, once heavily forested, now support agriculture, commercial, industrial, and growing residential communities. These require new networks of roads and a patchwork of parking lots. These changes impact the health of Puget Sound rivers and streams.

There are numerous efforts by state, local, and tribal partners to protect and restore the Puget Sound ecosystem, including the rivers and streams. The [Puget Sound Partnership] coordinates these efforts into an ecosystem-scale recovery program that is aligned at a regional level. The Puget Sound Partnership organizes recovery around six broad goals. These are:

- Healthy human population
- Vibrant quantity of life
- Thriving species and food web
- Protected and restored habitat
- Abundant water
- Healthy water quality

Each Puget Sound recovery goal is represented by one or more Vital Sign (Figure 1-1). Vital Signs represent important components of the Puget Sound ecosystem such as orca and salmon populations, marine water quality, land cover and development, freshwater quality, etc. Each Vital Sign is measured by one or more indicators that represent of components of the Vital Signs (https://www.psp.wa.gov/evaluating-vital-signs.php). And each of the indicators has an associated target that described the desired condition of the systems.

The strategies described in this document focus on the Freshwater Quality Vital Sign and the Benthic Index of Biotic Integrity (B-IBI) indicator. Two targets have been identified for the B-IBI indicator: 1) restoring the streams that are classified as "fair" condition, and 2) protecting and maintaining the streams that are classified as "excellent." The stream classifications are identified and evaluated based on B-IBI data (see section 2.1).

B-IBI utilizes the abundance and types of macroinvertebrates present in a stream to characterize stream health. Macroinvertebrates are small, soft-bodies animals such as aquatic insects, snails, worms and mites, which typically live a year or more. They vary in their sensitivities to environmental stressors; some are quite sensitive and cannot thrive outside pristine environments, while others are tolerant of change. Thus, the macroinvertebrate community found in a stream reflects the overall stream condition. B-IBI scores are highly correlated with the extent of forests in the contributing basin. Scores decline as development intensity increases. Scores reflect the cumulative impacts associated with these land use changes, which include degraded water quality, hydrology, riparian and instream habitat, energy inputs, and biotic interactions (Karr 1991). B-IBI scores are used to classify stream conditions from "very poor" to "excellent."

B-IBI scores have been used to help identify and prioritize streams for protection and restoration (King County 2015, 2019).

Figure 1-1. The Puget Sound Vital Signs wheel.
Demonstrating the relationship between overall recovery goals and specific Vital Signs. Each Vital Sign is represented by a suite of indicators. (Puget Sound Partnership/EPA)

1.1 Purpose and Components of this Document

Implementation Strategies are recovery plans that are meant to achieve specific recovery targets for a Puget Sound Vital Sign. In this case, the Implementation Strategy focuses on the recovery targets for stream health as measured by B-IBI. This Implementation Strategy describes a high-level strategic direction for the Puget Sound recovery community, and provides a frame to coordinate efforts of recovery partners. It should help the recovery community identify challenges and barriers, and act as a guide to identify actions that will help recover Puget Sound streams.

This strategy document includes the following topics:

- Freshwater Vital Sign B-IBI indicator - a description of the B-IBI indicator and existing data (Section 2)

- Recovery Context – a brief introduction to 1) the pressures and stressors that impact benthic invertebrates, and 2) the regulatory context (Section 3)
- Recovery Strategies for Achieving the B-IBI Targets – a description of the strategies developed under this process (Section 4)
- Alignment with Regional and Local Strategies – a description of relative strategies that have been developed by other ecosystem management agencies (Section 5)
- Climate Change – a brief description of considerations related to climate change (Section 6)
- Research and Monitoring Priorities – a description of the research and monitoring priorities that are critical for stream restoration and protection (Section 7)
- Cost Estimates for the Strategies – a survey of costs for activities that are relevant to the stream restoration and protection (Section 8), and
- Adaptive Management of the Implementation Strategy – a description of potential approaches and focus areas for the adaptive management (Section 9)

In addition to this Implementation Strategy narrative, there are key appendices that support the Implementation Strategy, including a State of Knowledge report and Base Program Analysis.

The State of Knowledge report contains a review of the scientific literature and summarizes the best available science on the causes, impacts, and relationships that are important in understanding stream health. It includes information on the effectiveness of remediation and restoration activities, as well as the effectiveness of programs and policies in stream recovery and maintaining stream health.

The Base Program Analysis provides information on the programmatic and policy context under which stream restoration and protection occurs in Washington. It includes a summary of relevant land use and water quality regulations, as well as an inventory of the policies and programs that are implemented in response to those regulations. It describes the regulatory and policy tools that could be leveraged. Together, these three documents can be used as a comprehensive orientation for those working on Puget Sound recovery

1.2 Strategy Development

This Implementation Strategy was developed through an expert elicitation process. A group of regional experts, known as the Interdisciplinary Team (IDT), provided input and guidance on the root causes of impairment, barriers to protection and restoration, and strategies and activities that address the barriers and lead to recovery.

To achieve this, the IDT conducted a situation analysis, based on the methods described in the *Open Standards for the Practice of Conservation* framework and the *Guidelines for Developing an Implementation Strategy* (Puget Sound Partnership 2017). The situation analysis identified key pressures and barriers relating to the recovery targets, as well as opportunities to intervene. After the situation analysis, the IDT selected the most promising intervention points and developed them into strategies. By using this approach, participants evaluated causes and avoid the temptation to develop strategies that may not address the core issues.

The IDT made efforts to ensure expert guidance, best available science, and a robust understanding of the regulatory and social environment informed the Implementation Strategy. To do so, a "Starter Package" was prepared at the beginning of the process to provide a broad overview of relevant science and policy.

The work of the IDT was coordinated and supported by a Core Team that facilitated meetings and discussions, and pulled together the recommendations and outcomes into this Implementation Strategy document.

A detailed description of the Implementation Strategy development process is in Appendix IVa.

1.3 Watershed Terminology

Various geographic terminologies are used in restoration, stormwater management, and land use planning, which can often create confusion among practitioners with different backgrounds. The use of terminology in this document is as follows:

- Water Resource Inventory Areas (WRIAs) are used by agencies in the State of Washington to define major watersheds. There are 19 WRIAs within the Puget Sound watershed.
- A watershed is the land area that channels precipitation through a stream or river to an outflow point. The outflow point is the confluence of that stream or river with another stream or river, or another water body such as a lake or estuary.
- A B-IBI basin is defined as the portion of a watershed that contributes flow to a given B-IBI site. B-IBI basins are delineated upstream from the sampling location. If the sampling location (B-IBI site) is at the base of a watershed (i.e., at the outflow point), the B-IBI basin land area is the same as the watershed, but typically B-IBI sites are upstream of the watershed outflow point. Therefore B-IBI basins are often smaller in land area than the watersheds they are in (King County 2015).
- Sub-basins are sub-units of basins.
- Catchments are the smallest unit, and can include areas of natural and constructed drainage systems.

"Regional freshwater quality," "stream health," and "freshwater quality" are used interchangeably throughout the text.

1.4 References

Karr, J.R. (1991) Biological Integrity: A Long-Neglected Aspect of Water Resource Management. Ecological Applications 1(1), 66-84.

King County. 2015. Strategies for Protecting and Restoring Puget Sound B-IBI Basins. Prepared by J. O. Wilhelm, K. Macneale, C. Gregersen, C. Knutson, and D. Bouchard. King County Water and Land Resources Division, Seattle, WA.

King County. 2019. Stressor Identification and Recommended Actions for Restoring and Protecting Select Puget Lowland Stream Basins. Prepared by Kate Macneale and Beth Sosik, Water and Land Resources Division. Seattle, WA.

Puget Sound Partnership (2017) Guidelines for Developing an Implementations Strategy v2, Tacoma, WA.

2 Freshwater Quality Vital Sign Indicator: B-IBI

The Freshwater Quality Vital Sign uses three indicators: 1) the Water Quality Index, which compiles eight measures of water quality, 2) freshwater impairments, as listed under Section 303(d) of the Clean Water Act, and 3) the B-IBI. This Implementation Strategy focuses on B-IBI.

2.1 B-IBI Background

The Puget Lowland B-IBI was developed in the 1990s as an integrative measure of the biological health of wadeable streams in the Puget Sound lowlands (Karr 1993, Karr and Chu 1997). It is based on research showing that the number and type of aquatic macroinvertebrates in a stream vary along a gradient of land use intensity. King County Water and Land Resources Division serves as the lead advisor on the B-IBI indicator.

B-IBI is an index composed of ten metrics that characterize aquatic macroinvertebrate communities by measuring taxa richness, relative abundance, and other ecological characteristics of stream macroinvertebrates (Table 2-1). The metrics included in the index were selected because each varied systematically along a gradient of human impact, from pristine to urban (King County 2014). The benthic community in a forested stream is much different from the benthic community in a stream running through a city or town, and the metrics were selected to characterize those differences. When combined into a single index, the B-IBI score describes the condition of the stream and its contributing basin. Details describing how the index is calculated can be found on the Puget Sound Stream Benthos website.

B-IBI is calculated by: 1) measuring the numbers and types of benthic macroinvertebrates through field samples, 2) calculating the scores of each of the ten metrics, and 3) adding up the scores of the individual metrics to determine the overall B-IBI score. Streams can then be categorized as “excellent,” “fair,” “good,” “poor,” and “very poor” based on the B-IBI score across a 0 to 100-point scale. Higher scores indicate better condition, and a stream that supports a diverse assemblage of macroinvertebrate species (Table 2-2). A site with a B-IBI score above 80 is deemed “excellent.” Low scores indicate a site is impaired. Impaired sites support only the most tolerant species.

B-IBI is generally considered an indicator of condition and, in itself, is not necessarily diagnostic. Additional analysis is needed to relate B-IBI with pressures or stressors (see State of Knowledge report).

Table 2-1. The Ten Metrics Included in the Puget Lowlands B-IBI

Metric	Description
Taxa richness	The number of unique taxa found in a sample. Overall taxa richness declines with increased urbanization.
Ephemeroptera richness	The number of unique mayfly taxa in a sample. Many mayfly taxa are intolerant of stressors associated with increased urbanization, and several are especially sensitive to fine sediment and contaminants.
Plecoptera richness	The number of unique stonefly taxa in a sample. Many stonefly taxa are intolerant of stressors associated with increased urbanization, including low dissolved oxygen concentrations and a lack of riparian vegetation.

Metric	Description
Trichoptera richness	The number of unique caddisfly taxa in a sample. Several caddisfly taxa are relatively tolerant of environmental stressors, but generally taxa richness declines with increased fine sediment, loss of complex habitat, and disruption of the stream food web.
Clinger richness	The number of taxa identified as clingers in a sample. Clingers have behavioral or morphological adaptations that allow them to attach and persist in stream riffles or other high- energy habitats. These taxa tend to disappear when exposed to an excess of fine sediments.
Long-lived richness	The number of taxa in a sample that require more than a year to complete their life cycle. The number of these taxa decline if conditions vary year to year due to disturbances such as flooding or drought.
Intolerant richness	The number of especially sensitive taxa in a sample. These taxa are the first to disappear from a stream when urbanization in the watershed increases. These taxa represent approximately 15% of common taxa in the Puget Sound Lowlands.
Percent dominant	The percent of a sample composed of the three most abundant taxa. As urbanization increases in a watershed, sensitive taxa disappear and the relative abundance of a few tolerant taxa often increases.
Percent predator	The percent of a sample composed of individuals that are obligate predators. The structure of the stream food web changes with increased urbanization, often resulting in the loss of predators.
Tolerant percent	The percent of a sample composed of tolerant individuals. Tolerant taxa are defined as taxa that are more likely to be found in sites with greater watershed urbanization. These taxa represent approximately 15% of common taxa in the Puget Sound Lowlands.

***** Each metric is scored from 0-10 based on the sampling results and all of the metrics are added together to determine an overall B-IBI score.

Table 2-2. Descriptions and Scores Associated with Five Categories of Biological Condition (Morley 2000)

Biological Condition	Description	B-IBI (0-100)
Excellent	Comparable to least disturbed reference condition; overall high taxa diversity and mayfly, stonefly, and caddisfly richness especially high. Relative abundance of predators high.	[80 - 100]
Good	Slightly divergent from least disturbed condition; absence of some long-lived and proportion of tolerant taxa increases.	[60 - 80]
Fair	Total taxa richness reduced – particularly intolerant, long-lived, stonefly, and clinger taxa; relative abundance of predators declines; proportion of tolerant taxa continues to increase.	[40 - 60]
Poor	Overall taxa diversity depressed; proportion of predators greatly reduced as is long-lived taxa richness; few stoneflies or intolerant taxa present; dominance by three most abundant taxa often very high.	[20 - 40]
Very Poor	Overall taxa diversity very low and dominated by a few highly tolerant taxa; mayfly, stonefly, caddisfly, clinger, long-lived, and intolerant taxa largely absent; relative abundance of predators very low.	[0 - 20]

* B-IBI was recalibrated in 2014 to represent a range of 0-100. Prior to this the range was 0-50 (King County 2014).

2.2 B-IBI Indicator Targets

The Puget Sound Partnership established two targets for the B-IBI indicator. The first focuses on protecting high quality streams and applies to streams in "excellent" or "good" condition. The second focuses on restoring streams that have been impacted and applies to streams in "fair" condition. The specific language of the B-IBI indicator targets is:

- **Protect:** 100 percent of Puget Sound lowland stream drainage areas ranked as "excellent", retain "excellent" scores for the Benthic Index of Biotic Integrity for biological condition.
- **Restore:** Improve and restore at least 30 streams ranked "fair", so their scores become "good".

2.3 Relation to Other Freshwater Quality Targets

Multiple indicators and targets have been established to improve the characterization of Puget Sound streams. The B-IBI targets are intended to address the region's best remaining streams as well as those with potential for recovery (Wulkan 2011). The B-IBI targets do not address highly degraded stream sites (e.g., those with "very poor" or "poor" B-IBI scores). Two other Freshwater Quality Vital Sign indicators better capture highly degraded streams: Freshwater Impairments and Water Quality Index.

The *Freshwater Impairments* indicator lists all of the rivers, streams, and lakes in the Puget Sound watershed as impaired based on a water quality assessment under the Clean Water Act (CWA) section 303(d). The target is to reduce the number of impaired listings.

The *Water Quality Index* utilizes a measure based on dissolved oxygen, pH, temperature, fecal coliform bacteria, nitrogen, phosphorus, suspended sediment, and turbidity. In general, stations with an index score of 80 or above meet water quality standards. The target for the *Water Quality Index* is that half of all monitored stations score greater than or equal to 80.

2.4 Current B-IBI Baseline Data Collection

B-IBI data are routinely collected and reported by nearly 20 local jurisdictions, tribes, and state and federal organizations in Puget Sound. In 2018, for example, B-IBI scores were calculated for 510 sites, based on samples collected by 19 agencies for 31 different projects. Some projects include ambient monitoring programs with a random sampling design, while others collect B-IBI data to monitor priority streams. Sampling data are routinely uploaded to the Puget Sound Stream Benthos website.

Stream condition and B-IBI are reported in several ways. The first is a snapshot of the most recent scores across Puget Lowland streams. The second is with an analysis of trends in scores at sites that have been monitored for multiple years. A third way is tracking the change in condition at certain sites over specific periods. This last approach was initiated in 2006, as part of the Vital Signs reporting on "fair" and "excellent" scores.

Typical reports track changes of current conditions compared to a baseline. For the Vital Sign updates in 2019, scores from baseline samples (2006-2009) were compared to current conditions (2015-2018). The mean score during each period is based on the data available (1-4 years). The 4-year window for each timeframe ensures that biomonitoring data collected by Ecology are included and that inter-annual variability is reduced.

2.5 Status and Trends of Vital Signs Indicators

A brief summary of the indicator status and trends is presented here. More detail can be found at the Puget Sound Partnership Vital Signs web page.

2.5.1 Status Monitoring

The results of the status monitoring based on data collected from 2009-2018 in shown in Figure 2-1. In the Puget Lowlands, B-IBI scores range from "very poor" to "excellent" and largely correspond to the urban gradient across the region.

2.5.2 Trends Monitoring Overall

The results of the trends analysis are shown in Figure 2-4. General trends in the region are encouraging. Many sites are in "very poor" and "poor" condition, overall scores in the region are improving. Of 125 sites monitored annually since 2002, scores at 29 are significantly improving (Figure 2-2). These trends are also reflected in sites that have been monitored for a shorter time period. The trends data indicate that, of the more than 400 sites analyzed, significant improvements are seen at 14% of sites, while significant declines are only seen at 1% of the sites (based on Mann-Kendall testing).

2.5.3 Trends Monitoring – Vital Signs Targets

The trends specifically related to the Vital Signs targets are shown in Figure 2-3 and Figure 2-4. For the first target (maintain 100% of "excellent" streams) progress is mixed. Of the 83 Puget Sound stream sites that scored "excellent" between 2006 and 2009, 17 were sampled again between 2015 and 2018. Of these, 71 percent (12 sites) maintained their "excellent" ranking (Figure 2-3) meaning that the target was not technically met. However, 10 streams that were previously ranked as "good" improved to "excellent" indicating that the total number of "excellent" stream sites increased.

The results of the trends associated with the second target (restore 30 "fair" streams to "good") are shown in Figure 2-4. Of the 172 stream sites that scored "fair" between 2006 and 2009, 52 were sampled again between 2015 and 2018. More than half of these sites remained “fair” over this period. Of the sites that did change fifteen stream sites improved and eight sites declined, indicating that this target was not met.

Overall, when considering all sites sampled in the two time periods (and not just the “fair” and “excellent” sites), more sites improved than declined. The number of sites that scored “fair”, “good”, or “excellent” improved over time, whereas the number of sites that scored “very poor” or “poor” declined.

Although these trends are encouraging, it is difficult to identify specific actions to explain them. In the last two decades, land use conversion has continued and land use intensity has increased, and yet macroinvertebrate communities appear to be recovering in many streams across the region. Macroinvertebrate communities are impacted by a variety of stressors that are associated with land use conversion and increased land use intensity, such as excessive fine sediment, contaminants in stormwater runoff, loss of riparian vegetation, and high flows. Thus, improvements in B-IBI scores are presumably due to reductions in these environmental stressors. More research is needed to assess how environmental conditions, management practices, and restoration actions may have changed over time and whether these changes can explain the trends in B-IBI scores.

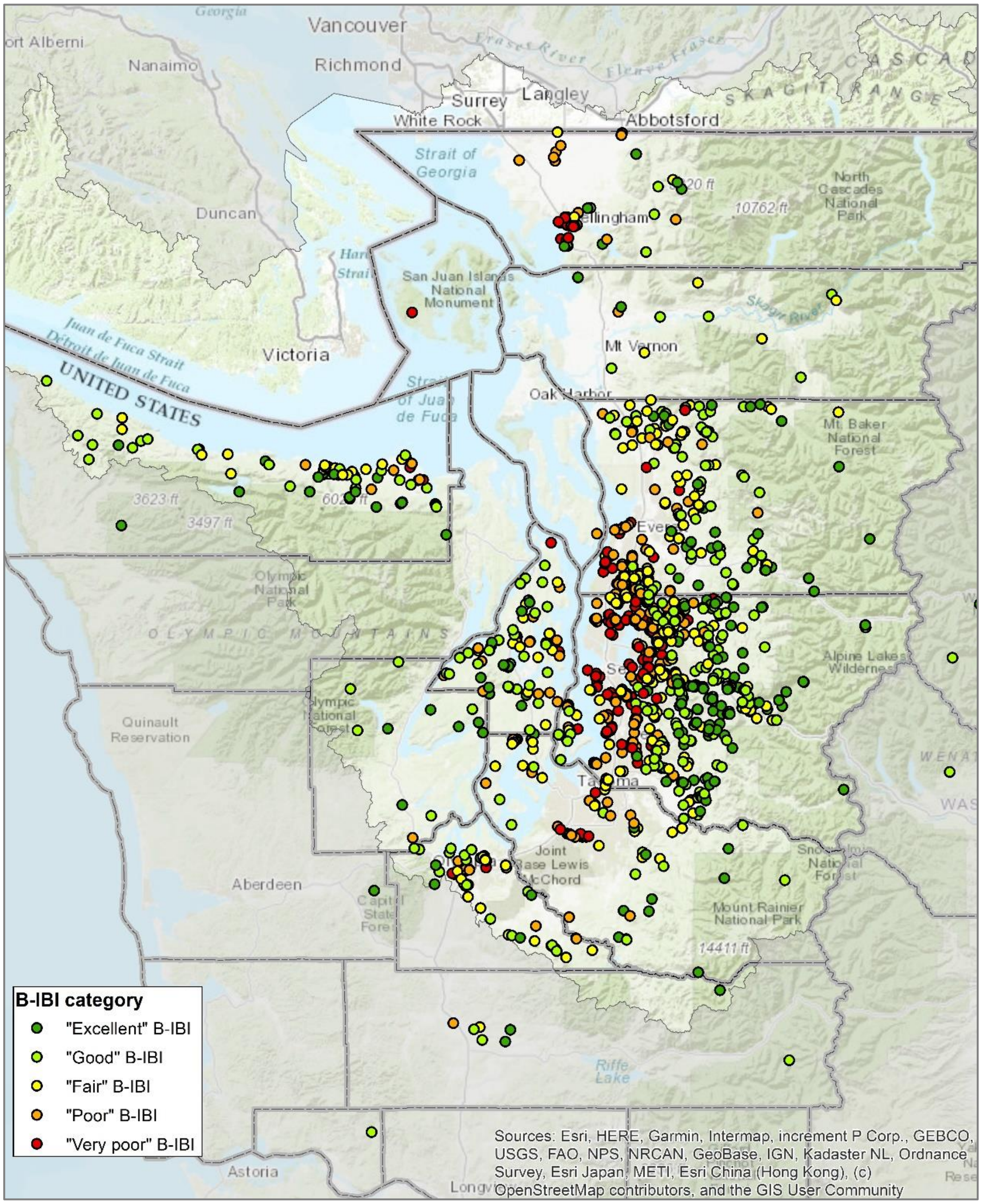

Figure 2-1. Biological Condition of Stream Sites in Puget Sound Lowland Streams as Measured by B-IBI. Data from 2009-2018. The map reflects the data available as of January 2020 for each sampling location.

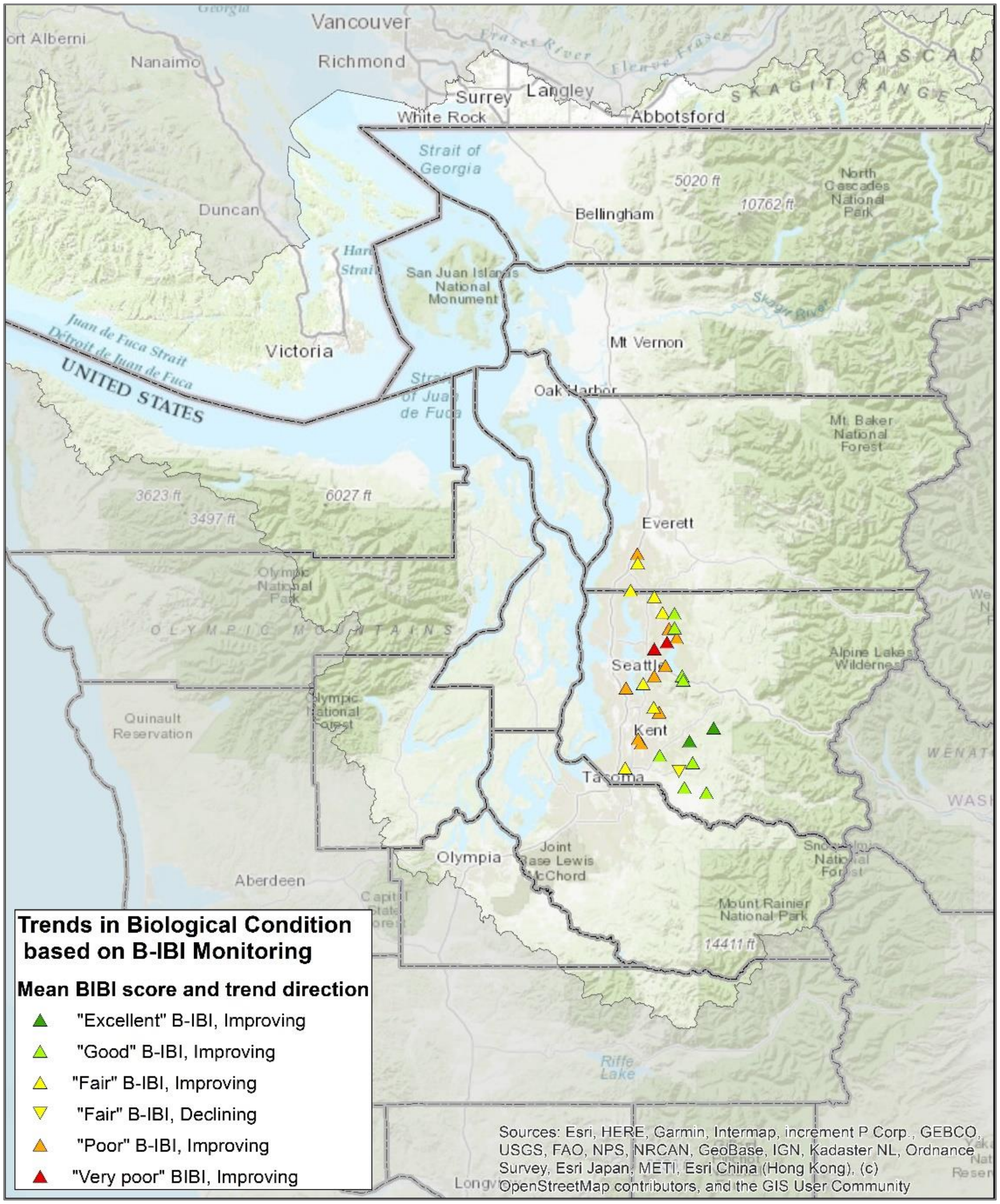

Figure 2-2. Trends in Biological Condition as Measured by B-IBI.
All sites with more than 10 years of data were evaluated for significant trends per Mann Kendall test. Only sites with statistically significant trends are shown (p<0.05).

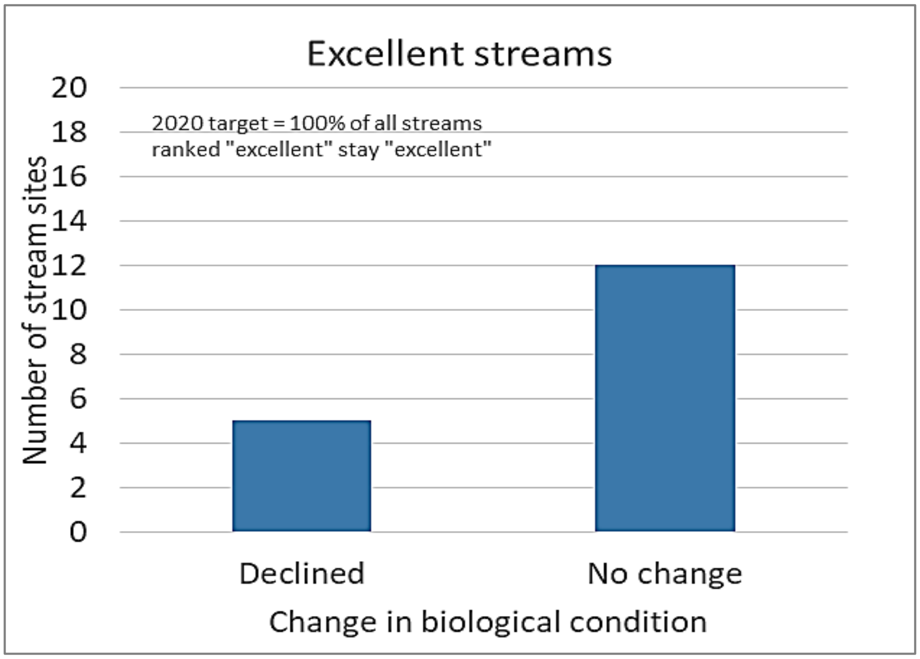

Figure 2-3. Change in the Biological Condition of Streams in Puget Sound Classified as “excellent” based on the Benthic Index of Biotic Integrity. (2006 – 2009 vs. 2015 – 2018)

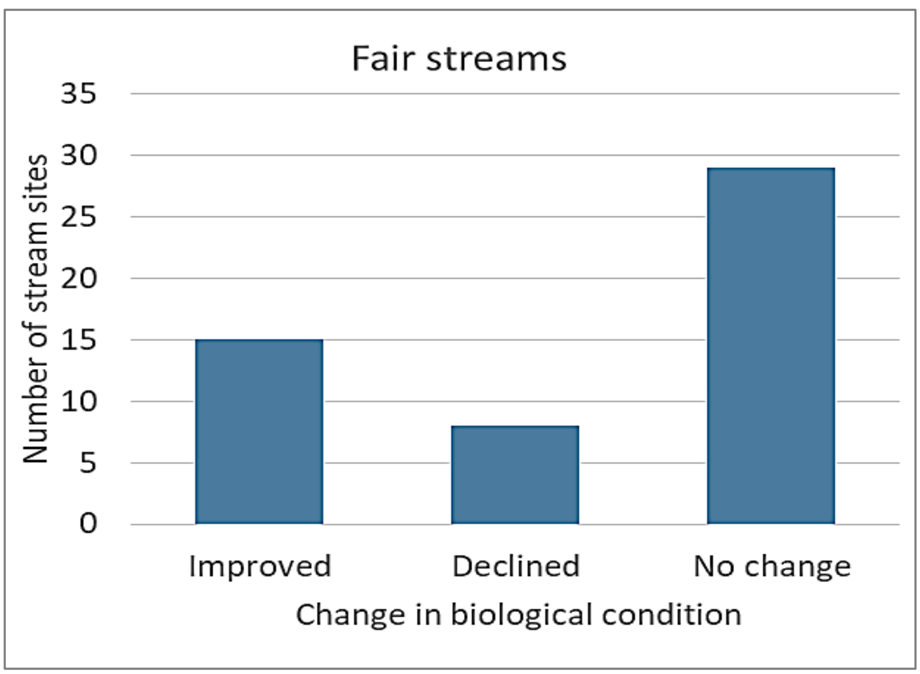

Figure 2-4. Change in the Biological Condition of Streams in Puget Sound Classified as “fair” based on the Benthic Index of Biotic Integrity. (2006 – 2009 vs. 2015 – 2018)

2.6 B-IBI Data Considerations

The B-IBI indicator targets focus on "fair" and "excellent" streams based on B-IBI scores, though there are different considerations that may result in inconsistent classifications. In addition, B-IBI scores can vary over time. Some sites have been sampled only once, while others have more than 10 years of measurements. As such, decisions related to data sufficiency and summary statistics may affect the final categorization of a given site. One suggested approach is summarized in Section 2.6.1.

In addition, not all catchments have been characterized with B-IBI monitoring and the IDT suggested that some jurisdictions may choose to undertake protection and restoration activities in such areas. There are other tools that can help inform on catchment conditions and provide a suitable framework for planning. An introduction to some of these assessment tools is presented in Section 2.6.2.

2.6.1 Selecting "Fair" and "Excellent" Stream Sites: King County Example

The identification of the "fair" and "excellent" sites can vary based on data screening. Since the intent is to protect or restore streams on a watershed scale, the size of the watershed is an important criterion – very large basins may be beyond the scale of management interventions.

Here, we provide an example method that King County used for its site selection for restoration and protection using B-IBI scores (King County, 2015 a, b). Data were reviewed from all sites available at the time (n=1053) and a series of filters were applied to identify "fair" and "excellent" sites.

For "fair" sites, the selection criteria included:

- the site had been sampled at least three times, and at least once since 2007;
- the site had a median score of "fair";
- the site was in the Puget Lowland ecoregion;
- the basin upstream of the site was moderate in size (200-3000 acres);
- the basin was hydrologically important and not already significantly degraded (as determined by the Puget Sound Watershed Characterization model (Stanley 2019)).

This resulted in a list of 54 "fair" stream basins that were recommended for potential restoration. King County repeated this site selection and prioritization process for a recent project that involved narrowing the "fair" list further (King County 2019).

For "excellent" sites:

- The site had to have scored "excellent" at least once;
- A site was excluded if its median score was "fair", or if it had scored "poor" or "very poor" even once.

This resulted in a list of just over 100 basins that were recommended for protection. In the recent King County project (2019), additional criteria were used to prioritize "excellent" sites.

It is important to note that other jurisdictions may have different stream conditions or data availability, and therefore, may elect to modify the site selection procedure.

Overall, the process of selecting the candidate restoration sites should ensure that sites: 1) have minimal inherent variability in response to natural factors; 2) have reliable B-IBI data quality and recent sampling history; 3) are at a scale where change could be tracked effectively and measured against local and watershed-scale conditions; and 4) are considered hydrologically important without already being degraded (King County 2015).

2.6.2 Additional Stream Selection Guidance - Assessment Tools

The use of B-IBI data to guide restoration and protection actions and to evaluate status and trends of stream health is limited to the sites where data have been collected. There are other tools and information resources to consider in the planning process for restoration and protection.

For example, the relationship between B-IBI scores and measures of development in a watershed, such as percent impervious surfaces, number of road crossings, etc., has been clearly demonstrated (see Section 3.1 on Pressures and references therein). While there are exceptions, this suggests that basins with a high level of development typically have lower B-IBI scores, and may not be the best locations for protection activities.

Protection activities might be focused mainly in basins with low levels of development and low measures of impervious surfaces, as these are areas with the best potential for excellent biological condition (and high B-IBI score). One tool for evaluating stream condition at a broad, region-wide, WRIA, or sub basin scale is the Puget Sound Watershed Characterization Project. This project provides, among other things, a description of the level of overall degradation to water flow processes, based on land use characteristics (see Section 3.2). Protection activities could be located in areas with a low level of degradation, while restoration activities could be located in basin with a moderate/high level of degradation.

Appendix IIh also provides a simple, stepwise approach to assess the restoration potential of streams to improve B-IBI scores by using calculations of percent of urban development to categorize and compare sites to understand the biological potential of streams, which may or may not be present given limiting factors upstream due to land use. The Puget Sound Watershed Characterization indices and steps outlined in Appendix IIh provide an opportunity for multi-scale assessments of restoration potential, which accounts for both broad (e.g. WRIA or sub-basin) water flow processes and finer-scale (catchment to stream reach) conditions which affect stream condition and hence.

Additional site selection considerations may also include:

- The availability of data on potential stressors in the watershed (e.g., water quality monitoring data, gage and history of flow data, 303d listing status or TMDL).
- Opportunities for funding or synergistic activities (e.g., alignment with salmon recovery priorities and funding, stormwater management planning, TMDL).
- The accessibility of the monitoring site and areas upstream.
- The land ownership within the basin (i.e., the site is on public property or there are willing and interested landowners).
- The presence of an active and engaged watershed or citizen science group.
- The potential overlaps with critical habitat for salmonid.
- The potential for the basin to provide quality refugia or stepping stone for nearby basins.

2.7 References

King County. 2014. Recalibration of the Puget Lowland Benthic Index of Biotic Integrity (B-IBI). Prepared by J. O. Wilhelm, L. Fore, D. Lester, and E. Dorfmeier, editors. King County Water and Land Resources Division, Seattle, WA

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Stanley, S., S. Grigsby, D. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, and G. Wilhere. 2019. Puget Sound Characterization. Volume 1: The Water Resource Assessments (Water Flow and Water Quality). Addendum - Version 2.0 Update of the Puget Sound Watershed Characterization Broad-Scale Models. Washington State Departemtn of Ecology, Olympia, WA.

3 Current Recovery Context

This section introduces a brief summary of the elements important to stream protection and restoration. It is provided as background and includes a description of pressures and stressors, programs, and barriers. A more detailed presentation is in the B-IBI State of Knowledge report (Appendix IIb) and the Base Program Analysis (Appendix IIc).

3.1 Pressures and Stressors on Freshwater Streams

The conversion of natural landscapes usually affects the way they function. When we clear tree canopy, we increase the amount of water that reaches the ground. When we disturb the natural soils, we reduce the ability of the ground to absorb and slowly release rainfall back into streams. Streets and buildings create impervious surfaces, which increase the rate and volume of stormwater runoff, and increase the delivery of pollutants into streams. During strategy development, a specific pressures/stressors framework was used to describe the changes to the landscape (i.e., pressures) with the functional and process changes (i.e., stressors) with the resulting impacts. This framework was used in the development of this Implementation Strategy by first identifying the pressures and stressors that may affect the condition of Puget Sound streams, and then developing strategies to prevent them or mitigate their impacts.

Pressures are human actions that lead to degradation of one or more of the elements we are trying to preserve (i.e., the conservation target). Stressors are the human-caused factor that causes a change on the ecosystem. They are the results of the pressures. For example, development might be the pressure that leads to altered hydrology (a stressor).

There are other frameworks which describe the interrelated factors, or functions, that impact (and define) stream condition (Karr 1991, Harman et al. 2012). While these generally align with the pressure/stressor framework presented here, the organization and language are sometimes different. Alternative framework are summarized briefly below (Section 3.1.2).

3.1.1 Pressures

The primary pressure affecting stream condition in the Puget Sound basin is land conversion/development, and the increased intensity of land uses. Both the scale and patterns of development influence the way the resultant stressors affect stream condition. Categories of development pressures include:

- **Conversion of rural lands for residential, commercial, and industrial uses:** Land conversion includes conversion of: working lands to mixed rural lands → low density residential → high density residential → commercial/industrial. Land use conversion is associated with increased impervious surfaces, affecting water flow and contaminant transport (May et al. 1997, Morley and Karr 2002, Roy et al. 2003, Allan 2004, Booth et al. 2004, Kennen et al. 2010, Fore et al. 2013).
- **Conversion of lands for transportation:** Transportation infrastructure is highly impervious, resulting in altered flows, generally containing high levels of contaminants (Fore et al. 2013).
- **Conversion of lands for natural resources production:** Timber harvest can degrade stream conditions by altering runoff, increasing fine sediments, changing inputs and transport of large woody debris, altering canopy cover and stream temperatures. Farming is associated with alterations to stream channel, sediment loading, and chemical and nutrient runoff (Noel et al. 1986, Carlson et al. 1990, Fore et al. 1996, Allan et al. 1997, Hutchens et al. 2004, Karr and Yoder 2004, Herlihy et al. 2005, Hernandez et al. 2005, Nislow and Lowe 2006, Banks et al. 2007).

While each type of development pressure can result in a different suite of stressors, in general, the more developed a given watershed, the higher the impacts on benthic communities. There is a demonstrated relationship between B-IBI scores and a number of measures of land use intensity such as transportation infrastructure, population density, and percent imperviousness (May et al. 1997, Morley and Karr 2002, Roy et al. 2003, Booth et al. 2004, Kennen et al. 2010, Fore et al. 2013). Increased agriculture in a basin is also associated with increased pressure on stream condition.

3.1.2 Stressors

Stressors can be broadly categorized based on impacts to hydrology, water quality, and habitat (e.g., physical habitat structure). Karr (1991) utilized an analogous framework that describes the ecological impacts of human alterations: changes in food/energy sources, changes in water quality, changes in habitat structure, changes in flow regime, and changes in biotic interactions. These align with the framework used in this process, as described below.

- **Altered hydrology:** Includes higher peak flows, increased flashiness, and lower base flows. (Morley and Karr 2002, Booth et al. 2004, Cassin et al. 2005, Konrad et al. 2008, DeGasperi et al. 2009, Kennen et al. 2010). Karr (1991) described this as altered flow regimes.
- **Degraded water quality:** Includes changes in natural conditions (pH, nitrogen, phosphorus, suspended sediments, etc.) and the inputs of specific toxicants such as metals, hydrocarbons, and pesticides, either in dissolved phase or sediments (May et al. 1997, Clements 2004, Pollard and Yuan 2006, Wang et al. 2007, Evans-White et al. 2009, Kail and Hering 2009, Lawrence et al. 2010, Vander Laan et al. 2013, Weston and Lydy 2014, Chiu et al. 2016, Eden 2016). Karr (1991) also included this category in his framework.
- **Degraded habitat:** Includes changes to the stream channel (e.g., straightening, disconnecting wetlands and floodplains, etc.); the removal or change of riparian habitat which provides shade, wood, nutrients, and food to the stream communities; or changes to in-stream habitat such as reduced complexity and sedimentation. (Hawkins et al. 1982, Wallace et al. 1995, Hilderbrand et al. 1997, May et al. 1997, Roy et al. 2003, Hutchens et al. 2004, Herlihy et al. 2005, Hernandez et al. 2005, Shandas and Alberti 2009, Parkyn and Smith 2011, Tonkin et al. 2014). Karr (1991) also included habitat structure. This current framework also includes some specific impacts of altered habitat such as changes in food/energy inputs that may result from altered riparian habitats.

Finally, it is important to note that stressors commonly co-occur and can be interrelated; e.g., the condition of in-stream habitat can be changed by altering the hydrologic patterns of runoff entering streams. It remains challenging to isolate the impacts of any single stressor on benthic communities. This key uncertainty affects the recovery context, as it is not always clear what to do to meet the indicator targets.

3.2 Alternative Recovery Frameworks

The IDT indicated it might be useful to present a functional pyramid model, as described by Harman et al. (2012), to illustrate the conceptual relationships between stream functions (Figure 3-1), particularly as they relate to pressures and stressors. Briefly, if all functions are working well, the stream can support a diverse suite of organisms (the "biology" at the top of the pyramid) and the B-IBI score will be "excellent". If one or more of the functions are impacted, the stream community may suffer and the B-IBI scores may decrease. Generally, the factors lower in the pyramid affect the factors higher up. The factors are (from lowest to highest): hydrology, hydraulic, geomorphology, physiochemical, and biology.

The pressure/stressor framework aligns with this functional pyramid. Development (pressure), such as the conversion of forests to residential, commercial, and industrial land uses, results in stormwater runoff that impacts hydrology, water quality, and habitat.

A more complete discussion is included in the State of the Knowledge Report.

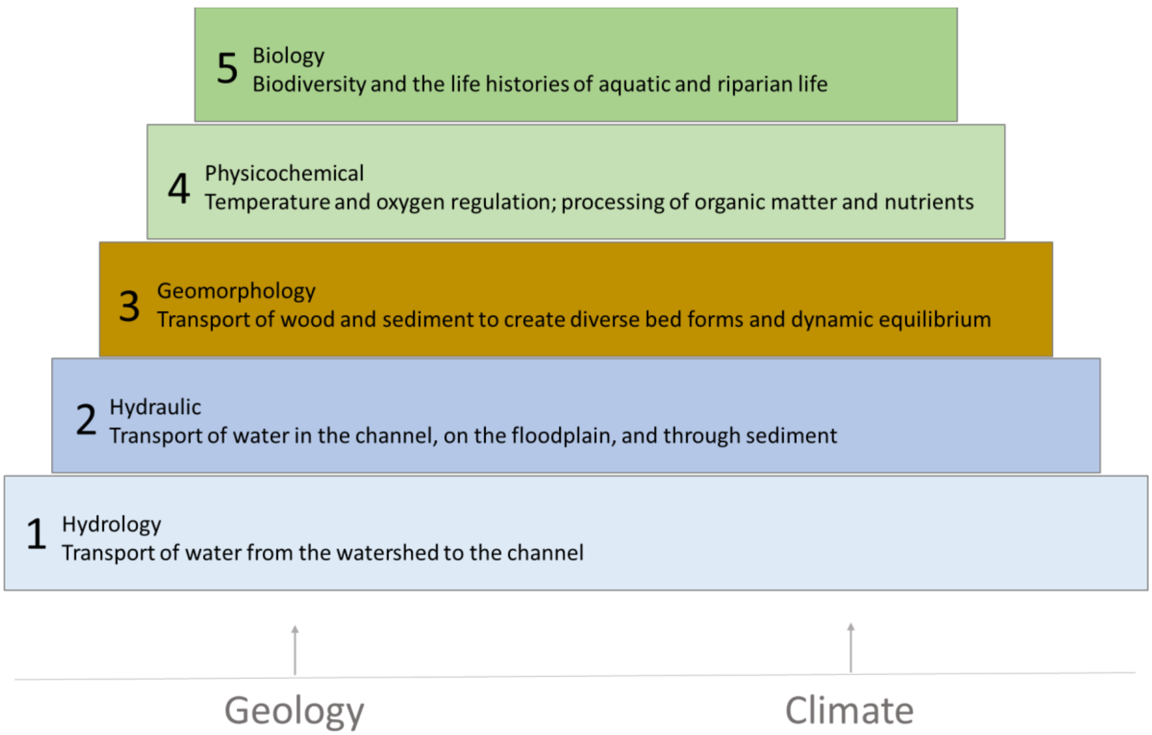

Figure 3-1. Functional pyramid of stream restoration, adapted from Harman et al. (2012). Within this framework, the higher-level functions are supported and defined by the lower level functions. For example, the hydrology (runoff from a landscape) supports and defines the in-stream hydraulics.

3.3 Watershed Conditions

Many basins within the Puget Sound watershed have undergone development, and so current conditions should be considered in site selection and planning for restoration and recovery activities, particularly since overall watershed condition may limit the potential extent of recovery (Paul et al. 2009, Bernhardt and Palmer 2011, Wahl 2012, Stoll et al. 2016). As such, watershed condition should be included when developing plans and setting expectations for restoration projects (see Section 2.6).

One method for evaluating watershed condition is with existing B-IBI scores. Other assessments, such as land use characterization, can be useful for identifying restoration or protection potential. Paul et al. (2009) compared land use intensity (the urban gradient) and biological index for a suite of sites and used the resulting relationship to identify an observed biological potential. They demonstrated that there was an upper limit to the biological condition at any given site as defined by the extent of development in the surrounding watershed. The potential for recovery is likely limited in developed watersheds (see also Beck et al. (2019)). This notion is applicable to Puget Sound recovery as well; the recovery potential at sites in basins with high impervious surfaces may be low (i.e., the best that can be achieved is “fair”).

Another assessment effort is Ecology’s Puget Sound Watershed Characterization Project (Stanley et al. 2019). The work utilized a suite of land cover and land use data sets to predict degradation based on an evaluation of water delivery (e.g., changes in timing), movement (e.g., loss of recharge area and alterations to discharge), and loss (e.g., changes to evapotranspiration; Figure 3-2). Areas with relatively high levels of degradation to flows may not respond to localized restoration activities without addressing larger scale flow processes. This context may prove useful for recovery planning and illustrate how best to utilize use of information about existing watershed conditions and existing monitoring data.

Read more about these stressors, and B-IBI response, in State of Knowledge Report (Appendix IIb).

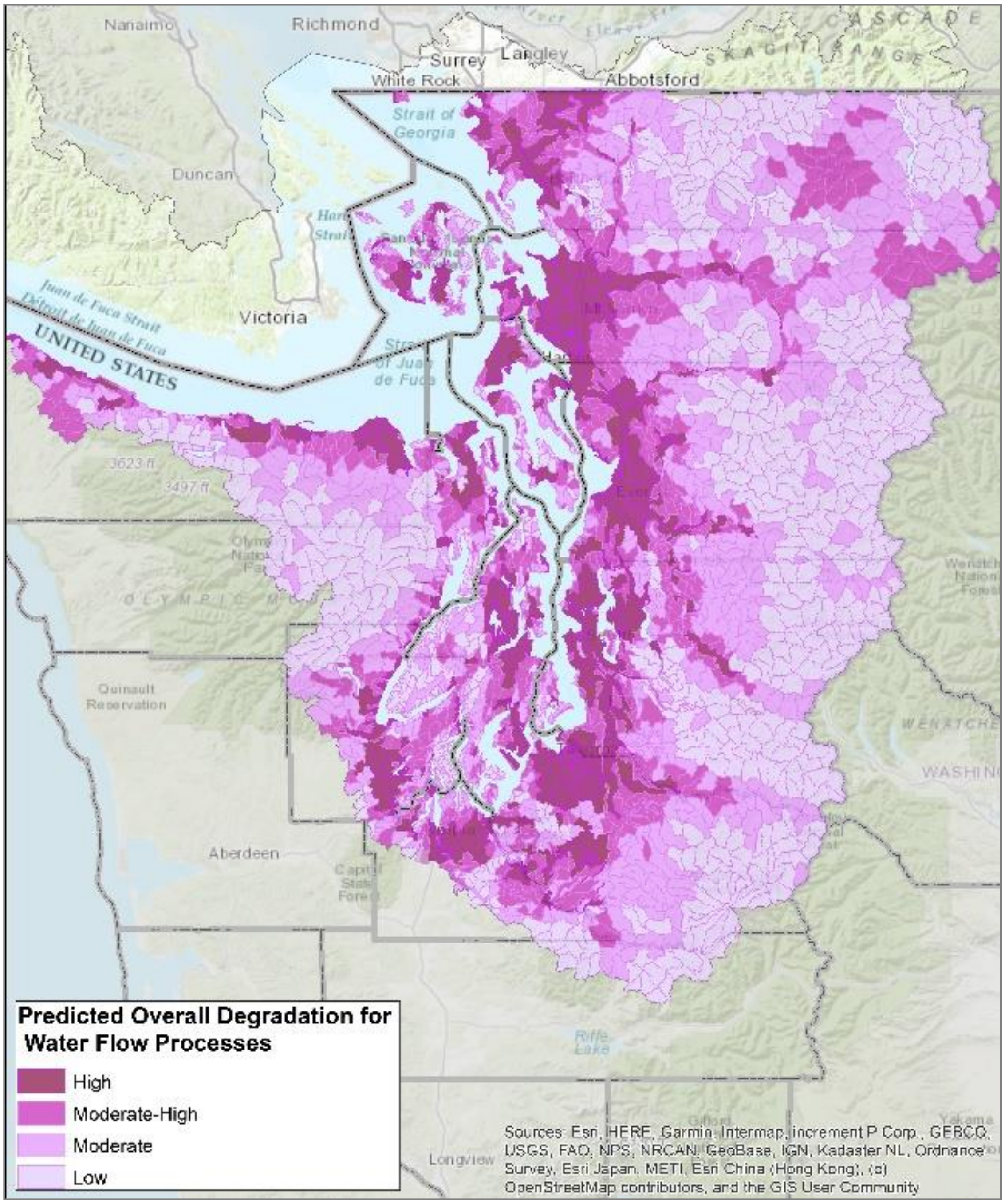

Figure 3-2. Results of Evaluation to Overall Degradation to Water Flow Processes per Puget Sound Water Characterization Project (Stanley et al, 2019).

Predicted degradation was based on evaluation of water delivery (e.g., changes in timing), movement (e.g., loss of recharge area and alterations to discharge), and loss (e.g., changes to evapotranspiration). Areas with high levels of predicted degradation to flows may be less responsive to localized restoration activities that do not also address larger-scale processes.

3.4 Current Regulatory and Programmatic Approaches for Protecting and Restoring Stream Health

This section presents an overview of the regulatory framework for protecting and restoring stream health and a summary of current, applicable programs. Additional information and analysis are provided in the Base Program Analysis (Appendix IIc).

3.4.1 Regulatory Framework for Protecting and Restoring Stream Health

A complex set of laws and regulatory requirements guide land use and stormwater management in the Puget Sound region. In addition to multiple federal and state agencies, a large number of local jurisdictions - 12 counties and 113 cities - are involved in the regulation of actions with the potential to affect stream quality and B-IBI scores.

Regulations that guide land use and stormwater management provide an opportunity to protect and restore stream integrity. Regulatory requirements for Low Impact Development (LID) and stormwater retrofits are meant to reduce impacts of development by reducing impervious surfaces and/or managing flows. Habitat restoration and incentive programs have been implemented to restore and protect habitat. Best Management Practices (BMPs), driven by fish protection and water quality regulations, can reduce the magnitude of agriculture or forestry impacts.

The laws and regulatory programs that can influence development patterns, habitat protection, conservation practice, and water quality are described below. The focus is on stormwater management and land use because the IDT identified land conversion/development and the increasing intensity of land uses as the primary pressure affecting stream condition in the Puget Sound basin.

Clean Water Act

The federal Clean Water Act requires program development that will restore and maintain the chemical, physical, and biological integrity of the nation's waters. The U.S. Environmental Protection Agency (EPA) delegated authority to administer Washington State's water quality program to Ecology. The two components of Ecology's water quality program that are particularly relevant to B-IBI indicator targets are National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits and the Nonpoint Source Pollution Program.

- **NPDES Municipal Stormwater Permit:** The Phase I permit covers larger cities (population >100,000) and counties (population > 250,000), while the Phase II permit covers over 60 cities and five counties in Western Washington (see Figure 3.4). The Washington State Department of Transportation is covered under a separate NPDES stormwater general permit.

  These permits require the development of stormwater management programs and implementation of BMPs to reduce pollutant concentrations, discharge volume, and flow rates. The 2013 NPDES permit revisions required permittees to revise local development codes to incorporate LID principles and BMPs to minimize impervious surfaces, the loss of native vegetation, and the management of stormwater runoff for in all types of development.

The 2019 permit revisions require both Phase I and Phase II permittees to conduct a basin plan (study) for one large scale (400-600 acres) watershed. The planning process is used to identify specific stormwater management actions to protect designated uses in selected receiving waters. The resulting Stormwater Management Action Plans (SMAPs) should identify ways individual jurisdiction, or several jurisdictions who share a watershed, can accommodate future growth and development while preventing water quality degradation and/or improve conditions in receiving waters harmed by past development.

- **Nonpoint pollution programs:** Runoff not covered under one of NPDES permits is addressed through the Nonpoint Pollution Program. Ecology works with other state agencies (Agriculture, Health, Natural Resources) and local partners (conservation districts, city and county governments, non-profit watershed groups) to support administration of and provide a regulatory backstop for programs addressing non-point source pollution (e.g., Dairy Nutrient Management Program, Forest Practices Rules, On-site Sewage System programs).

Growth Management Act

The Growth Management Act requires local governments to identify and protect critical areas and natural resource lands, designate urban growth areas, prepare comprehensive plans, and implement these programs through capital investments and development regulations.

- **Critical Areas:** Cities and counties are required to designate critical environmental areas (wetlands, aquifer recharge areas, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas) and promulgate development regulations to protect their functions and values. Counties and cities are directed to require compensatory mitigation if development is allowed to harm those functions and values; this may limit direct habitat degradation that can degrade stream health.
- **Voluntary Stewardship Program:** This is an alternative to critical area regulations for agricultural lands that seek to address the Growth Management Act's sometimes competing goals for environmental protection and the enhancement of natural resource industries. The Voluntary Stewardship Program promotes development of locally directed plans that balance environmental and economic goals. The Washington State Conservation Commission administers funding to counties to engage diverse stakeholders to develop then implement watershed work plans.
- **Comprehensive Planning:** Cities and counties above population size and growth rate thresholds specified in statute are required to develop comprehensive plans that guide local decisions relating to land use, housing, capital facilities, utilities, transportation, economic development, and open space corridors. Jurisdictions are also required to designate urban growth areas (UGAs) intended to focus development and that are sufficient to accommodate the level of growth projected for the next 20-years, and discourage development outside of UGAs.

The following regulations protect stream habitat in the Puget Sound region.

- **Endangered Species Act (ESA):** This federal law requires federal agencies to consult with the National Marine Fisheries Service and/or U.S. Fish and Wildlife Service when any action they carry out, fund, or authorize "may affect" a species listed as endangered or threatened. The Endangered Species Act also requires development of Habitat Conservation Plans and implementation of measures to minimize adverse effects of authorized activities on listed species. The listing of Puget Sound salmonids has had wide-ranging effects on many programs relating to freshwater streams.
- **Forest Practices Act:** Forest activities on non-federal public and private lands are regulated under the state Forest Practices Act. Corresponding Forest Practices Rules detail requirements related to growing, harvesting, and processing timber to meet natural resource protection goals. Forest practices include road construction, water crossing structures, thinning/brush control, and reforestation. Management of federal forest land is guided by the Northwest Forest Plan.

- **Hydraulic Code:** This state law was established for the protection of "fish life." It requires a Hydraulic Project Approval, issued by the Washington State Department of Fish and Wildlife, for construction and activities in, or near, state waters that will use, divert, obstruct, or change the natural flows or bed.

3.4.2 Other Drivers of Restoration and Protection Activities

A summary of programs that drive restoration and protection activities is presented here and in Table 3-1.

- **Habitat Restoration:** Federal and state salmon recovery programs drive extensive investment in stream habitat restoration. For example, the Conservation Reserve Enhancement Program, implemented by the Washington State Conservation Commission, is a joint federal and state funded program that restores riparian habitat for salmon and protect that habitat for 10-15 years under renewable contracts. Another example is the March 2013 federal court injunction (20 F. Supp.3d 986), sometimes referred to as the culvert decision, which required the state to significantly increase efforts to replace state-owned culverts that block habitat for salmon and steelhead. This work could result in improved stream function and B-IBI scores in those areas.
- **Water Quality Improvement:** Several federal and state programs provide grants for improving degraded water quality and reducing nonpoint pollution. Examples include: Section 319 Nonpoint Source Management Program under the Clean Water Act, which provides grant money for state and local agencies to enhance a range of nonpoint source implementation efforts; EPA Puget Sound National Estuary Program, which provides funding for Puget Sound ecosystem recovery; State Revolving Funds, which provide low-interest and forgivable principal loans for wastewater treatment, nonpoint source pollution, and other "green" projects; and tribal grants, such as those under the EPA Indian Environmental General Assistance Program, to assist in implementation of tribal solid and hazardous waste programs.
- **Land Conservation:** Acquisition programs for habitat, recreation, and forestland/farmland preservation reduce development pressure and help maintain stream health. Conservation programs can be structured as fee-simple purchases, conservation easement, or transfer or purchase of development rights. Example programs include the Conservation Futures Tax, which supports acquisition programs through grants, and the King County Land Conservation Initiative.
- **Incentives:** Several existing programs provide technical, regulatory, and/or financial assistance to landowners implementing Low Impact Development (LID) techniques or other conservation measures. Incentive programs that directly address barriers (e.g., high cost, insufficient knowledge) are more likely to achieve desired results compared to strictly educational programs and should be encouraged (Puget Sound Partnership 2015). For example, conservation programs implemented by county conservation districts, such as the King County Landowner Incentive Program, which provides 50% to 90% of costs of conservation projects on private working lands, can be crucial for encouraging conservation practices and ecosystem protections.
- **Education and Outreach:** Multiple on-going education and outreach campaigns focus on preventing and reducing pollution, as well as encouraging LID techniques. Providing information to landowners can increase awareness of the linkages between human activities and habitat, stormwater, and stream health. Regional examples include: SalmonSafe, which is a peer-reviewed certification and accreditation program to ensure agricultural practices and urban development protect water quality, maintain watershed health, and restore habitat; the Skagit County Poop Smart program, a social media campaign that encourages the safe handling of waste in septic systems, farms, and

from pets; and Puget Sound Starts Here, which raises awareness of how everyday actions impact waterways in the Puget Sound region. Building public awareness can create a social environment that supports change, but may have limited reach when used to influence specific behaviors and actions (Puget Sound Partnership 2015).

For more about the regulatory framework, read the Base Program Analysis (Appendix IIc).

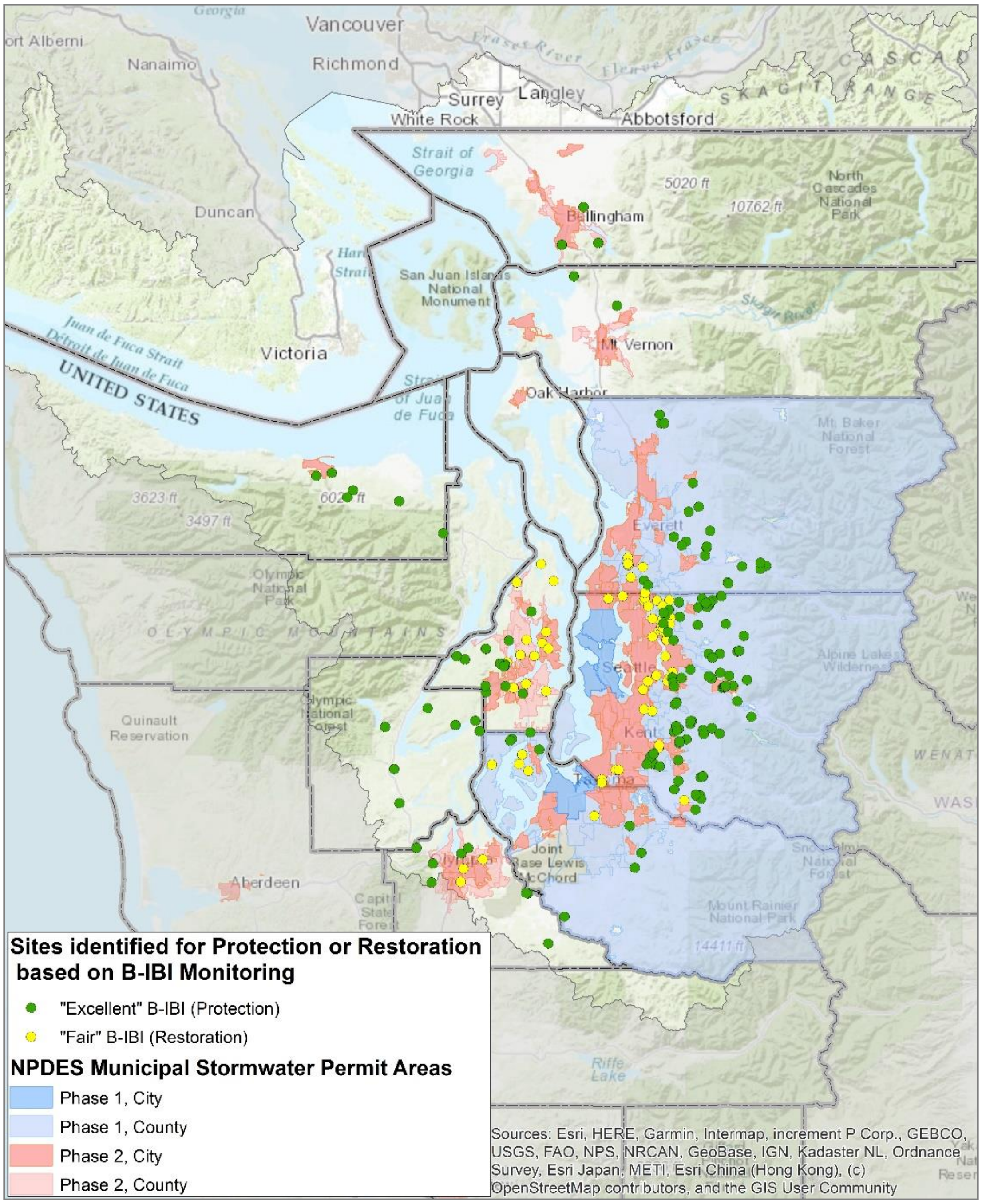

Figure 3-4. Jurisdictions in Puget Sound watershed covered under a Phase I or Phase II NPDES Stormwater Permit and sites identifed as areas for potential restoration or protection based on measures of B-IBI (King County, 2018). Restoration aimed at the "fair" sites may be augmented by ongoing activites under the NPDES stormwater permits, which likely vary for each jurisdiction. Coordination between stormwater control and stream restoration programs is recommended.

Table 3-1. Summary of programs related to the protection and restoration of Puget Sound streams. See also the Base Program Analysis

Program	Implementers and/or funders	Description
Programs providing support to local governments		
Low Impact Development Program	Washington Stormwater Center	Development and evaluation of stormwater technologies
Municipal Resource Program	Washington Stormwater Center	Training and technical assistance for municipalities and businesses
Municipal Research and Services Center	Washington Department of Commerce	Nonprofit that supports local governments by providing legal and policy guidance, training, and online resources
National Estuary Program	U.S. Environmental Protection Agency and Washington State agencies, tribes, and nonprofits	Provides funding and planning support to protect and restore the water quality and ecological integrity of estuaries of national significance
Puget Sound Regional Council	Federal Highway Administration, Federal Transit Administration, U.S. Department of Commerce Economic Development Administration, Washington State Department of Transportation, and 80+ member jurisdictions within King, Pierce, Snohomish, and Kitsap counties	Offers planning services to help ensure local plans are coordinated and meet regional/state requirements, as well as a peer networking series covering best practices and local planning implementation (among many other activities)
Small Communities Initiative Program	Washington Department of Commerce	Provides technical assistance to small, rural communities that must upgrade their drinking water or wastewater systems
Statewide Low Impact Development Training Program	Washington Stormwater Center	Online training and certification program for municipalities and businesses
Stormwater Action Monitoring	90+ Western Washington municipal stormwater permittees and Washington Department of Ecology	Regional collaboration to satisfy monitoring needs under the Western Washington municipal stormwater permits. Funds effectiveness studies, status and trends of receiving water monitoring, and source identification.
Stormwater Capacity Grants Program	Washington Department of Ecology	Non-competitive grants to Phase I and Phase II NPDES municipal permittees to support permit implementation
Stormwater Grants of Regional of Statewide Significance Program	Washington Department of Ecology	Grants that assist with completing projects that benefit multiple Phase I and Phase II NPDES municipal permittees

Program	Implementers and/or funders	Description
Watershed Characterization Technical Assistance Team	Washington Departments of Ecology, Fish and Wildlife, and Commerce, U.S. Environmental Protection Agency	Provides local jurisdictions with guidance interpreting and applying the Puget Sound Watershed Characterization in support of planning processes
Washington Infrastructure Assistance Coordination Council	6 state and 5 federal agencies, plus 15 associations/boards/non-profits	Provides technical and financial assistance to local governments and tribes
Programs providing financial assistance for water quality protection and improvement projects		
Brownfields Grants	U.S. Environmental Protection Agency	Provides grants for cleanup, investigations, and studies related to contaminated sites, as well as training for affected communities
Centennial Clean Water Grants	Washington Department of Ecology, U.S. Environmental Protection Agency	Grants for nonpoint activities, on-site sewage systems, and wastewater facilities for hardship-eligible small communities
Clean Water State Revolving Fund	Washington Department of Ecology, U.S. Environmental Protection Agency	Provides low-interest loans for wastewater facilities, on-site sewage systems, some stormwater facilities, and nonpoint source pollution reduction activities
Clean Water Act Section 319 Grants	Washington Department of Ecology, U.S. Environmental Protection Agency	Grants for nonpoint source pollution control activities
Community Development Block Grant General Purpose Grants	Washington Department of Commerce, U.S. Department of Housing and Urban Development	Grants for community and economic development projects, including sewer infrastructure design/construction and planning
Local Source Control programs	Washington Department of Ecology and multiple local jurisdictions	Funds staff at local levels to work directly with business owners to reduce pollution through outreach, technical assistance, and financial assistance
Natural Resource Investments Program	Washington State Conservation Commission, 12 local Conservation Districts, U.S. Department of Agriculture	Grants and technical assistance to complete natural resource enhancement projects necessary to improve water quality in non-shellfish areas
Public Works Program	U.S. Department of Commerce Economic Development Administration	Provides grants to communities in economic decline for upgrade of critical infrastructure, including wastewater facilities
Stormwater Financial Assistance	Washington Department of Ecology, U.S. Environmental Protection Agency	Grants to retrofit existing infrastructure with stormwater facilities and activities for stormwater pollution control

Program	Implementers and/or funders	Description
Transportation Enhancement Activities	Federal Highway Administration	Provides funding for non-highway transportation projects. Mitigation of polluted highway runoff and purchase of farmland easements are eligible activities.
Urban Waters Small Grants Program	U.S. Environmental Protection Agency	Grants for activities that improve water quality while advancing community priorities, including education and monitoring
Washington Public Works Board	Washington Department of Commerce	Loans for critical public infrastructure, training for local governments, and state project support staff
Watersheds Small Grants Program	Pierce County with watershed councils and other local organizations	Financial support for projects that improve habitat and water quality in WRIAs 10, 12, and 15
Waterworks Small Grant Program	King County Wastewater Treatment Division	Grants for Green Stormwater Infrastructure; education and community engagement; research and monitoring; stream and river bank restoration
Water and Waste Disposal Loan and Grant Program	U.S. Department of Agriculture Rural Development	Loans and grants to and finance acquisition, construction, or improvement of infrastructure including sewer and stormwater systems
Programs providing financial and/or technical assistance for habitat restoration and acquisition projects		
Conservation Futures Funds	10 Puget Sound counties	Provide funding to acquire, operate, and maintain conservation futures or other rights and interests in real property
Cooperative Watershed Management Grants	King County Flood Control District	Grants for implementation of WRIA 7, 8, 9, and 10 watershed forum/salmon recovery priority restoration projects and monitoring
Family Forest Fish Passage Program	Washington Department of Natural Resources	Provides financial and technical assistance for private forest landowners to remove and replace fish passage barriers
Puget Sound Acquisition and Restoration Fund	Puget Sound Partnership, Salmon Recovery Funding Board	State capital funding for large habitat restoration and acquisition projects. Provides state match for several federal grant programs.
Regional Fisheries Enhancement Groups	Washington Department of Fish and Wildlife, 7 non-profit regional groups	Implement restoration projects and lead community-based stewardship activities

Program	Implementers and/or funders	Description
Salmon Recovery Grants	Washington Recreation and Conservation Office, Salmon Recovery Funding Board, National Oceanographic and Atmospheric Administration	Grants for projects to restore damaged habitat, fix fish migration barriers, and preserve pristine habitat
Washington Wildlife and Recreation Program	Washington Recreation and Conservation Office	Provides funding for a broad range of land protection actions, including park acquisition and development, habitat conservation, and farmland/forestland preservation
Watersheds Small Grants Program	Pierce County with watershed councils and other local organizations	Financial support for projects that improve habitat and water quality in WRIAs 10, 12, and 15
Programs providing education and outreach materials		
12,000 Rain Gardens	Stewardship Partners, Washington Stormwater Center	Provides a clearinghouse for information and resources for rain garden installation in the Puget Sound region
City Habitats Coalition	The Nature Conservancy, Stewardship Partners, Washington Environmental Council, and 80+ affiliate organizations	Cross-sector partnership working to increase nature in cities to improve human wellbeing and ecosystem health. Extensive toolkit of web resources including case studies, how-to guides, finance options, and educational materials.
Dump Smart	Washington Stormwater Center	An education campaign providing fact sheets with best management practices for painters, carpet cleaners, and pressure washers in multiple languages
Puget Sound Starts Here	Puget Sound Partnership, Department of Ecology, U.S. Environmental Protection Agency, 700+ partner organizations	An education campaign to raise awareness about impact of everyday actions on water quality and ways to prevent pollution
Stormwater Outreach for Regional Municipalities (STORM)	Puget Sound Partnership, Department of Ecology, 83 municipal permittees	Regional collaboration to meet outreach requirements under the Western Washington municipal stormwater permits. Provides a platform to share outreach materials and messaging research.
Washington Waters	Washington Department of Ecology	Educational posters and videos on pollution prevention topics including yard care, on-site septic systems, and managing manure

Program	Implementers and/or funders	Description
Programs providing financial and/or technical assistance for working lands		
Agricultural Conservation Easements Program	Natural Resources Conservation Service	Provides financial and technical assistance to help conserve agricultural lands (Agricultural Land Easements Program) and wetlands (Wetlands Reserve Program)
Community Forest Trust Program	Washington Department of Natural Resources, U.S. Forest Service	Provides funding to acquire forests near urban and suburban populations that are at high-risk of conversion to non-forest uses
Conservation Innovation Grants	Natural Resources Conservation Service	Provides grants to stimulate development of innovative conservation approaches or technologies
Conservation Partners Program	National Fish and Wildlife Foundation, National Resources Conservation Service	Grants to support organizations that provide staff and technical assistance to private landowners. Increasing landowner awareness and participation in Farm Bill conservation programs is one goal
Conservation of Private Grazing Land Initiative	Natural Resources Conservation Service	Provides technical assistance for better grazing land management. Reducing soil erosion and improving water conservation are two focus areas
Conservation Reserves Enhancement Program	12 local Conservation Districts, U.S. Department of Agriculture	Provides enrolled participants with annual rental payments and cost-share assistance for removing sensitive lands from production for a contract period of 10-15 years. Operates as a partnership between state and federal governments
Conservation Stewardship Program	Natural Resources Conservation Service	Provides technical assistance and education to landowners about conservation-enhancing practices tailored to specific-site goals
Conservation Technical Assistance Program	Natural Resources Conservation Service	Staff provide technical assistance to landowners, communities, and state agencies to develop resource management plans and support decision-makers
Continuous Conservation Reserve Program	Local Farm Service Agency Centers and U.S. Department of Agriculture	Provides enrolled participants with annual rental payments and cost-share assistance for removing sensitive lands from production for a contract period of 10-15 years

Program	Implementers and/or funders	Description
Current Use tax programs	Multiple Puget Sound counties	Reduces property taxes for private landowners maintain their lands as open space, or working farms and forests in order to lessen the pressures to convert such lands to development
Environmental Quality Incentive Program	Natural Resources Conservation Service	Provides financial and technical support to farmers, ranchers, and forest landowners for implementing conservation practices to improve water quality
Farmland Preservation Grants	Washington Recreation and Conservation Office	Provides funding to cities, counties, non-profit organizations, and the Washington Conservation Commission to buy development rights on farmlands
Forestland Preservation Grants	Washington Recreation and Conservation Office	Provides funding to lease or buy conservation easements on working forests, as well as forest habitat restoration
Forest Legacy Program	Washington Department of Natural Resources, U.S. Forest Service	Provides grants for conservation easements to within working forests. Receives funding from the Land and Water Conservation Fund
Forest Stewardship Program	Washington Department of Natural Resources, U.S. Forest Service	Provides advice and assistance to help family forest owners manage their lands, including development of Forest Stewardship Plans needed to help landowners qualify for financial assistance and current use taxation
Forestry Riparian Easement Program	Washington Department of Natural Resources	Reimburses landowners for the value of the trees they are required to leave to protect fish habitat
Healthy Forests Reserve Program	Natural Resources Conservation Service	Helps landowners restore, enhance and protect forestland resources on private lands through easements and financial assistance
Land and Water Conservation Fund	U.S. Department of Fish and Wildlife, U.S. Forest Service, National Parks Service, Bureau of Land Management	Funds acquisition of land and conservation easements by federal agencies to protect national parks, forests, wildlife refuges, and recreation areas. Also funds 2 state grant programs to support voluntary conservation on private land: Forest Legacy Program and Cooperative Endangered Species Conservation Fund
Natural Resource Investments Program	Washington State Conservation Commission, 12 local Conservation Districts, U.S. Department of Agriculture	Grants and technical assistance to complete natural resource enhancement projects necessary to improve water quality in non-shellfish areas

Program	Implementers and/or funders	Description
Northwest Agricultural Business Center	U.S. Department of Agriculture, Washington Department of Commerce, Washington Department of Agriculture, and other local/foundation sponsors	Provides business training and resources to support farmers in Island, King, San Juan, Skagit, Snohomish and Whatcom counties
Puget Sound Extension Forestry Program	Washington State University Extension	Provides research-based classes and educational resources for owners of forested and wooded properties in a six-county region
Readiness and Environmental Protection Integration Program	U.S. Department of Defense	Funds working lands conservation easements to provide a buffer between military installations and residential/commercial development. Joint Base Lewis-McChord is a "sentinel landscape" given high priority under this program
Regional Conservation Partnership Program	Natural Resources Conservation Service, Alliance for Puget Sound Natural Resources	Provides funding and technical assistance for conservation partners and agricultural producers to plan and implement conservation activities that address natural resource priorities on eligible lands

3.5 Barriers to Progress – Interdisciplinary Team Situation Analysis

A key part of the strategy development process is to identify key pressures, underlying factors that support or maintain those pressures, and barriers to alleviating the pressures and achieving the recovery targets. These were identified by the IDT in early 2017, through a process called a situation analysis (see Open Standards for the Practice of Conservation and Guidelines for Developing an Implementations Strategy (Puget Sound Partnership 2017)). Following the situation analysis, the IDT identified potential intervention points and developed them into strategies.

The situation analysis process initially resulted in three conceptual models focused on legacy development, new development and redevelopment, and working lands. These were the three primary pressures that the IDT selected to focus on to improve stream protection and restoration. Much of the process was initially focused on identifying factors and barriers related to stormwater management. Subsequent stakeholder input indicated that habitat considerations were important in achieving the recovery targets. As a result, the Watershed Planning strategy was developed which includes a strong emphasis on protecting functioning ecosystems and habitat forming processes. In addition, the IDT explicitly expanded the Education and Incentives, and Watershed Planning strategies to ensure they included habitat restoration in addition to stormwater retrofits. The Working Lands strategy originally focused on reducing runoff from working lands; the strategy was expanded to include protecting working lands, and habitat-focused elements to improve B-IBI scores.

Table 3-2, Table 3-3, and Table 3-4 summarize the results of the situation analysis. The tables present key contributing factors, associated barriers, and the resulting strategies developed to address them.

The situation analysis and conceptual models were developed based on an expert elicitation and represent the views and experience of the IDT. They should not be considered as comprehensive representations of the entire stream restoration and protection domains. Rather, these products should be considered a starting point for identifying strategies, approaches, and activities which were more rigorously reviewed and augmented during the Implementation Strategy development process (Appendix IVa).

Table 3-2. Summary of the situation analysis focusing on pressures related to stormwater runoff from new development and redevelopment. The table shows the factors that were identified which support or maintain the pressure, barriers to their mitigation or removal, and strategies to address the barriers.

New Development and Redevelopment – Stormwater Runoff		
Factors	**Barriers**	**Strategy**
• Local codes not consistent • Implementation of regulations not consistent	• Lack of local political will	Local Capacity
• Local jurisdictions do not have stormwater expertise	• Lack of public understanding or concern about stormwater issues • Insufficient funding to hire or train staff	
• Lack of maintenance • Lack of enforcement • Lack of understanding in private sector	• Lack of training and/or technical support • Insufficient staffing • Insufficient funding	
• Assumption that site-scale regulations deal with cumulative impacts • Difficult to replace natural function • Complex systems are treated homogeneously	• Regulations are one size fits all • Effectiveness of regulations is unknown • Regulations are outdated	Watershed Planning
• Lack of understanding of effectiveness of BMPs • Monitoring not integrated across landscapes and biological metrics	• Funding for monitoring, evaluation, and synthesis is not available	
• Not all areas are covered by stormwater regulations	• Lack of political will • Lack of capacity for enforcement and oversight	
• Lack of planning at watershed-scale	• Cross-jurisdictional planning is difficult • Lack of incentives for cross-jurisdictional planning	

Table 3-3. Summary of the situation analysis focusing on pressures related to stormwater runoff from legacy development. The table shows the factors that were identified which support or maintain the pressure, barriers to their mitigation or removal, and strategies to address the barriers.

<table>
<tr><th colspan="3">Legacy Development</th></tr>
<tr><th>Factors</th><th>Barriers</th><th>Strategy</th></tr>
<tr><td>• People don't change behavior because they don't understand how it affects them and the broader community
• No recognition that nominal changes can make a big difference
• Harmful products (e.g., pesticides) are inexpensive and readily available</td><td>• Lack of understanding of stormwater impacts</td><td rowspan="4">Education and Incentives</td></tr>
<tr><td>• Impact fees not enough to induce behavior change
• Legacy areas are complex (other infrastructure is in place)
• Retrofit construction risks exposing other problems</td><td>• High costs of stormwater infrastructure</td></tr>
<tr><td>• Education and messaging do not result in behavior change</td><td>• Lack of understanding of effectiveness of education</td></tr>
<tr><td>• Infill is more expensive
• Infill land may include contaminant liability
• No incentive funding to meet regulatory requirements</td><td>• Lack of incentive to redevelop or retrofit</td></tr>
</table>

Table 3-4. Summary of the situation analysis focusing on pressures related to stormwater runoff from working lands. The table shows the factors that were identified which support or maintain the pressure, barriers to their mitigation or removal, and strategies to address the barriers.

<table>
<tr><th colspan="3">Working Lands</th></tr>
<tr><th>Factors</th><th>Barriers</th><th>Strategy</th></tr>
<tr><td>• Economics, and uncertainty
• Lack of technical assistance
• Lack of incentives to implement BMPs
• Buffers reduce productive areas
• Short rotation forestry increases profits</td><td>• Costs</td><td rowspan="3">Working Lands</td></tr>
<tr><td>• Installation of BMPs, buffers, and protections is voluntary
• BMPs require (many) individual permits
• Grandfathered exemptions
• Regulations are driven by political compromise
• Forestry roads are not regulated</td><td>• Lack of regulations or regulatory disincentives</td></tr>
<tr><td>• Conversion of working lands</td><td>• Regulations not protective enough
• Economic incentives lead to development</td></tr>
</table>

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4 Regional Recovery Strategies

The intent of this Implementation Strategy is to identify approaches and actions to accelerate attainment of the B-IBI indicator targets. Making progress towards the targets is expected to help protect and restore freshwater quality by preventing or reducing stormwater impacts (degradation of hydrology, water quality, and habitat) while protecting and improving habitat (riparian, in-stream, and wetlands). These strategies do not attempt to mitigate effects of climate change, or overcome the natural condition of a given site, like underlying geology.

The IDT and Core Team developed four strategies based on facilitated discussions of the IDT meetings, as well as the input from technical, partner, and working lands workshops. Expert elicitation is a key tenet of the Implementation Strategy development process. Due to the nature of the process (i.e., a series of in-person meetings) there is limited ability to add depth and rigor during the elicitation. The Core Team evaluated the recommendations and outputs based on a review of reports and the published literature, and recommended edits and adjustment to strategy elements. All such edits and adjustments were presented to the IDT for final approval prior to finalizing the strategies.

The four strategies are:

1. **Local Stormwater Management Capacity Strategy**: Improve funding, staff capacity, and availability of decision support tools for local stormwater management programs (Section 4.1).
2. **Watershed Planning Strategy:** Promote multi-program and cross-jurisdictional planning for water resource protection and restoration coordinated on a basin scale (Section 4.2).
3. **Education and Incentives Strategy**: Accelerate pollution prevention (e.g., source control activities, etc.), stormwater retrofits and habitat restoration efforts with education and incentives (Section 4.3).
4. **Working Lands Strategy (Draft)**: Reduce impacts of working lands on stream health and the risk of conversion of working lands to more intensive land uses (Section 4.4).

Each section includes detail on recommended actions, geographic focus areas, and potential policy changes. The relationship among the strategies is described in Section 4.4.5, and the alignment of the Freshwater Quality/B-IBI strategies with other Implementation Strategies is described in Section 4.6.

Additional details are included in the following appendices:

- Results Chains**:** Graphic depictions of the sequence of outcomes of the strategy implementation, and assumed progress towards the indicator target (Appendix Ib).
- Ongoing Programs: A mechanism to operationalize these strategies. Relevant programs are reviewed in the Base Program Analysis. (Appendix IIc).
- Process to Develop the Strategies: A complete description of the strategy development process, including strategy prioritization (Appendix IVa).

There are three additional considerations on the focus areas of the strategies. First, the B-IBI targets focus on “fair” and “excellent” basins so strategies focus mainly on those. However, the IDT recommended the inclusion of “good” streams within the strategies as well because they are biologically relevant and merit consideration for the investment of resources.

Second, not all strategies are applicable in all watersheds. There is value in highlighting areas where they are appropriate and clustered.

And third, there is value in implementing strategies in areas where data exists to optimize effectiveness monitoring. While there are alternative assessment tools that can be used to identify protection and restoration sites (see Section 2.6.2), the IDT strongly recommended either focusing on a site with existing data or collecting data prior to implementation of restoration or protection activities. This will help understand what is (and is not) working to improve B-IBI scores and stream condition.

4.1 Local Stormwater Management Capacity Strategy (Local Capacity)

The objective of this strategy is to improve funding, staff capacity, and availability of decision support tools for local stormwater management programs.

4.1.1 Rationale

Many stormwater programs are underfunded, and jurisdictions lack the capacity, in terms of personnel and/or expertise to implement stormwater management programs. This lack of capacity is limiting our ability to address the impacts of stormwater on a regional scale.

4.1.2 Strategy Elements

Three priority approaches were selected under this strategy:

1. Stormwater program funding**:** build political support to increase funding for stormwater investments.
2. Staffing resources**:** increase staff and/or provide external support.
3. Management tools and information resources: increase availability, training, and accessibility.

4.1.2.1 Stormwater Program Funding

The primary outcome under the Local Capacity Strategy is increased investment in stormwater management, including capital facilities projects (e.g., retrofits), particularly in jurisdictions where stormwater management is limited by funding. This can apply at both state and local levels. Most jurisdictions in the Puget Sound watershed have stormwater utility fees, particularly those under the Phase I or Phase II NPDES Stormwater permits. However, it is not clear that the levels are sufficient to make a meaningful impact in stormwater management (a more detailed presentation on stormwater utility fees is in the Base Program Analysis report).

Among all public works programs in Washington State, stormwater programs had the largest reported funding gap (Visitacion et al. 2009). State funding is available through many mechanisms but it is often difficult for stormwater programs to compete with other higher profile programs such as roads and schools. Furthermore, constituents are often more aware of other issues such as drinking water or wastewater treatment. This tends to leave local stormwater management programs underfunded.

The current deficit of political will is likely caused by a lack of understanding of the benefits, or cost avoidance, of stormwater management (Visitacion et al. 2009). Therefore, the IDT identified upstream social marketing[1] as the framework to be used to encourage action on stormwater issues (e.g., Wilbur (2006), and references therein). Social marketing will help develop and deliver meaningful messages about the need for, and value of stormwater management to elected officials, decision makers, and the public so that they make more funding available for local programs. The resulting increases in funding will improve local stormwater management capacity by augmenting staffing resources, enhancing information resources, and increasing capital funding.

4.1.2.2 Staffing Resources

Lack of stormwater expertise, either in the number of staff and/or levels of training, especially in smaller jurisdictions, was identified as a barrier to progress.

The IDT recommend increasing capacity in jurisdictions with limited resources in several ways including: hiring additional stormwater management staff, providing access to externally supported staff, and providing technical support. Increased staff resources will improve intra- and inter-jurisdictional coordination, improve planning, help apply for grants, and enable increased inspections, enforcement, maintenance, and monitoring.

In some jurisdictions, it may not be possible or desirable to hire additional staff, so external support could be provided through existing programs. An example is the USDA Circuit Rider program, which provides technical assistance to rural water systems for water/wastewater management. It is implemented in Washington by the Evergreen Rural Water of Washington program. Increasing training and continued education is another way to address barriers related to technical expertise.

4.1.2.3 Stormwater Management Tools and Information Resources

There are a range of technical resources and tools that can facilitate and improve stormwater management. These tools and resources can also help otherwise modest stormwater investments go further. These include mapping of local stormwater features and infrastructure, hydrologic modeling tools for the design of stormwater treatment infrastructure elements and LID, and information such as cost and effectiveness. The IDT decided that making such information resources more readily available, and providing training on their appropriate use and interpretation, would improve overall management capacity. As for all of the approaches described in this section, the recommendations here are targeted towards the smaller jurisdictions that lack the capacity (in terms of available staff) and/or expertise (in terms of experience or training) to effectively implement stormwater management programs.

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[1] Social marketing applies traditional marketing principles to influence behavior change in target audiences. This approach differs from traditional community outreach and education programs in that it focuses on identifying and addressing specific barriers to action (Puget Sound Partnership 2015). Formative research is a key element of social marketing. Once barriers to and motivators for desired actions are known, targeted messages and/or incentive tools can be applied to achieve specific behavior changes. Social marketing is a rigorous, evidence-based approach that has been used for decades to improve public health. "Upstream" social marketing targets decision makers and influential peripherals to affect policies, legislative agendas, and/or budget allocations. "Downstream" social marketing targets individuals to affect specific behaviors.

4.1.3 Proposed Actions

The priority action under this strategy is the development of an upstream social marketing campaign to influence budget allocations for local stormwater management programs. This will entail research to identify barriers and motivators for increasing funding, determining target audiences, developing compelling messages, and identifying effective delivery channels.

Since it will take time to implement this work and secure additional program funding, interim actions to boost local capacity in the short-term could include:

- Expand the Washington State Department of Commerce Small Communities Initiative (SCI) to provide external support to small jurisdictions. The SCI supports small communities, which may lack administrative, technical, or financial capacity to meet health and environmental mandates.
- Develop regional technical support/planning teams to provide external support to small jurisdictions. Relevant examples include the USDA Circuit Rider program, which provides a roving team of water/wastewater related technical experts to rural communities.
- Encourage sharing of stormwater program elements among neighboring jurisdictions via inter-local agreements or joint utility services authority.
- Support information sharing and collaboration through annual stormwater management workshops for jurisdictions and stormwater practitioners and/or support attendance at conferences such as Northwest Environmental Business Council (NEBC) Managing Stormwater in Washington Conference, Water Environment Federation's Technical Exhibition and Conference (WEFTEC) or the Washington State Stormwater Center's Washington State Municipal Stormwater Conference (MuniCon).
- Increase state funding to local programs through Department of Ecology Capacity Grants.

Other actions identified by IDT participants in support of this strategy include:

- Track cost/benefit data to demonstrate the effectiveness of stormwater investments. Topics of particular interest to IDT participants included: LID life-cycle costs, facility maintenance requirements, costs related to damage due to lack of stormwater management, and who pays/who benefits. There are some studies evaluating the cost effectiveness of individual installations, or which compare different installations under specific treatment scenarios (Chui et al. 2016, Osouli et al. 2017, Nordman et al. 2018); these are summarized in the State of Knowledge Report (Appendix IIb).
- Conduct economic analyses to quantify environmental, social, and economic benefits of stormwater management, especially as they relate to flood risk management, climate resiliency, and parks/open spaces. There are limited studies that provide a holistic evaluation of costs and benefits of stormwater management (e.g., Visitacion et al. (2009)); a review is provided in the State of Knowledge Report (Appendix IIb).
- Develop regional data standards and portals for reporting so that reliable, consistent, and comparable data are available for implementation tracking and cost-benefit evaluations. Existing tools that could serve as models or be developed further include:
  - Sound Impacts tracking tool (beta version): Stewardship Partners has developed a tracking tool that maps and provides information on implemented Green Stormwater Infrastructure projects (type, completion date, square footage, gallons of runoff managed), as well as the cumulative impact (in gallons managed).

- BMP Map Tool: The Tahoe Regional Planning Agency Stormwater Management Program has developed a BMP Map Tool that tracks implementation and maintenance certificate status by catchment.

- Improve modeling capabilities and stormwater tools to support local stormwater investment decisions. This includes tools for small project developers to encourage the performance standard approach under the Stormwater Management Manual for Western Washington (SWMMWW). Examples of available resources include:
  - Western Washington Hydraulic Model (WWHM): this model was developed and updated to help stormwater managers and designers to design and size stormwater control facilities to mitigate stormwater effects. It includes LID related elements.
  - The Kitsap BMP Sizing Calculator: A spreadsheet tool developed by Herrera Environmental Consultants that provides information for selecting and sizing stormwater BMPs.
  - Stormwater Planning Tool (beta version): The Nature Conservancy and Geosyntec Consultants have developed a beta Stormwater Planning Tool for the Puget Sound region. This produces pollutant loading heat maps to estimate contributions of nine common urban stormwater pollutants at a parcel scale. Land use and imperviousness data are used to calculate average annual pollutant loadings. These data are then coupled with a multi-criteria decision analysis module that incorporates proximity to fish-bearing streams, 303(d) listings, BMP performance, and other factors to identify optimal locations for stormwater investments.
  - Tree Canopy Planner Tool: Developed by King Conservation District, this tool helps cities analyze existing urban tree canopy and identify space available for planting. An online map includes a tool that can be used to visualize different community priorities, including stormwater management.
  - BMP Screening Tool: The Interstate Technology and Regulatory Council (ITRC) has developed a tool to serve as a guidance for BMP screening, selection, installation, operation, and monitoring and maintenance. It provides information on strengths and weaknesses of specific BMPs and some indication of potential performance.

- Develop asset management[2] tools to support local jurisdictions in managing stormwater system infrastructure as well as natural resources.[3]
  - Rapid assessment methodologies: The Tahoe Regional Planning Agency Stormwater Management Program has developed methodologies to help local jurisdictions determine relative condition of stormwater controls and prioritize/evaluate maintenance activities.

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[2] Asset management methods can be applied to physical infrastructure and ecosystem services. Asset management involves maintaining systematic records of assets; defining a standard of service expected; developing a defined program for sustaining the assets through planned maintenance, repair, and replacement; then implementing and managing information systems to support the program (e.g. IDDE Admin via asset management software).

[3] A natural resources asset management framework includes the following: 1) inventory natural assets 2) establish levels of ecosystem services provided by natural assets 3) quantify likelihood and consequence of natural asset degradation, 4) identify critical natural assets, 5) optimize interventions necessary to maintain natural assets, and 6) establish a long-term funding strategy. Asset management can feed executive-level decision support tools.

- Causal Analysis-Diagnosis Decision Information System (CADDIS): The CADDIS approach to causal inference involves comparison of alternate candidate causes. These causes are evaluated to determine which is best supported by the totality of evidence. The causal assessment process used in CADDIS is derived from the Stressor Identification Guidance document. The method weighs all relevant evidence to identify the most likely cause or causes of undesirable biological effects.

- Encourage education programs to shift focus from downstream behaviors to upstream considerations to build awareness within the public, decision makers, and policy makers for funding stormwater programs and projects.
  - The Puget Sound Stormwater Messaging Project provided audience-tested framing and messaging recommendations; photos and line drawings of stormwater concepts and pathways; and a toolkit with fact sheets, slide decks, and other materials. Materials are available at https://pugetsoundstormgroup.org/.

4.1.4 Strategy Geography

The focus areas for this strategy are those locations where the lack of funding resources or capacity are limiting the extent or quality of stormwater management. A proposed metric for this would be the value of stormwater utility fees. While the existence or amount of the fees does not provide information on their sufficiency, it may be reasonable to equate a lack of such fees with an overall lack of sufficient funding and, therefore, capacity to implement stormwater programs. Regional information on stormwater utility fees is presented in the State of Knowledge Report. (Appendix IIb).

4.1.5 Policy Changes

Policy changes that could support progress along priority recovery pathways include:

- Encourage jurisdictions to restructure and/or implement stormwater utility and/or development impact fees. The IDT indicated that stormwater fee structures may not capture the single-family residential land base adequately (i.e., they may be underpaying for stormwater programs). Stormwater utility fees can be an efficient and sustainable source of revenue to support long-term planning and implementation of stormwater management programs, though they are often viewed as politically unfavorable (Zhao et al. 2019).
- Develop a comprehensive funding strategy to pay for restoration and protection actions led by a regional or state organization, including the establishment of appropriate institutional arrangements and capacity (King County 2015b).
- Encourage jurisdictions to consider using alternative financing options and/or procurement methods such as environmental impact bonds and public private partnerships.
- Incentivize all Puget Sound jurisdictions to utilize LID and establish stormwater utilities.

4.2 Watershed Based Protection and Restoration Strategy (Watershed Planning)

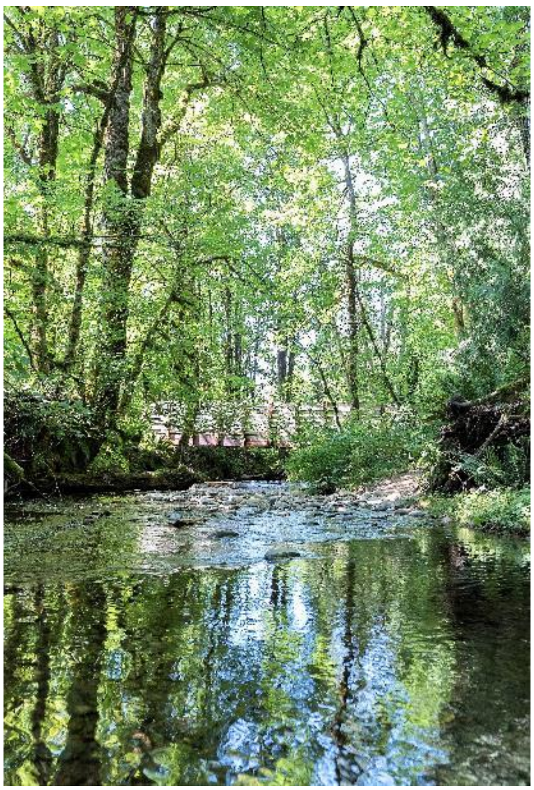
The objective of this strategy is to promote multi-program and cross-jurisdictional planning on a coordinated watershed-scale to maximize synergistic outcomes.

4.2.1 Rationale

Stream conditions are affected by local-to-watershed-scale pressures. The overall watershed condition may limit the extent of recovery from local restoration or mitigation activities (Bernhardt and Palmer 2011, Wahl 2012, Stoll et al. 2016). Watershed condition can overwhelm the benefits of localized restoration, or obscure the impacts of localized degradation. As such, the condition of the entire watershed needs to be considered in restoration and protection activity planning to maximize benefits and set expectations. Planning can focus restoration where it is most useful and focus growth where it is least harmful.

4.2.2 Strategy Elements

The watershed planning process should increase the understanding of the watershed and the risks to receiving waters, and sustain planning capacity and processes within jurisdictions for informed, methodical, and integrated decision making.



There are five priority approaches to meet the strategy objective:

1. Enabling conditions: encourage collaboration with neighboring jurisdictions, and between departments within the same jurisdiction, to restore and protect watershed function and habitat (i.e., remove inter- and intra-agency barriers that make it difficult to work together).

2. Planning for protection: improve the capacity for developing plans that focus on the retention of high value habitats and catchments with "excellent" stream condition.

3. Planning for restoration: improve the capacity for developing plans that focus on restoration and mitigation in catchments in "fair" condition.

4. Implementation: plans and projects should be supported with strong political will so they are more likely to be successfully implemented.

5. Monitoring and evaluation: provides information on how to improve B-IBI scores in any given watershed.

There are specific, recommended approaches and actions within these elements that would most likely improve the effectiveness of planning at a watershed-scale, as described in the following sections.

4.2.2.1 Enabling Conditions

Enabling conditions address the motivation to undertake planning, the structural barriers which might inhibit cross-programmatic and cross-jurisdictional planning, and the information and incentives which form the basis of the planning activities. Once enabling conditions are established in a jurisdiction, we expect an increased likelihood that jurisdictions will plan protection and restoration interventions on a watershed scale.

Motivators refer to the primary reasons that a jurisdiction engages in the planning process. External motivators are those which originate from outside a jurisdiction. Examples of external motivators for watershed scale planning include NPDES permit requirements, and the integration of stormwater and GMA planning requirements. Exploring the development and adoption of more holistic regulatory motivators, which may help comprehensively address watershed stressors, might prove to be a valuable long-term recovery approach.

Information requirements include data on current and future conditions, as well as an understanding of the biological responses to development and restoration activities – the latter is an acknowledged gap and research priority. Incentives that could encourage jurisdictions to engage in coordinated planning include direct financial and/or staff support from regional entities.

4.2.2.2 Planning for Protection

Planning for protection focuses on retaining the conditions in catchments with “excellent” stream health (high B-IBI scores), though it is important to include “good” basins in the protection planning process. It generally requires maintaining existing land cover or mitigating the effects of changes in land use as they occur.

Existing land cover could be maintained through regulatory development restrictions, property or conservation easement acquisitions, or transfer of development rights programs. The effects of development and redevelopment on stream hydrology could be reduced through implementation of stormwater BMPs intended to reduce effective impervious surface. Considering the regional development pressures, it is unlikely that excellent conditions will be maintained without such efforts.

Key concepts for protection planning include:

- Jurisdictions should set clear protection goals.
- Jurisdictions should adopt growth management strategies that are consistent with ecosystem needs (including stream health). For example, Cappiella et al. (2006) suggest eleven key principles for protecting sensitive areas through watershed planning[4]. These principles are valid for stream protection as well.
- Protection planning should proceed from the watershed to the site scale, and apply across jurisdictions when watershed boundaries cross jurisdictional lines.
- New and redevelopment impacts should be mitigated either on-site, preferably with LID and green stormwater infrastructure approaches, or in areas of a watershed where they might achieve the greatest environmental benefit.

4.2.2.3 Planning for Restoration

The B-IBI restoration target focuses on “fair” basins. Restoration planning should address projects and programs that lead to water quality, hydrologic, and habitat improvements, which are thought to be the best ways to improve “fair” B-IBI scores, though the data for such outcomes is limited (King County 2015).

Specific restoration activities that may improve stream conditions include:

- In-stream restoration: add wood, add substrate, enhance sinuosity, replace culverts, and stabilize stream banks.

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[4] Cappiella et al. (2006) provide eleven key principles for protecting sensitive areas through watershed planning: compile information on a watershed basis, assess local protection capacity, identify partners and roles, define goals and objectives for the watershed, create an inventory of critical areas in the watershed, screen critical areas for further assessment, evaluate critical areas in the field, adapt watershed tools to protect critical areas, prioritize critical area recommendations, coordinate implementation, and monitor progress.

- Riparian restoration: stabilize slopes, plant vegetation, remove invasive species, and establish and extend buffers.
- Stormwater BMPs: BMPs are implemented to restore the natural hydrology and reduce contaminant and/or nutrient inputs. This can be achieved through retrofits for flow control and/or treatment, the use of Green Stormwater Infrastructure, maintenance of existing stormwater infrastructure, street sweeping in areas with high-traffic roads, and source control.

The IDT identified several key concepts which are important in restoration planning:

- Restoration planning should proceed from the watershed to the site-scale. Coordination of investments on a basin-scale is expected to maximize overall benefits.
- Costs and benefits should be incorporated into the planning process to help identify the most impactful investments.
- The limits of restoration should be recognized in a given watershed; it may not be possible to completely restore a stream to "excellent" condition in a developed watershed. The overall watershed condition can reduce the effectiveness of restoration activities and limit the practical outcomes (Kail and Hering 2009, Bernhardt and Palmer 2011, Wahl 2012, Leps et al. 2016, Stoll et al. 2016). As such, there is likely a point of diminishing returns where additional restoration investments will not result in improved stream quality (or improved B-IBI scores). Thus, the maximum extent of practical restoration should be taken into account in the planning process.
- The tiered aquatic life use (TALU) framework should be utilized in goal setting. The TALU framework sets protective goals for high-quality water resources and allows for the development of reasonable and attainable goals for modified water resources, such as channelized streams and ditches (Davies and Jackson 2006, Bouchard et al. 2016). It is not be possible to restore all streams to pre-development conditions.

4.2.2.4 Implementation

Plans and projects must be implemented to achieve protection and restoration goals. Lack of political will was identified as a barrier to plan implementation since funding and local support are necessary for watershed planning and implementation.

4.2.2.5 Monitoring and Evaluation

Monitoring and evaluation for both protection and restoration were identified as key priorities under this strategy. This acknowledges a key uncertainty under the B-IBI Implementation Strategy- that there is limited information on how to improve B-IBI scores in any given watershed (King County 2015). As such, there should be a clear and deliberate focus on improving our understanding of the effectiveness of not only restoration projects on measures of stream health, but also on the regulations and other management activities that are meant to protect (or mitigate impacts to) high-quality catchments.

For this strategy to be successful, jurisdictions must incorporate data collection, evaluation, synthesis, and lessons learned into future watershed planning.

4.2.3 Proposed Actions

The priority actions to support watershed planning are research, monitoring, and synthesis of activities related to watershed recovery.

Proper planning should be based on a solid understanding of the effectiveness of proposed actions with regard to B-IBI and stream health. We currently have limited understanding of these relationships. In order to improve our understanding, it is essential to continue to synthesize results from ongoing research and monitoring that address aspects of stream recovery. Examples include:

- The Stormwater Action Monitoring (SAM) program. The Western Washington municipal stormwater permits monitoring program conducts Puget Sound area stream health monitoring and effectiveness studies of stormwater control measures.
- Incorporate lessons from previously funded EPA National Estuary Program investments into planning activities. Several previous projects are applicable to planning efforts related to habitat protection, stormwater management, and development patterns. For example:
    - The Washington State Department of Commerce's Building Cities in the Rain, guidance on watershed prioritization for stormwater retrofits and stormwater control transfer is relevant. Similarly, the Puget Sound Regional Council Building Green Cities provides resources for promoting LID.
    - The Washington State Department of Fish and Wildlife has produced two documents addressing riparian ecosystems. Volume 1 is a science synthesis with management implications. Volume 2 provides management recommendations.
- Continue ongoing stream monitoring programs at the county, regional, and state level.

An additional priority for the Watershed Planning Strategy is to integrate land use and water quality protection planning. This would require policy changes (Section 4.2.5), but interim actions that could support this priority include:

- Identify and address barriers to more widespread adoption and use of market-based approaches such as:
    - Stormwater Control Transfer Programs (SCTP), in which participants can satisfy regulatory or permit requirements for flow control by directing efforts to watersheds within a jurisdiction where new construction or redevelopment are not taking place. For example, according to Appendix I.E of the 2019 SWMMWW, Phase I and Western Washington Phase II Municipal Stormwater Permittees can implement an SCTP to satisfy flow control permit requirements triggered at new and redevelopment project sites. Out-of-basin transfers may be granted with Ecology approval.
    - Transfer of Development Rights (TDR) programs, which aim to conserve farms, forests, and open space by transferring the development rights from the land intended to be conserved to more urbanized area in return for compensation and incentives. The Transfer of Development Rights Alliance works to encourage TDR programs in King, Pierce, Snohomish, and Kitsap counties.
- Identify watershed conservation priorities by making additional funding available for acquisition of property and/or conservation easements. An example is the King County Land Conservation Initiative, which has identified and prioritized 65,000 acres of critical natural lands and green spaces for conservation in King County, and uses bond funding to accelerate the acquisition schedule.
- Encourage the formation of watershed councils (i.e., watershed protection/restoration coordination districts) to generate funding for plan/project implementation and to promote watershed-scale planning exercises and collaboration across jurisdictions.
- Encourage the use of inter-local agreements for watershed planning and project implementation across jurisdictional boundaries. Several examples exist, including WRIA 9 Inter-Local Agreement

between WRIA 9 and King County, and the Snoqualmie and South Fork Skykomish Watersheds Agreement.

- Conduct financial gap analyses during watershed planning. Estimating the cost of stormwater infrastructure required to maintain stream health, and then comparing those costs to available funding could help decision makers recognize that protecting stream health via land use planning is more cost-effective than restoring degraded conditions.

4.2.4 Strategy Geography

The Vital Sign target for B-IBI focuses recovery actions on catchments that are characterized as "fair" or "excellent" based on B-IBI scores. King County (2015) developed a methodology for identifying priority basins based on extent and availability of monitoring data, potential biological value, an engaged stakeholder group, potential access to property, etc. Planning activities should focus on priority catchments, since there are existing data for characterization of status, trends, and responses. Additional consideration for basin selection includes jurisdictional boundaries and the overall watershed condition. Catchments that occur in more than one jurisdiction would require cross-jurisdictional coordination. Overall watershed condition should be used to estimate potential for recovery (Section 3.3) and to guide planning. To fully and effectively implement this strategy, the selected geography should include areas to concentrate development (i.e., near "very poor" and "poor" streams or segments), areas to target restoration (i.e., "fair" streams or segments) and areas designated for protection (i.e., "excellent" streams or segments).

4.2.5 Policy Changes

The IDT identified opportunities where policy changes and/or increased coordination between existing policy elements could result in improved protection and restoration. We acknowledge that some of these policy recommendations would entail major effort to develop and implement. Potential approaches include:

- Integrate watershed planning into Growth Management Act planning requirements. Approaches could include:
    - Require jurisdictions to consider long-range stormwater planning in comprehensive plans prepared pursuant to the Growth Management Act.
    - Require state approval of local comprehensive plans to ensure that adequate protection and restoration are included which address stream health.
- Update zoning requirements to maintain protections in high functioning watersheds.

4.3 Encourage Retrofits and Restoration through Education and Incentives (Education and Incentives)

The objective of this strategy is to encourage stormwater retrofits, pollutant source-control activities, and habitat restoration efforts on privately owned legacy properties[5].

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[5] Legacy properties are those that have already been developed and currently have houses, buildings, etc. A substantial portion of legacy development occurred without stormwater controls.

4.3.1 Rationale

Many existing developments were built without stormwater controls and there are few regulatory mechanisms that address stormwater runoff from legacy development areas. The redevelopment of a property generally triggers retrofit requirements that address stormwater runoff. However, the rate of mitigation through this mechanism is slow and stormwater retrofits are generally not required on private properties with existing structures that are not undergoing development or redevelopment. The rate of stormwater retrofit and habitat restoration work on private lands could be improved with education and incentive programs that address key barriers.

Retrofits, including LID and/or Green Stormwater Infrastructure designs, will reduce the effective imperviousness of a given watershed and lead to reduced impacts and improved stream health.

4.3.2 Strategy Elements

As illustrated by the Results Chains (see appendix) the IDT selected separate approaches for restoration target addressing “fair” streams, and the protection target addressing “excellent” streams, though both protection and restoration will likely be appropriate for any given basin.

Two priority approaches to meet the strategy objective are:

1. Increase stormwater retrofits and source control: identify key barriers to the widespread implementation of retrofits, and then use incentives like technical assistance, financial assistance, and/or permitting advantages to address those barriers.
2. Increase the restoration of riparian, in-stream and wetland habitats: leverage opportunities to coordinate and concentrate existing and planned restoration investments for stream enhancements, and provide incentives like technical assistance and financial support.

4.3.2.1 Stormwater Retrofits and Source Control

The retrofit component of this strategy focuses on stimulating actions beyond existing stormwater requirements by first identifying key barriers and motivators, and then providing appropriate incentives to encourage landowners to undertake projects and implement best practices. Opportunities include disconnecting down-spouts from stormwater systems or installing simple infiltration trenches or bioinfiltration facilities (e.g., rain gardens). LID and GSI approaches to retrofits should be encouraged. The suite of local projects will eventually lower the overall effective impervious area from existing developments.

Common barriers to implementing stormwater control projects that are relevant to this education and incentives strategy are (Oregon Sea Grant 2008, UNH Stormwater Center 2011, Sightline Institute 2014, Kim et al. 2017):

- the lack of understanding of the impacts of development and growth;
- lack of leadership/promotion in local governments;
- lack of technical understanding of implementation, both within local government and the public; and,
- concerns about long term function and maintenance requirements.

Under this strategy element, locally important barriers will be identified and then addressed through focused education and incentive campaigns. Potential education programs are:

- presentations on costs and effectiveness of LID approaches to improve their acceptance;

- interactions with community groups and homeowners to improve understanding of stormwater-related environmental impacts; and,
- working with contractors on design and construction elements, perhaps combined with certification.

Incentive programs could be designed to reduce cost of LID construction to homeowners, streamline permitting processes, and/or provide rebates or tax credits. These activities could be encouraged and supported statewide through modification or revisions to future NPDES stormwater permits, and implemented at a local jurisdictional level. To be consistent with the recommendations in the other strategies, education and incentives should be coordinated on the watershed scale.

4.3.2.2 Restoration of Riparian, In-stream, and Wetland Habitats

The restoration strategy focuses on identifying opportunities for incorporating restoration activities in coordination with other infrastructure projects to achieve benefits beyond the original scope. Examples include flood control projects (e.g., the Seattle Thornton Confluence Restoration) or the removal of fish passage barriers (WSDOT fish passage-habitat restoration partnerships) which include aspects of channel and riparian restoration. The strategy aims to identify opportunities for multi-benefit collaborations and then create incentives that will make them more likely to occur.

In addition, this strategy component will encourage conservation districts and regional fishery enhancement groups to include private property owners in the development of and support for restoration activities.

4.3.3 Proposed Actions

The priority actions under this strategy are to identify the barriers to widespread implementation of retrofits and then develop targeted education and incentive programs to address these barriers.

Some barriers may already be well understood based on existing work, such as the Washington State Department of Commerce's Building Green Cities project. It uses a social marketing/economic behaviors approach to research and identify incentives for developers to go beyond municipal stormwater permit requirements in urban centers. Lessons from Building Green Cities (e.g., clearly describe existing incentive programs, highlight successful case studies and expedited permit processes for LID installations, etc.) should be applied outside urban centers, which may provide cost effective opportunities for mitigating and avoiding impacts to high functioning streams. The lessons from Building Green Cities should inform this strategy.

Example education and incentive activities include:

- Expand the implementation of curricula for grades K-12 addressing the impacts of development and stormwater-runoff on ecosystem services and specifically stream conditions. Examples include Axler et al. (2006), Braun et al. (2014), and Rabourn et al. (2018).
- Expand funding and implementation of pollution prevention programs such as Ecology's technical assistance for pollution prevention in businesses focusing on spill prevention, stormwater management, and management of hazardous wastes.
- Expand contractor training for the design and construction of GSI and other stormwater control infrastructure. The IDT identified a lack of trained contractors as a barrier to implementation of LID/GSI projects on private properties. Current training examples include:
    - Washington Stormwater Center LID Training Certificate program.

- King County/Seattle Public Utility RainWise program that provides lists of certified contractors available for limited areas. This could be expanded to cover the entire region.

- Support programs that cover the costs of planting native plants or livestock exclusion fencing to landowners along selected creeks. Examples include:
  - Snohomish Streamside Solutions and other cost-share programs through the Snohomish Conservation District.
  - Washington State Conservation Commission Conservation Reserve Enhancement Program (CREP) supports the restoration and protection of riparian habitat for salmon recovery. Benefits likely apply to benthic communities as well.

Examples of programs, activities, and tools that may support multiple benefits, including B-IBI restoration include:

- The Washington State Department of Transportation Fish Passage Project, which replaces approximately 15 culverts per year throughout the state. Many of these corrections are within the Puget Sound watershed. These projects could be leveraged to include additional habitat restoration to further improve condition.
- The Thornton Creek Confluence project (Seattle Public Utilities), which was primarily designed for flood control, also included extensive habitat rehabilitation. Similarly, salmon habitat restoration such as the Boise-Evans Habitat Restoration (King County) likely results in improved biotic condition.

4.3.4 Strategy Geography

The Education and Incentives Strategy aims to increase the number of stormwater retrofits on properties with existing development to improve the condition of stormwater-impacted streams. As such, programs should focus on streams with "fair" condition, as it is unlikely that a stormwater-impacted stream remains "excellent". The focus area could be basins identified as "fair" with existing data (Figure 2-1) or based on other watershed assessments (Section 3.3). Preference should be given to basins with existing data so that the effectiveness of the activity can be evaluated with historic and ongoing monitoring.

4.3.5 Policy Changes

There is a need for increased and stable sources of funding for stormwater incentive programs. Several existing education and incentive programs in the Puget Sound watershed are underfunded or funded only through short-term grant programs. As such, they are not able to meet demand.

4.4 Working Lands Strategy (Draft)

The objective of this strategy is to reduce the risk of forestry and agricultural areas being converted to more intensive land uses, and to reduce ongoing impacts of working lands on stream health.

4.4.1 Rationale

There is ample evidence that impacts on stream quality are commensurate with the level of development in a given watershed and, in general, impacts increase as land use intensity increases from: working lands → low density residential → high density residential → commercial/industrial (Hall et al. 2001, Moore and Palmer 2005). Therefore, there is benefit in preventing the conversion of working lands, to the extent possible, despite ongoing development pressures. Additionally, activities on working lands affect stream quality, so the implementation of BMPs on working lands can mitigate impacts.

The scope of ecosystem recovery issues associated with working lands extends well beyond the B-IBI Vital Sign and its indicator targets; it also includes estuaries, floodplains, salmonids, etc. The Core Team recommended that future planning efforts relating to working lands be conducted in a cross-cutting manner across different Vital Signs. This suggestion is based on input from the agriculture community, which indicated that a siloed approach to Implementation Strategy development was not efficient and may not lead to the best outcomes. Participants in a September 2017 agricultural workshop had been asked to participate in multiple Implementation Strategy processes (Shellfish, Estuaries, Land Development and Cover, Chinook, B-IBI) which would result in different actions for each.

Utilizing a cross-cutting framework would result in more coordinated implementation of the varied regional recovery plans and strategies that have been developed by different organizations and sectors. It would enable joint consideration of the economic viability and environmental sustainability of working lands. The notion of cross-cutting coordination is explicitly identified in the Land Development and Cover Implementation Strategy. The alignment across recovery strategies is discussed further below.

The following content is intended to capture input received from participants in the B-IBI Implementation Strategy development process and provide a starting point for future work.

4.4.2 Strategy Elements

Three priority approaches to meet the strategy objective are:

1. Decrease conversion risk: support long-term economic and ecosystem sustainability of forestry and agricultural operations and improve local implementation of the Growth Management Act to direct growth away from working lands.
2. Increase incentives and technical assistance: support the development and increased availability of technical assistance and economic incentives to support implementation of Best Management Practices in working lands.
3. Monitoring and Evaluation: focus and expand monitoring and evaluation so that the relationships among stressors, management practices, and B-IBI scores on working lands are better understood.

4.4.2.1 Conversion Risk

The protection element of this strategy is based on the idea that maintaining working lands in their current state is beneficial in preventing the degradation of downstream environmental condition. And while there are impacts from agricultural activities on stream health, the magnitude is often lower than after conversion to residential or commercial land uses (Hall et al. 2001, Moore and Palmer 2005). This generally reflects the relationship between increased impervious surfaces and lower B-IBI scores (May et al. 1997, Morley and Karr 2002, Allan 2004, Booth et al. 2004, Kennen et al. 2010, Fore et al. 2013). Knowing that there was limited participation from agricultural stakeholders in the IDT, the strategy development team held a workshop to solicit agricultural stakeholder feedback. While there are myriad approaches for balancing agricultural production and conservation (e.g., see Fischer et al. (2008) and references therein), participants in the 2017 Implementation Strategy Agricultural Workshop emphasized the importance of ensuring the long-term economic sustainability of working lands to reduce conversion risk.

Several important factors for agricultural viability were identified. First, it is important to preserve an agricultural land base to support agricultural communities. Increased land/community fragmentation makes it more difficult to provide farm support services and reduces value of conservation. Second, it is important to properly value conservation easements to ensure long-term viability of protection and cover opportunity costs lost when such land is taken out of production. Third, heir or succession/transition planning is needed to maintain intergenerational continuity. And fourth, it is important to have a supportive and viable insurance market to mitigate risks. All of these considerations should be evaluated in a more sophisticated analysis of agricultural viability.

This approach aligns with the Land Development and Cover Implementation Strategy (Phase 2 Draft, Feb 2018), which recommended providing regional support to reduce the conversion of working lands. Improving local implementation of the Growth Management Act and directing growth away from working lands via regional infrastructure planning are two key elements of the Land Development and Cover Implementation Strategy that would support B-IBI indicator goals.

4.4.2.2 Best Management Practices Implementation

The restoration element focuses on increasing technical assistance and financial incentives to support implementation of forestry and agricultural BMPs. Many BMPs have been identified for working lands. Examples of forestry BMPs include selective harvest instead of clearcutting, maintaining riparian buffers, road maintenance and/or decommissioning, maintaining culvert passage, and replanting soon after harvest. Agricultural BMPs include fencing along streams to exclude livestock, maintaining riparian buffers, managing livestock waste, managing soil loss, minimizing use of fertilizer and pesticides, and rotating crops.

The IDT generally supported the notion of expanding existing economic incentives and technical assistance programs to increase BMPs on working lands. However, given the wide diversity of working lands (e.g., livestock/crop/hobby farms and private/state/federal forests), the complexity of associated regulatory requirements, and the recommendation to defer the detailed analysis for the development of a cross-cutting agricultural Implementation Strategy, a comprehensive set of recommendations was not developed under this Implementation Strategy.

4.4.2.3 Monitoring and Evaluation

Consistent with other strategies, an improved understanding of the effectiveness of BMPs and mitigation activities on stream condition and B-IBI scores was identified as a key element of the Working Lands Strategy. Currently, there are only a limited number of sites in agricultural or forestry areas where the stream condition and/or B-IBI is regularly monitored. This strategy element will address that gap, focusing specifically on working lands. While some information on the effectiveness of BMPs in working lands exists (see State of Knowledge Report, Appendix IIb), the IDT indicated that further study is needed.

Additional research and monitoring activities are summarized in Section 7.

4.4.3 Proposed Actions

Although the Working Lands Strategy is not fully developed, several actions were identified which would support the key strategy elements.

- Support studies investigating the effectiveness of agricultural and forestry BMPs, such as the Discovery Farms programs overseen by the King Conservation District and Whatcom Conservation District (King Conservation District 2018), and the Natural Resources Conservation Services (NRCS) National Water Quality Initiative in Whatcom County. The Discovery Farms are undertaking research to better understand the effectiveness of riparian systems and manure storage techniques.
- Develop a landscape-level agricultural viability plan to decrease conversion risk. There are many tools and programs addressing agricultural viability in the state and county conservation districts.

For more on agricultural viability, see the memo describing an Agricultural Viability Toolkit from the Washington State Conservation Commission. An example of a viability plan is the Snohomish Sustainable Lands Strategy.

- Support agricultural-focused business incubators like the Northwest Agriculture Business Center and WSU's Bread Lab.

4.4.4 Strategy Geography

The IDT recommended that a separate effort be undertaken to develop a holistic Working Lands Strategy for the Puget Sound region. This strategy would not only address the B-IBI Implementation Strategy, but also Land Development and Cover, Floodplains, Estuaries, etc. To support that effort, a set of map products were developed describing the regional forestry lands (federal, state, private, and tribal, etc.) and agricultural activities (commercial, hobby farms, etc.), along with locations with measured B-IBI scores and estimated B-IBI potential based on hydrologic degradation (Section 2.6).

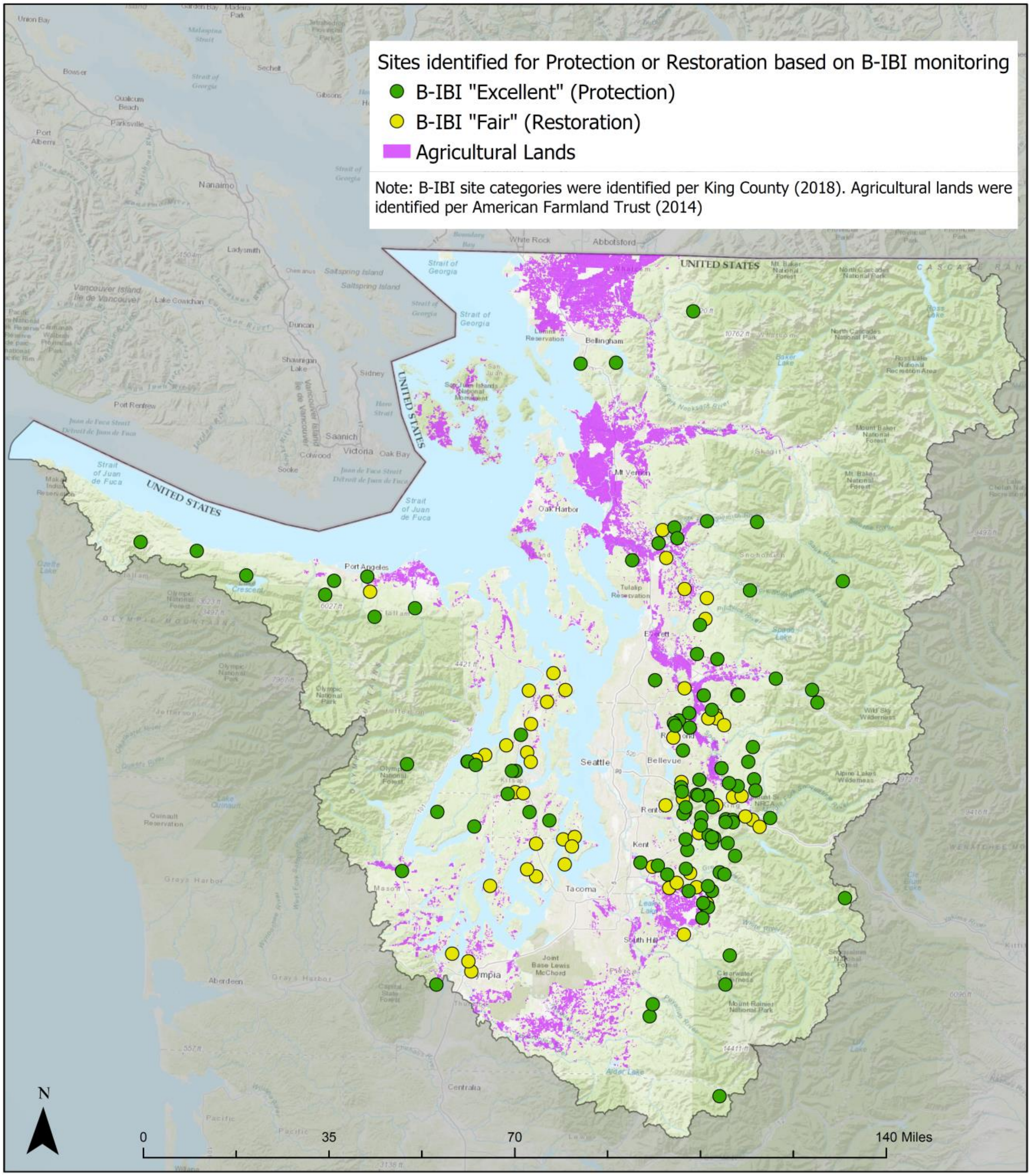

Figure 4-1 shows agriculture areas in the Puget Sound watershed to indicate the overlap of agriculture (commercial and hobby farms) and "excellent" and "fair" B-IBI sample locations. Figure 4-2 shows the ownership categories of forest lands (e.g., state, private, federal, or tribal) in Puget Sound region and "excellent" and "fair" B-IBI sample locations. Each forest type has different management implications.

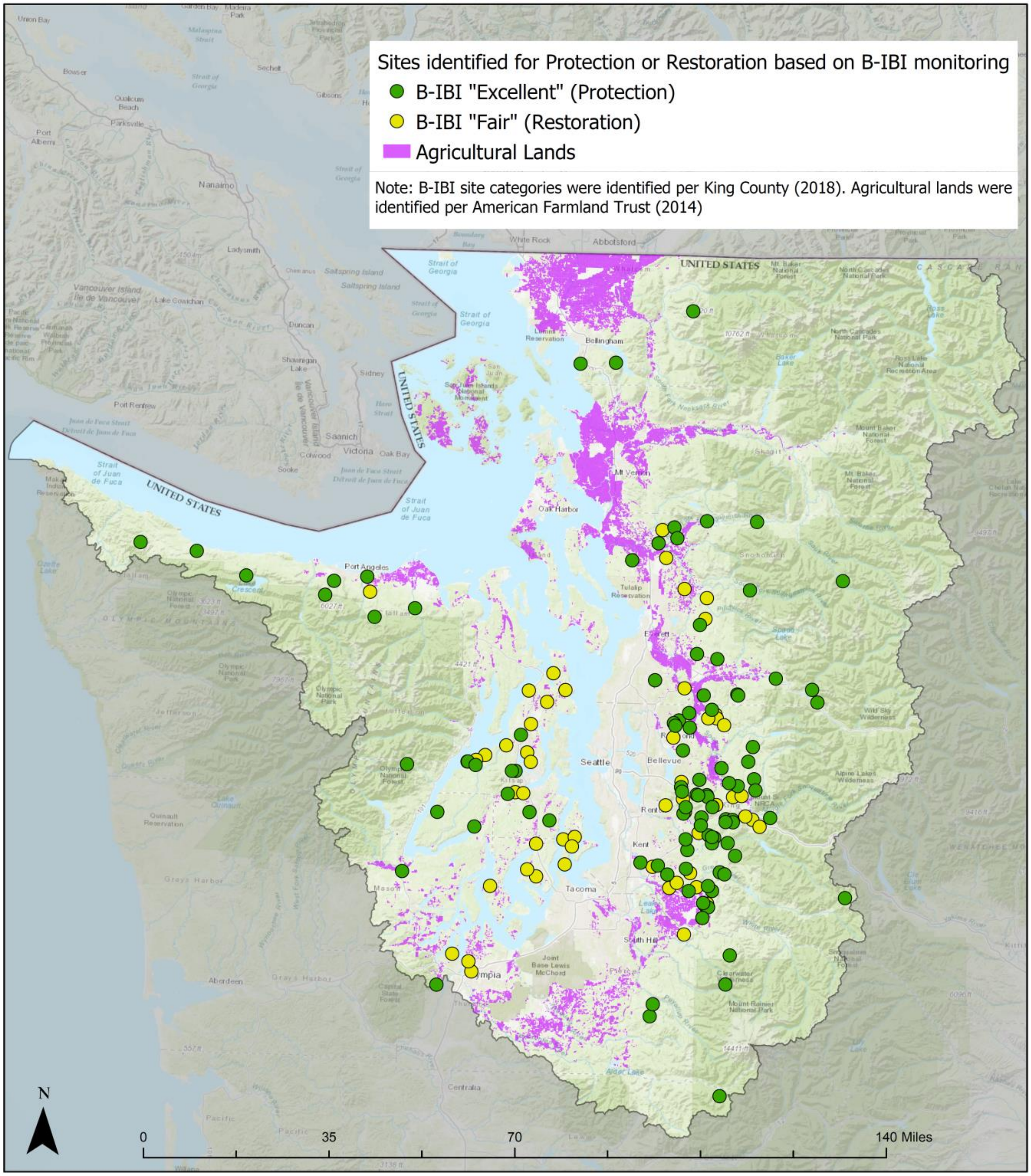

Figure 4-1. Farmlands and B-IBI Monitoring Locations in the Puget Sound Basin Farmlands were identified per analysis by American Farmland Trust.

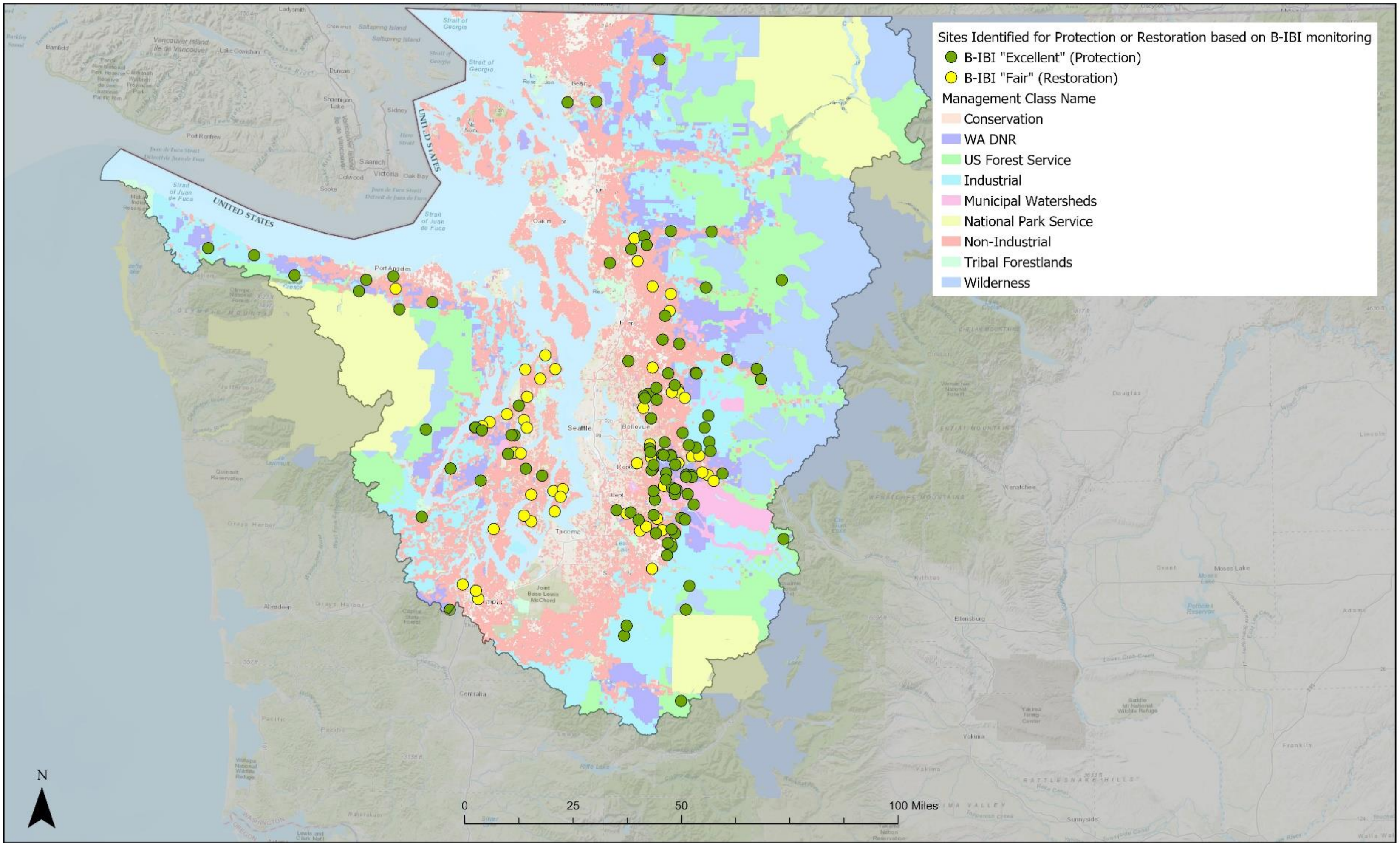

Figure 4-2. Locations of Forest Lands and Forest Land Ownership Types in Western Washington.
Federal, state, private, and tribal forest lands are all managed under different regulatory schemes, which should be taken in to consideration during the planning and implementation of restoration and protection programs. Forest lands identified in the 2007 Washington State Forestland Database (Rogers and Cooke, 2009). Map adapted from Washington State Private Forest and Public Lands (Rogers, Cooke, and Robbins, 2008). Note: Conservation - WA DNR – Washington State Department of Natural Resources; Industrial – Private Industrial Forest Land; Non-Industrial – Washington State Small Forest Land Owner

4.4.5 Policy Changes

Suggested policy changes that could support a Working Lands Strategy include:

- Restore funding for the Washington Department of Natural Resources' forestry programs.
- Modify cost-share agreements to improve flexibility and options when property is sold.
- Address barriers to the implementation of market-based tools such as water quality trading and Transfer of Development Rights programs.
- Encourage alternative appraisal techniques to promote conservation and the maintenance of open space and working lands. "Highest and best use" valuations may result in taxation rates that discourage conservation programs. Examples include the four programs under the King County Current Use Taxation Program – the Public Benefit Rating System (also known as Open Space), the Timber Land program, the Forestland program, and the Farm and Agricultural program.

4.5 Relationships among Strategies

The strategies describe an interrelated approach to selected aspects of stream protection and restoration as shown in the strategy schematic (Figure 4-3). Each of the strategies promote a variety of approaches, which lead to key outcomes, and an eventual reduction of the pressures that degrade stream conditions.

Watershed Planning explicitly accounts for pressures and stressors that act on a local-to-watershed-scale; mitigation actions implemented at a local scale without consideration of watershed condition will likely not lead to successful outcomes. Watershed planning requires a more holistic evaluation of all pressures and stressors in a given watershed and provides the basis for a realistic evaluation of the range of possible responses. The development of watershed plans also requires coordination across jurisdictional lines, as most watersheds do not align with political boundaries.

The Local Capacity and Education and Incentives strategies address specific barriers identified through the situation analysis, and should ideally be coordinated based on the development, adoption, and implementation of watershed plans.

The Working Lands Strategy focuses on barriers in specific geographies that may not otherwise be addressed through the other strategies. The IDT recognized the need for a more holistic, cross-cutting strategy. The IDT elected to limit strategy development but wanted to highlight the importance of reducing conversion and the implementation of BMPs on working lands.

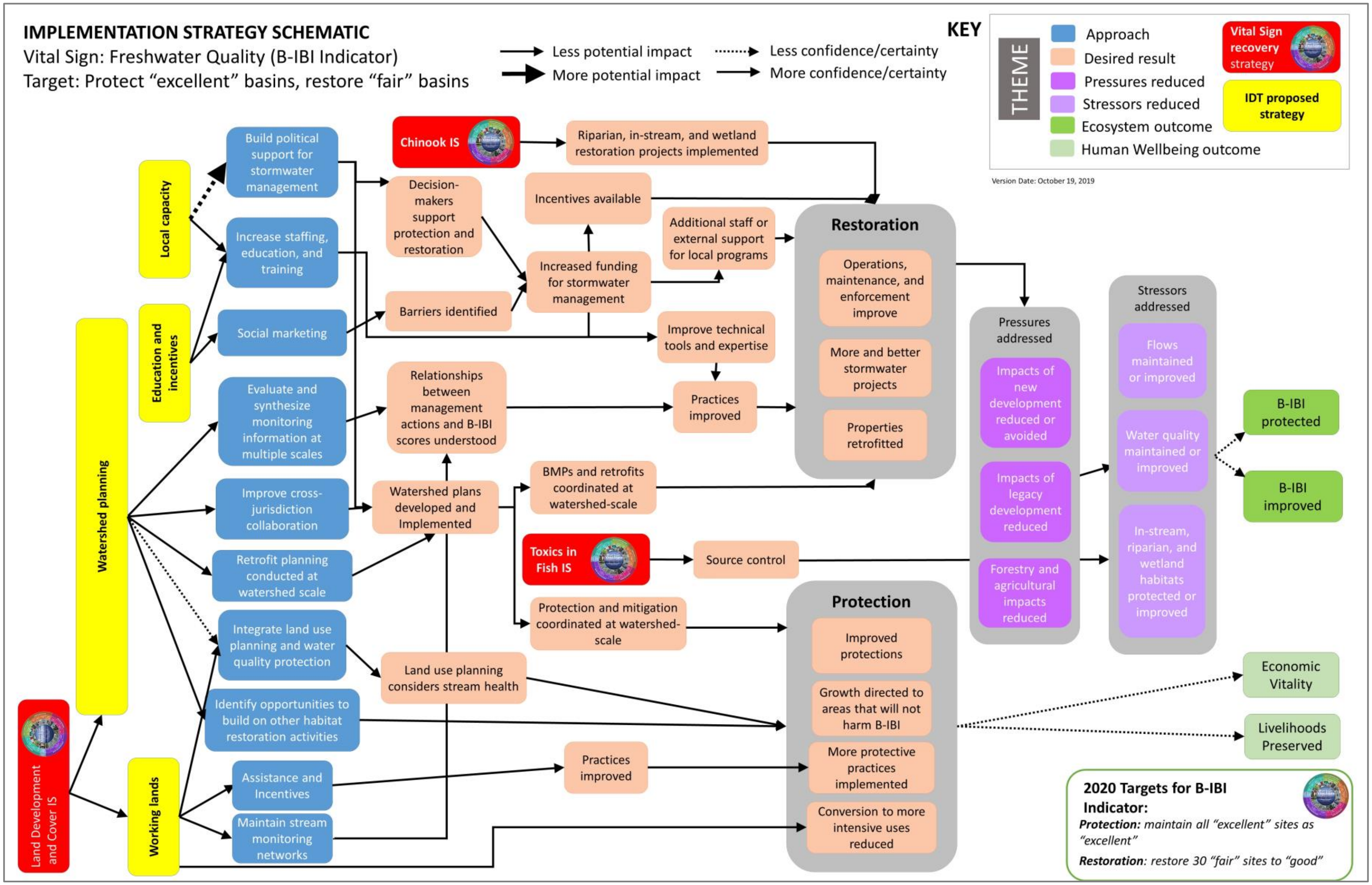

Figure 4-3. B-IBI Implementation Strategy schematic diagram showing the relationship between strategies, results, and pressures and stressors.

4.6 Integration with Other Implementation Strategies

The B-IBI indicator under the Freshwater Quality Vital Sign is just one of the many foci for the development of Implementation Strategy recovery plans. Many of the pressures and stressors that affect B-IBI also impact other Implementation Strategy components. Therefore, strategies developed under one Implementation Strategy will also address a pressure or stressor common to another, and a program or activity which mitigates them will be beneficial to more than one ecosystem component. The relationships between the B-IBI Implementation Strategy and other developed Implementation Strategies is discussed below.

4.6.1 Land Development and Cover

There are clear relationships between the approaches identified in this Implementation Strategy and the Land Development and Cover (LDC) Implementation Strategy. The LDC Implementation Strategy is meant to mitigate the effect of regional pressures associated with landscape development. These same development pressures result in the stressors that directly impact stream condition (degraded water quality, altered hydrology, impacted habitats, etc.) and the B-IBI indicator. In theory, a completely successful LDC Implementation Strategy would relieve the B-IBI related stressors and pressures. Further, many of the barriers identified under the LDC Implementation Strategy are likely to prove beneficial to stream condition. These are summarized in Table 4-1.

There is not, however, complete alignment between the strategies. One of the key focus areas of the LDC Implementation Strategy is to locate and identify ecologically important lands, especially those under high pressure for development. While the notion of ecologically important lands aligns with "excellent" basins as defined by B-IBI, the LDC approach takes a broader view, encompassing other lands in addition to those affecting strictly "excellent" catchments. Ecologically important lands in the LDC context is defined by the Puget Sound Basin Characterization project and includes a water flow assessment by the Washington State Department of Ecology and a habitat assessment by the Washington State Department of Fish and Wildlife (Lee et al. 2011, Wilhere et al. 2013, Stanley et al. 2019). From the water flow assessment, important lands are identified by evaluating data on precipitation, snow and rain on snow, the presence of wetlands, lakes and floodplains, and permeability. The habitat value is determined by considering the land use, size, proximity to other open-spaces, and location within watershed, as well as species occurrence and vegetation type to create a standardized rank of importance.

There is value in including considerations of multiple benefits in funding allocations moving forward. For example, a project that protects "excellent" B-IBI streams while also reducing the conversion pressure on ecologically important lands may be of higher priority compared to activities that accomplish only one of these objectives.

4.6.2 Chinook Salmon

An updated Chinook Salmon Implementation Strategy was finalized in January 2018 and identified several strategic approaches which align with the B-IBI strategy elements. The Chinook Salmon Implementation Strategy organized strategy approaches under habitat strategies, harvest and hatchery strategies, and H-integration strategies (where the inter-related aspects of habitat, harvest, and hatchery, often referred to as the "H factors," are considered collectively to ensure that actions and approaches meant to address an individual H are not deleterious to the others). The Chinook salmon habitat strategies with the highest degree of alignment with the B-IBI strategies include increased regional support for protections (via both regulation and acquisition), and increased regional support for restoration. The Chinook salmon protection strategy focuses on increased regional support for acquisition and incentive programs, in addition to improved regulations and implementation of regulations. Conceptually, there is significant alignment between these and the B-IBI strategies, though the focus areas for Chinook, which included stream and river habitat as well as estuaries and marine shorelines, are broader than that of B-IBI (Table 4-2). Acquisition and incentives that occur in basins with “excellent” B-IBI scores would serve both strategies.

4.6.3 Toxics in Fish

The Toxics in Fish Implementation Strategy addresses the presence of anthropogenic contaminants (PCBs, PAHs, PBDEs, and endocrine disrupting compounds) in a range of marine species within Puget Sound to determine best approaches to prevent harm to the indicator species, as well as the species that consume them (including humans). There is some overlap between the B-IBI and Toxics in Fish Strategies and many of the identified pathways, including stormwater runoff, are common to both. However, the Toxics in Fish strategies tend to focus on contaminant hot spots and/or sources that are proximate to marine species and, thus, thought to be the most impactful in terms of contaminant loading and eventual exposure. Most of these areas are in highly urbanized catchments, which most likely have highly impaired benthic communities ranked as “poor” or “very poor”, and therefore outside the scope of the B-IBI Implementation Strategy.

One strategy under Toxics in Fish focuses on incentivizing the implementation of retrofits in developed areas, while also incentivizing the redevelopment of brownfields and urban cores. Incentivizing retrofits aligns directly with the B-IBI strategy focused on education and incentives to increase retrofits for legacy development. While there is some disconnect in that Toxics in Fish prioritizes more developed areas that are sources of toxics contaminants, while B-IBI prioritizes catchments that affect areas that are “fair” or “excellent”, programs that incentivize the installation of stormwater retrofits will not be limited to a single geography. Further, the incentives for the redevelopment of brownfields or urban core areas may reduce the development pressure outside urban growth areas, or urban centers, and lead to the protection of existing “excellent” B-IBI sites.

Table 4-1. Alignment between the Land Development and Cover Implementation Strategy and the B-IBI Implementation Strategy

Land Development and Cover sub-strategy or barrier addressed	B-IBI related outcome
Regulatory limitations on protection, preservation, and restoration.	Identifying priority B-IBI basins and incorporating them into the regulatory lexicon is an important step in recognizing the value of ecosystem services and facilitating eventual protection and restoration.
Large-scale planning for cumulative impacts.	Aligns directly with the notion of Watershed Planning Strategy. Intent in the LDC context is to regulate ecologically important areas beyond the parcel scale to align with ecological processes, which occur across watershed and landscape scales.
Increase understanding of Low Impact Development in rural environments.	Direct alignment with the use of Education and Incentives to increase demand for retrofits and restoration.
Protect ecologically important lands that fall within and outside of Urban Growth Areas.	This sub-strategy will align directly with the B-IBI protection approach in areas where "excellent." B-IBI basins overlap with ecologically important lands.
Reduce barriers to infill and redevelopment in Urban Growth Areas.	Will direct development to areas that are not likely to impact B-IBI "excellent" basins.
Create strategic plans for working lands.	Promotes the development of a strategic plan for Working Lands which includes cross-cutting considerations.

Table 4-2. Alignment between the Chinook Salmon Implementation Strategy and the B-IBI Implementation Strategy

Chinook Salmon sub-strategy or barrier addressed	B-IBI related outcome
Increased support for Chinook Salmon habitat acquisition includes not only increased acquisition funding but also funding for stewardship and regional growth planning that is aligned with conservation needs.	In areas where "excellent" B-IBI basins align with critical Chinook habitat there is a high degree of alignment. Increase acquisition and stewardship is one method of protecting B-IBI basins. Regional planning which directs growth away from critical lands was a stated approach in the B-IBI Watershed Planning Strategy.
Increased support for Chinook habitat incentive programs includes investment to improve the understanding the effectiveness of incentive programs as well as expansion of incentive payments for behavior change.	The B-IBI Education and Incentives Strategy focuses on a social marketing campaign to identify and address barriers to implementing stormwater control measures. This process will improve our understanding of the effectiveness of behavior change. The strategy also calls for expanded incentive programs for stormwater retrofits; improved water quality improves salmon habitat.
Increase collaboration with resource industries.	The Chinook strategy identifies elements (improved collaborations, improved incentives) that are key to the B-IBI Working Land Strategy elements of developing an overarching agriculture strategy along with improved incentives.

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5 Alignment with Regional and Local Strategies

This section briefly describes existing local and regional plans and their alignment with the goals and strategies of this B-IBI Implementation Strategy.

5.1 2018 Action Agenda

The 2018-2022 Action Agenda Regional Priorities for Freshwater Quality and B-IBI were developed based on an early iteration of this Implementation Strategy. While subsequent work has resulted in updated strategies (as described in Section 4 of this Implementation Strategy) the previous regional priorities remain in the Action Agenda. These are:

- Increase Local Capacity to Manage Stormwater Programs (Section 4.1, Local Capacity Strategy)
- Provide Education and Incentives for Legacy Retrofits (Section 4.3, Education and Incentives Strategy)
- Facilitate the Increased Use or Performance of Best Management Practices in Working/Rural Lands (Section 4.4, Working Lands Strategy)
- Identify Strategies and Approaches to Reduce the Impacts from Forestry on Freshwater Quality
- Conduct Watershed-Scale Planning to Protect and Restore Water Quality (Section 4.2, Watershed Planning Strategy)

A regional solicitation was conducted by the Puget Sound Partnership to identify Near-Term Actions (NTAs) that could contribute to achieving the regional priorities. They are listed in Appendix IIIb - Stormwater SIL NTAs.

5.2 Tribal Habitat Strategy

The Northwest Treaty tribes, in conjunction with Northwest Indian Fisheries Commission, developed a Tribal Habitat Strategy (2018), called *gʷədᶻadad* (which, as translated from Lushootseed means, "Teaching of our Ancestors"). It outlines an approach to identifying and protecting the lands, waters, and ecological processes critical to maintaining tribal treaty rights, associated resources, and the cultures that rely on these resources. It is based on preserving and restoring the processes and functions of riverine, marine, and terrestrial ecosystems. The Tribal Habitat Strategy includes targets, goals, and indicators for habitat priorities in five target areas, as well as overarching tasks. Target areas and overarching tasks include specific actions.

The five target areas are:

- Pacific Ocean
- Inland Marine and Nearshore (Salish Sea)
- Floodplains
- Riparian
- Water

Overarching tasks include:

- Land-use Management
- Coordinated Land Acquisition for Ecosystem Health

- Local Government Engagement
- Evaluate Tribal Science
- Outreach and Coalition Development

The Tribal Habitat Strategy has approximately 32 components with sufficient details to evaluate high-level strategy alignment with B-IBI strategy subcomponents. These were compared with B-IBI strategies to understand where B-IBI strategies might support tribal priorities, or where tribal priorities might also complement B-IBI outcomes. The high-level crosswalk indicated that there was substantial alignment between the two strategies. Of the 128 possible points of alignment (32 tribal habitat priority components x 4 B-IBI strategies = 128 alignment opportunities), we found that there was a 38% alignment between B-IBI and the Tribal Habitat priorities where one strategy's implementation would support the objectives of the other (Table 5-1).

Table 5-1. Alignment of Tribal Strategies and Strategies in the B-IBI Implementation Strategy

	Strategy alignment opportunities	Total Aligned	% Alignment	Count of strategy alignment by B-IBI strategy			
				Watershed Planning	Working Lands	Local Capacity	Education and Incentives
Tribal Habitat Strategy	128	48	38%	26	8	7	7

5.3 Federal Task Force Action Plan

Co-lead by the National Oceanic and Atmospheric Administration (NOAA) and the EPA, the 2017-2021 Action Plan identifies priority federal actions that can be implemented to protect and restore Puget Sound. It was developed by the Puget Sound Federal Task Force and includes the following federal partners:

- The United States Department of the Interior
- The United States Environmental Protection Agency
- The United States Department of Commerce, including NOAA
- The United States Department of the Army, including the U.S. Army Corps of Engineers
- The United States Department of the Navy
- The United States Department of Agriculture
- The United States Department of Transportation
- The United States Coast Guard
- The Council on Environmental Quality

65 federal actions were compared to the four B-IBI strategies. Watershed Planning, Working Lands and Education, and incentives for retrofits tended to be highly aligned with federal actions. Local Capacity of stormwater management had the least alignment. Alignment is summarized in Table 5-2.

Table 5-2. Alignment of Federal Strategies and Strategies in the B-IBI Implementation Strategy

	Strategy alignment opportunities	Total Aligned	% Alignment	Count of strategy alignment by B-IBI strategy			
				Watershed Planning	Working Lands	Local Capacity	Education and Incentives
Federal Work plan	296	60	20%	23	16	5	16

5.4 Local Integrating Organization Recovery Plans

Local Integrating Organizations (LIOs) are local forums that meet regularly to collaboratively develop, coordinate, and implement strategies and actions that that contribute to the protection and recovery of the local ecosystem. There are currently ten LIOs throughout the Puget Sound watershed. Each LIO has developed local recovery plans, which identify priority strategies. The Core Team compared LIO strategies to the B-IBI strategies to get a better understanding of alignment. A LIO strategy crosswalk is presented in Appendix IIe.

The B-IBI strategy aligns with 19 to 35% of a given LIO's strategic priorities, with an average of 27%. This suggests that there may be strategic opportunities to adaptively manage underdeveloped Implementation Strategy components (the Working Lands Strategy, for example) to better address LIO priority strategies. The crosswalk exercise highlighted that forestry issues were generally absent from the current B-IBI strategy, but present in several local plans indicating that forestry conversion/protection and runoff are important issues in local planning areas.

A summary of the LIO strategy crosswalk is presented in Table 5-3.

Table 5-3. Alignment of LIO strategies and B-IBI Implementation strategies

LIO	LIO/B-IBI Strategy Alignment Opportunities	Total Aligned	% Alignment	Watershed Planning	Working Lands	Local Capacity	Education and Incentives
Hood Canal	372	74	20%	28	11	16	19
Island	208	63	30%	8	4	3	0
San Juan	112	34	30%	13	6	6	9
Snohomish-Stillaguamish	340	66	19%	19	8	21	18
South Central	104	29	28%	10	0	10	9
South Sound	92	27	29%	7	4	7	9
Strait	52	18	35%	6	2	4	6
West Sound	68	17	25%	7	1	5	7
Whatcom	136	34	25%	14	3	10	7

5.5 State Agency Strategic Plans

Many Washington State agencies have existing strategic plans that focus on elements identified in the B-IBI Implementation Strategy. A selection of them is presented below. In addition to these, work being led by the Department of Natural Resources, Department of Fish and Wildlife, Washington State Conservation Commission, Conservation Districts, and others is vital to making progress toward improving stream health across the region.

5.5.1 Washington State Department of Ecology

Ecology's 2017-2019 Strategic Plan includes two strategic priorities with direct relevance to this Implementation Strategy: "Deliver Integrated Water Solutions" and Protect and "Restore Puget Sound." These describe several key strategies that may be particularly relevant.

Deliver Integrated Water Solutions includes these priorities:

- Expand effectiveness monitoring to provide data helpful for evaluating innovative solutions. For example, using instream flows to influence permitting decisions that will reduce toxics loading to water bodies.
- Seize opportunities provided by projects that simultaneously improve both water supply and water quality. For example, flood hazard reduction projects.
- Prevent and reduce water pollution from point and nonpoint sources, and from stormwater runoff.

Key strategies from Protect and Restore Puget Sound include:

- Coordinate infrastructure investments and bring multidiscipline teams into early planning.
- Collaborate through the Puget Sound Partnership's Ecosystem Coordination Board to advance the Action Agenda's three Strategic Initiatives: stormwater, shellfish, and habitat.
- Collaborate through Puget Sound Salmon Recovery Council and watersheds to protect and restore habitat.
- Leverage cleanup of contaminated properties to improve the environment and spur economic opportunity.

In 2018, the Department of Ecology developed the Statewide Stormwater Strategy. Ecology developed it to complement the Toxics in Fish and B-IBI Implementation Strategies and to better align Puget Sound recovery planning with the state's strategic stormwater planning. The state strategy includes managing growth, preventing toxics, controlling nutrients, and cleaning up legacy pollutants.

- Managing growth: low impact development and other practices are working, but more is needed at the watershed-scale to prevent water quality problems as urban areas expand.
- Preventing toxics: banning harmful chemicals like copper in brakes and the toxics in Fire Fighting foams is helping. But other chemicals, and the continuing production of new chemicals, continue to pose challenges.
- Controlling nutrients: despite investments to manage nutrients from urban landscapes, stormwater is carrying excess nutrients into receiving waters. This contributes to low oxygen levels and more algae blooms.

- Cleaning up legacy pollutants: hundreds of millions of dollars have been invested cleaning up contaminated water and sediment and installing stormwater treatment retrofits in older neighborhoods to prevent toxic runoff. However, the investment demand remains in the billions of dollars (Ecology 2018).

5.5.2 Washington State Department of Transportation

Two goals of WSDOT's 2014-2017 Strategic Plan relevant to the Implementation Strategy are 1) Environmental Stewardship and 2) Community Engagement.

5.5.3 Washington State Parks

The Washington State Parks 2014-2021 Strategic Plan (State Parks 2018) priorities for 2017-2019 include "understanding the resources in our care"—to improve restoration, protection, and preservation of natural resource assets for future generations.

5.6 References

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6 Climate Change

Climate change is likely to bring increases in temperature and changes in the frequency, timing, and duration of precipitation (Snover et al. 2013). Increases in heavy rainfall events could further increase flood risk (Snover et al. 2013). In addition, there may be important synergistic impacts from climate change and urbanization on hydrology (DeWalle et al. 2000). Given the close relationship between hydrology and climate (Harman et al. 2012) and the relationship between hydrology and B-IBI scores (Alberti et al. 2007, Cassin et al. 2005, DeGasperi et al. 2009), the potential impact of climate change on stream recovery and protection is an important consideration for this Implementation Strategy.

While the current Implementation Strategy did not explicitly account for climate change during the Strategy development process, many elements should serve to mitigate the changes to hydrology due to climate change by, for example, decreasing runoff from legacy development or increasing riparian and in-stream habitat structures. As such, the Implementation Strategy can serve as a climate change resiliency strategy. By protecting and maintaining stream processes and functions, Puget Sound streams should become more hydrologically resilient, and therefore be more resilient to climate impacts. Better mimicking or restoring natural hydrology will better allow for adaptation.

As the climate warms, some basins with transitional and snowmelt-driven hydrology will function more like rain-driven basins (Snover et al. 2013). Salmonids that inhabit shifting hydrologic environments may have distribution, run timing, and life history adaptations that will be poorly suited to those future conditions. It could be beneficial to prioritize preservation and restoration in basins that have a rain-driven hydrology. This may better enable salmonids from rain-driven basins to colonize habitat and replace snow driven or transitionally adapted populations as they decline.

This Implementation Strategy also includes restoring and protecting habitat and riparian vegetation through watershed-scale planning and reducing the conversion of working lands. Riparian habitat can both reduce hydrological alterations, and it can buffer temperature changes that impact sensitive taxa. Changes in temperature regime may limit the future availability of suitable habitats for salmonids (Isaak et al. 2018). Again, these outcomes will likely make streams more resilient to climate change.

The IDT identified key issues to consider to better deal with climate change impacts:

- A future evaluation of the B-IBI Implementation Strategy should include an explicit evaluation of potential impacts to benthic communities and stream health, and how those impacts can be mitigated through adaptive management (see Section 9).
- Stormwater management is generally based on historical rainfall records, which could lead to infrastructure that is inadequate to accommodate future conditions. However, common modeling tools (e.g., the Western Washington Hydrology Model) can be manipulated to substitute predictive rainfall and temperature data for the historical rainfall and temperature data typically used as inputs for those models.

- Planning efforts for both growth and restoration purposes should also consider potential climate impacts.
- The most effective strategies for protecting streams and attenuating climate change impacts may be to retain existing tree canopy at both watershed-scale and riparian-scale. This would also help to maintain hydrologic processes.
- Climate change related alterations to flow and temperature may impact benthic community structure even in reference watersheds (Poff et al. 2010). These changes will need to be considered when evaluating status and trends of stream sites based on B-IBI, as future baseline conditions may be different from historic baseline conditions, even at the same site.

6.1 References

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7 Research and Monitoring Priorities

During the development of the Implementation Strategy, we performed a structured process to identify research and monitoring priorities. Additional work was performed to identify research and monitoring needs specific to each of the strategies. The prioritization process and outcomes are described below.

7.1 Need for Research and Monitoring

B-IBI is derived from the sampling and evaluation of in-stream benthic communities and reflects taxa abundance and diversity. It is strongly correlated with measures of development (e.g., impervious surfaces, road density), and impacted by multiple stressors associated with development (e.g., altered flows, contaminants, loss of riparian function). While B-IBI is a good tool for describing the integrated and cumulative effects of development, it is not a diagnostic measure. In other words, degraded streams can generally be identified by measuring and evaluating B-IBI, but B-IBI cannot be used to identify specific actions needed to recover a given stream. As such, a robust research and monitoring program is needed to better understand the ecosystem response to various actions, and to support the planning and prioritization of actions within a given watershed that are most likely to improve stream conditions, which should ultimately be reflected in benthic communities (as well as other measures of stream condition). This process was meant to prioritize those research needs.

7.2 Research and Monitoring Evaluation Process

7.2.1 Step 1: Cataloging and Organizing

Uncertainties and questions related to the B-IBI Implementation Strategy were cataloged during the development process of the B-IBI Implementation Strategy. These were identified during:

- the development of the Starter Package,
- the Interdisciplinary Team meetings; and
- the focus group workshops, including the technical workshop, the partner workshop, and the working land strategy workshop (fall 2017).

A running list of questions was compiled and updated after each meeting and workshop.

Questions were broadly screened (to remove redundancies, clarify questions, etc.) and organized into a master list of uncertainties. Questions were also broadly categorized into three groups based on the scope and level of effort estimated to be required to address them. Categories included:

- resolvable (~ a 1-5 day effort)

- research/monitoring (a 2-4 year effort)
- unresolvable (more than a 4 year effort)

Approximately 50 unique uncertainties/questions were identified during this process.

7.2.2 Step 2: Ranking

The resulting list of uncertainties/research questions was then ranked based on its overall importance to achieving recovery or protection according to the question, "How critical is this question to the implementation of a given strategy? Or to achieving the overall recovery goal?" The following rankings were applied:

- 1 – Unimportant
- 3 – May be valuable and result in moderate improvements to implementing strategies or activities
- 5 – Critical

Uncertainties/questions which scored 5 (critical) were carried forward, i.e., only those that were deemed to be critical to the implementation of actions and/or strategies related to achieving the recovery and protection goals. This resulted in approximately 20 priority uncertainties/questions for further evaluation.

The results of this ranking were recorded and available for review. Results are shown on a set of process worksheets (see Appendix).

7.2.3 Step 3: Workshop Review

The uncertainties ranking exercise was reviewed over the course of several Implementation Strategy workshops (Fall 2017), including a partner workshop, a technical workshop, and an agricultural workshop. In each case, participants were given the opportunity to rank the list of uncertainties/questions and to add additional uncertainties/questions that were not already included. The priority ranking from these workshops generally concurred with the evaluation steps described above. The results of the individual ranking exercises are shown on a separate set of worksheets (see appendices for B-IBI Uncertainties).

7.2.4 Step 4: Identification of Research and Monitoring Priorities

After the partner and technical workshops, an additional focus group meeting was held to: 1) review the final set of uncertainties/questions, and 2) identify those which are most likely to improve the success of the B-IBI Implementation Strategy and help achieve related recovery targets. Participants were Andy James (University of Washington Puget Sound Institute), Aimee Kinney (University of Washington Puget Sound Institute), Kate Macneale (King County), Karen Dinicola (Washington State Department of Ecology), and John Stark (Washington State University). The outcomes are described in Section 7.3.

7.3 Research and Monitoring Prioritization Outcome

The research and monitoring priorities fall within two broad categories and address fundamental barriers to the restoration, recovery, and protection of Puget Sound streams. Although the B-IBI indicator target has two stated goals (protect and restore), the majority of the uncertainties/questions were related to the restoration goal, and not the protection goal. This reflects the fact that while the approach to protection is well known, the approach to restoration is much less well understood.

The first set of uncertainties focuses on our ability to plan and implement stream restoration activities by understanding the causes and/or stressors of degradation, the extent of response required, and where efforts should be focused (Table 7-1). The second set of uncertainties focuses on the effectiveness of management tools. While effectiveness is clearly a critical and related aspect of planning, it is called out separately due to the high number of effectiveness-related uncertainties that were highlighted during the process (Table 7-2).

Additionally, there were several uncertainties related to the extent of activities required to achieve recovery targets, and whether there are geographic considerations critical to restoration planning. These are summarized below.

Table 7-1. Key research and monitoring priorities

Uncertainty	Example questions or activities
Stressor Identification - What are the primary stressors affecting condition (B-IBI scores) in a given basin?	Stream quality can be affected by changes in hydrology, contaminant inputs, degraded habitat, changes in food/energy inputs, and altered biology. Approaches for identifying predominant stressors (e.g., close examination of the individual metrics that comprise a B-IBI score and/or watershed evaluations) need to be developed and tested. What do B-IBI scores tell us?
How much investment is needed to improve stream quality (B-IBI scores)?	What are cumulative impacts of actions of various types? What is the minimum extent of stormwater treatment needed to result in an observable biological response, over what time period?
Where should investments occur for protection and for recovery?	Opportunities occur at the local scale, but planning occurs at the watershed or basin scale. It is important to understand the extent of parcel scale and sub-basin area activities needed for recovery, and if other approaches are needed. What is the rate/risk of conversion of agricultural and/or forest lands?

The overarching challenge (and uncertainty) specifically related to the recovery target is that there are not necessarily clear methods that are certain to improve B-IBI scores in a particular watershed. While there is ample evidence that B-IBI scores are correlated with land development, however there is little evidence that a given recovery action will lead to improved B-IBI scores. Therefore, while actions such as stormwater controls, stream restoration, etc. are expected to have benefits on a stream or river, there has been little research to track their effectiveness at altering benthic community and improving B-IBI scores (Miller et al. 2010). Consequently, there are many opportunities for research and monitoring.

Many key uncertainties are directly related to the effectiveness of management actions aimed at maintaining and improving stream condition, the extent to which a given activity will reduce stressors (e.g., contaminant inputs or hydraulic alteration) and how that might eventually result in changes in the B-IBI metric. The priority effectiveness uncertainties are summarized below.

Table 7-2. Research and monitoring priorities associated with the effectiveness of restoration actions.

Uncertainty	Example questions or activities
Effectiveness - How will the B-IBI metric respond to management actions? • Effectiveness of stormwater BMPs and technologies. • Effectiveness of regional stormwater treatment installations. • Effectiveness of enhanced maintenance approaches, such as line/catch basin cleaning and street sweeping.	Pre- and post-project monitoring of stormwater retrofits, riparian restoration, in-stream restoration, and other projects (e.g., ongoing through the Stormwater Action Monitoring (SAM) program) • How do site-scale management activities, like grass filter strips and bioswales, reduce contaminant loading? • Do catchment-scale management activities result in improved stream condition? • Do watershed-scale management activities result in improved stream condition?
Effectiveness of Education and Outreach	What behaviors are most important to influence? What are the best techniques to promote behavior change? What behavior change/social strategy might result in improved stream condition?

7.4 Strategy-Specific Research Needs

Specific research needs were identified based on the four strategies. They are presented below.

7.4.1 Research and Monitoring Needs – Increased Local Capacity

Specific research needs identified under the Local Capacity Strategy include:

- Understanding of the effectiveness of social marketing campaigns for behavior change and increased funding availability. There are several studies on the effectiveness of social marketing for broader environmental issues (see McKenzie-Mohr et al. (2012), and references therein) but the literature specific to stormwater management and funding is limited.
- Develop a locally derived understanding of the capture and transpiration of stormwater for common species of evergreen and deciduous trees in the Pacific Northwest by direct measurement of interception and transpiration.
- Evaluate if increased reliance on performance standards (as opposed to the BMP list in the SWMMWW) results in projects that do a better job of managing stormwater. If so, research is needed on which tools will help facilitate the use of performance standards in jurisdictions with limited capacity.

7.4.2 Research and Monitoring Needs – Watershed Planning

A key priority of the Watershed Planning Strategy is understanding the relationship between restoration activities and biological response on an individual site, project, and watershed-scale. A related priority is improved understanding between policy, implementation, and biological response. We need to understand the results of both on-the-ground activities and policy changes on B-IBI and stream health, in general. It was largely recognized that there is a lack of knowledge of what works, which is a key impediment to effective planning.

Examples of recommended research and monitoring needs include:

- Effectiveness monitoring of BMPs: monitoring activities which focus on the biological and physical/chemical impacts of single or multiple BMP installations should be undertaken. Monitoring should also focus on a basin scale understanding of multiple actions. There is currently a wide range of studies available on BMP effectiveness; e.g., Stormwater Action Monitoring effectiveness studies, Barrett (2008), Clary et al. (2017), etc. However, more is needed as there are still gaps on what works, where, and for how long.
- Improving our understanding of the relationship between the entirety of the biological data (B-IBI metrics, taxa abundance and trends, etc.) and stream condition stressors to inform management responses.
- King County (2015) identified several B-IBI basins with higher-than-expected scores (i.e., "excellent" basins that are >10% developed) throughout Puget Sound, and indicated there may be great value in exploring factors that allowed those areas to maintain "excellent" B-IBI scores despite high levels of development.
- Cost-benefit ranking of stormwater BMPs: the ranking could be based on existing information and act as a decision support tool to maximize the impact of limited funding. A brief review of existing cost-benefit publications is included in the State of Knowledge report (Appendix IIb).
- Determine which type of programs are more effective at achieving stream health objectives (i.e., B-IBI): non-regulatory incentive programs or regulatory programs.

7.4.3 Research and Monitoring Needs – Education and Incentives

The research and monitoring needs for the Education and Incentives strategy focused mainly on the effectiveness of education and incentive programs, and their role in increasing the number of stormwater BMPs on legacy properties. The strategy is based on the notion that education and incentives will lead to more stormwater treatment and/or a reduction in effective impervious surface areas in a watershed; it is important to know how well these programs actually work. Examples of research and monitoring needs include:

- What is the effectiveness of social marketing campaigns with regard to behavior change related to environmental and/or conservation issues? Reports and publications on behavior change are available (McKenzie-Mohr et al. 2012, Cettner et al. 2014, Boulet et al. 2017).
- What is the effectiveness of incentive programs in increasing the number of stormwater retrofits on developed properties? Is a certain level of incentives or rebate required to increase participation (Crisostomo et al. 2014, Kertesz et al. 2014)?

- What are the major barriers to the increased implementation of stormwater retrofits? Reports and publications on barriers are available (Oregon Sea Grant 2008, UNH Stormwater Center 2011, Sightline Institute 2014, Brown et al. 2016, Chaffin et al. 2016, Dhakal and Chevalier 2017, Kim et al. 2017, O'Donnell et al. 2017, Coleman et al. 2018).

Note that some information is available on these topics, as summarized in the State of Knowledge report (Appendix IIb) and Base Program Analysis (Appendix IIc).

7.4.4 Research and Monitoring Needs – Working Lands

Research and monitoring needs that could support the Working Land strategy include:

- Maintain and/or expand the B-IBI monitoring network in working lands.
- Buffer monitoring – there are many studies evaluating the effectiveness of agricultural and forestry buffers (Yuan et al. 2009, Sweeney and Newbold 2014). Long term monitoring projects could track the effectiveness of various buffer installations specifically on B-IBI scores. This could also include the evaluation of innovative approaches such as narrow configurations or working buffers. A recent set of studies by WDFW has provided a valuable synthesis of the science of riparian buffers as well associated management recommendations (Windrope et al. 2018, Quinn et al. 2019).
- Evaluate the cost-effectiveness of BMPs for contaminant reduction, specifically on working lands. Cost effectiveness studies exist but are limited, particularly in working lands (Weiss et al. 2007, Petit-Boix et al. 2015, Chui et al. 2016, Sun et al. 2016, Byrne et al. 2017, Osouli et al. 2017, Nordman et al. 2018, Brudler et al. 2019).
- Identify the key stressors affecting B-IBI in agricultural and forestry lands. Changes in hydrology and the release of sediments, nutrients, and pesticides into run-off are commonly identified stressors specific to benthic invertebrates (Matthaei et al. 2010, Rasmussen et al. 2012). Understanding the extent of impacts would help guide remediation measures.
- Improve the understanding of the effectiveness of agricultural and forestry BMPs in increasing B-IBI score and stream health (Rittenburg et al. 2015, Weyand 2018).

7.5 Ongoing Research

The current research related to stream restoration and recovery, and stormwater management effectiveness is included as part of the B-IBI State of Knowledge Report (Appendix IIb).

The personnel involved in this evaluation strongly recommend a focused research and monitoring program addressing one or more of the priority areas. Without these investments, regional partners will not have the information necessary to invest in actions most likely to result in progress towards B-IBI indicator targets. While there are many uncertainties and questions, we feel that those listed above are the most critical and should be addressed as soon as practical.

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8 Cost Estimates for the B-IBI Implementation Strategy

This section presents costs of existing B-IBI and stream health improvement projects related to the Implementation Strategy. These include in-stream restoration, riparian planting, stormwater retrofits, and water quality best management practices (BMPs) in agricultural lands. Cost estimates are also provided for conservation acquisitions, easements, and B-IBI monitoring activities.

8.1 Existing Costs

Although calculating existing costs for past or ongoing restoration projects would seem simple, these costs are complex, and no one number would be accurate. There are many factors that influence the total cost of restoration actions, such as:

- Location of restoration sites;
- Accessibility;
- Jurisdiction or entity performing or managing restoration;
- Cost of materials and labor;
- Experience performing proposed restoration activity (King County 2015).

For example, restoration planning can be supported by modeling, which alone can cost millions of dollars. However, if restoration happens on a site where modeling already exists, or if modelling is not necessary, then the estimated restoration costs would be reduced considerably.

Any cost estimate provided in this section does not account for geographic differences throughout the Puget Sound, including property values, design cost variation by site characteristics, and the tax/fee base of different jurisdictions. Much of the cost estimate information were adapted primarily from King County (2015), and therefore are mostly representative of projects completed in King County. The cost information presented here is not comprehensive and intended to be informative; actual costs will vary.

Other relevant cost information related to B-IBI, or any Implementation Strategy, includes:

- Staff time needed to implement new or expanded programs;
- Capital project implementation costs;
- Project planning costs;
- Education and outreach project costs;
- Cost savings achieved by leveraging public works projects for restoration;
- Cost effectiveness of specific incentives;
- Added benefits supported or created by strategy implementation.

8.1.1 Restoration and Protection Activities

Cost estimates for protection and restoration actions are provided in this section, including for in-stream restoration and riparian planting, stormwater retrofits, agricultural BMPs, land conservation actions (e.g., acquisition and easements), and B-IBI sampling and monitoring. Cost figures are based on plans and studies from several different jurisdictions.

This section does not intend to prioritize one action over another, but simply to provide examples of costs related to some B-IBI improvement actions. It can serve as a starting point towards implementation planning.

8.1.1.1 Stormwater Retrofits

Stormwater retrofits include detention/retention ponds, bioswales, cisterns, bioretention facilities, rain gardens, etc. The costs highlighted in this section are examples of a variety of estimates described in local stormwater watershed plans.

Table 8-1 describes stormwater retrofit cost estimates for stormwater facility projects in Water Resource Inventory Area [(WRIA) 9] in 2013 dollars, broken down by land use type. Costs are in thousands of dollars to retrofit one acre of each land use. The total amount includes 30 years of operation, maintenance, inspection and enforcement (discount rate assumed at 5%).

Table 8-1. Stormwater Retrofits Cost Estimates (King County 2015)

Types of Costs (USD) to retrofit one acre per land use	Land Use		
	Agriculture	Commercial	Residential
Capital (design, construction and permitting)	$57,000	$139,500	$90,000
Operation and Maintenance (30 years)	$33,500	$32,700	$43,500
Inspection and Enforcement (30 years)	$62,800	$59,600	$82,500
Total	**$153,300**	**$231,800**	**$216,000**

* Detailed information of costs included in this table can be found in the 2015 King County report. (p.54)

Phase I Municipal Stormwater permittees are required to prepare watershed-scale stormwater plans in order to plan for population increases and stormwater management. Through this process, many municipalities estimate costs to implement stormwater retrofits to meet future water quality standards for fecal coliform, temperature, dissolved copper and zinc, and aquatic biologic health as measured by B-IBI.

The Spanaway Lake Watershed-Scale Stormwater Management Plan by Pierce County developed a planning-level estimated cost per project for design and construction, based on unit prices available from public-works projects, previous project bids, and vendor quotes. The construction costs include percent increases for other project costs such as design engineering, environmental review and permitting, and contingency.

Table 8-2 illustrates cost estimates for potential stormwater management strategies like drywell retrofits, pond retrofits, and road infiltration activities. The estimate is in 2017 dollars and includes construction, construction cost range, and a 30-year life cycle cost, or net present value. The net present value is based on a 2% discount rate and includes total estimated capital costs. Net present value also includes the following assumptions per retrofit strategy. The drywell retrofit estimate assumes cleaning catch basins every five years. The pond retrofits estimate assumes filter cartridges replacement twice per five years, with minimal annual maintenance. The Military Road estimate assumes complete replacement of a sand filter at 30 years, thorough raking every five years, and minimal annual maintenance (Pierce County 2017).

Table 8-2. Cost Estimates for Watershed-Scale Retrofits (Pierce County 2017)

Stormwater Retrofit	Construction cost	Construction Cost Range (-30% to +50%)	30-year Life Cycle Cost
Drywell retrofits (15)[1]	$105,000	$73,500 - $157,500	$120,000
116 square feet pond retrofit	$240,000	$168,000 - $359,000	$313,000
149 square feet pond retrofit	$177,000	$124,000 - $1,899,000	$212,000
Military Rd infiltrating sand filter	$1,259,000	$881,000 - $1,889,000	$1,355,000[2]
Total	$1,781,000	$1,246,500 - $2,670,500	$2,120,000

1. Estimate for approximately 15 single-stage drywells located within 350 feet upgradient of surface water bodies.

2. Includes a rough estimate of land acquisition cost. For more detail on these costs, refer to page 7-10 of the Pierce County report (Pierce County 2017).

Similarly, the Little Bear Creek Basin Plan by Snohomish County includes a strategy to achieve water quality standards with cost estimates. The costs apply to a suite of activities in the watershed using a variety of BMPs, such as LID, water quality filtration, detention, and buffer restoration.

Table 8-3 summarizes the total amount and estimated costs of various approaches needed to achieve water quality standards and targets, grouped by type of BMP. Costs are planning level, in 2016 dollars.

Table 8-3. Planning-Level Cost Estimates for BMPs (Modeled Strategies) in Little Bear Creek Basin (Snohomish County 2017)

BMP Type	Strategy	Total for Study Area	Cost (million USD)
Low Impact Development (LID)	Filter Strip	64 miles	$5.1
	Modified ditches	30 miles	$17.5
	Rain gardens	7.4 acres	$9.4
	Bioretention	6.1 acres	$31.4
	Permeable pavement	3.7 acres	$4.6
Water Quality Filtration	Biofiltration	0.9 acres	$48.7
Detention	Wet pond	246 acre-feet	$167.4
Buffer Restoration	Riparian planting	204 acres	$4.5
		Total	**$288.6**

* Detailed information used for this table is on page ES-3 of the Snohomish County report (Snohomish County 2017).

The Stormwater Retrofit Analysis and Recommendations for Juanita Creek Basin in the Lake Washington Watershed Plan modeled twelve different scenarios. The scenarios covered three types of conditions:

benchmark, existing, and future. The benchmark scenarios included undisturbed fully forested; limited disturbance with 65% forest retention and 10% impervious surfaces; and moderately developed based in 1977 land use conditions. The existing conditions were defined based on land use interpretation from 2002 satellite imagery, with the inclusion of three existing regional stormwater facilities. Future conditions assumed full potential build-out to the most intensive land use allowed by current (~2010) zoning. Seven of these were stormwater mitigation scenarios that included a combination of gray and green infrastructure, such as ponds, cisterns, and rain gardens with various levels of retention and detention (King County 2012).

Table 8-4 describes the stormwater mitigation scenarios and associated implementation costs. The total net present value (2011 dollars) ranged from $200 million to $1.4 billion dollars depending on the scenario. This equals $30 million to $200 million per square mile or $5 million to $35 million per year, over a 40-year time span, to implement the necessary retrofits to maintain water quality standards in Juanita Creek. Capital costs are costs of retrofit implementation, private costs are any burdens on private citizens, and public costs are any burdens on government jurisdictions.

Table 8-4. Net present value costs per scenario, based on 40-year lifespan (all costs in million USD)

		Operation and Maintenance Costs (million USD)			
Scenarios	**Scenario Description**	**Capital**	**Private**	**Public**	**Total**
LEVEL2	Future land use with basin-wide retrofit utilizing detention ponds sized to a 2009 King County Surface Water Design Manual Level 2, applied to all drainage areas.	$207.52	$0.00	$2.98	$210.50
LID40	Future land use with basin-wide retrofit utilizing rain gardens applied to 40% of the total impervious area of the basin. 3 inches of storage provided for treated tributary impervious area (TIA) and rain garden facility footprints are consistent with 1 foot of storage.	$184.57	$339.74	$65.76	$590.06
ECY08	Ecology-proposed matching durations to 8% of the 2-year forested to the 50-year forested, using a combination LID80 (retrofits applied to 80% of total impervious surface in the basin) and stormwater detention ponds stacked on basic wet ponds applied basin-wide.	$559.00	$679.48	$134.45	$1,372.93
LID40+	Combination of LID40 throughout the basin and King County Level 2 stormwater detention ponds stacked on basic wet ponds in three catchments.	$185.32	$339.74	$65.95	$591.01
LID80	Future land use with 80% TIA captured by rain gardens.	$369.13	$679.48	$131.51	$1,180.12
LVL2WET	Future land use with King County Level 2 stormwater detention ponds stacked on basic wet ponds applied basin-wide.	$210.92	$0.00	$3.87	$214.79
CISTERN	Future land use where roof area runoff from a mild wet season of rainfall is captured then released July-Sept each calendar year at a constant rate.	$177.71	$0.00	$79.76	$257.17

*A detailed explanation of each scenario can be found in Chapter 2 pages 29-30 of the Stormwater Retrofit Analysis and Recommendations for Juanita Creek Basin in the Lake Washington Watershed Plan. Detailed information of costs can be found on page 59 (King County 2012).

As seen in the examples above stormwater retrofits can vary in costs depending on location, level of planning involved or still needed, and quality and quantity of stormwater treatment. Other restoration activities help increase B-IBI scores in streams such as riparian plating, instream restoration, agricultural BMPs, land acquisitions and easements, costs of these activities are explained below.

8.1.1.2 In-stream Restoration and Riparian Planting

In-stream restoration and riparian planting are activities that should help improve B-IBI and stream health in the region. Costs of these activities will vary by location.

In-stream restoration can include several activities. The estimated costs are specific to King County restoration actions, however similar actions performed throughout the Puget Sound should have similar costs. Table 8-5 included costs for placement of large woody debris, bank stabilization, importation of large gravel and establishing spawning substrate. The total cost calculations include rough construction estimates, tax contingency, design, and monitoring and maintenance.

Table 8-5. In-stream Restoration estimated costs per 100 meters of stream restored (King County 2015)

Restoration Action	Estimated Cost Total per 100 meters of restoration action*
Placement of large woody debris to increase hydrologic diversity	$47,000 - $108,0000
Bank stabilization	$105,000 - $252,000
Import of large gravel to establish spawning substrate	$236,000 - $720,000
Establish spawning substrate	$47,000 - $108,000

* More details on the numbers presented can be found on page 52 of the King County, 2015 report.

Riparian planting is another commonly used restoration activity throughout Puget Sound. The estimated costs presented in Table 8-6 are based on three different vegetative types (deciduous, coniferous and shrubs) quantity and spacing pattern implemented (King County 2015).

Table 8-6. Riparian planting cost estimates based on restoring one acre (King County 2015)

Plants	Estimated Costs Based on Restoring 1 acre
Conifers	$2,100
Deciduous Trees	$2,600
Shrubs	$2,600
Planting labor	$12,000
Mulch/weed fabric	$6,500
Weed control	$5,000
Watering	$5,000
Total	**$35,800**

* Detailed explanation of the costs included in the table can be found in the King County report.

Both in-stream restoration and riparian planting protect many functions important to B-IBI and stream health, such as treating and slowing down runoff, providing detritus, and large wood and shade to waterways that provide habitat for adult insects. Identifying costs with such activities can help to prioritize restoration and protections efforts where needed.

8.1.1.3 Water Quality BMPs in Agricultural Lands

Agricultural BMPs aim to limit the impacts of livestock and cultivation on nearby streams. These can include livestock fencing, managing waste so that excess nutrients and pathogens do not contaminate streams, and reducing inputs of fine sediments from banks and fields.

Water quality BMPs can be structural or non-structural methods recommended through planning processes that have demonstrated success for addressing and preventing water quality degradation (Washington State Department of Ecology 2019) BMPs are physical, structural or managerial practices that prevent or reduce non-point source pollution, thus reduce sediment, toxics, nutrient and bacteria load. The cost estimates for BMPs are based on 2015 King County projects, and are useful to get an idea of how much these actions can cost.

Table 8-7 indicates the estimated costs of implementation of specific BMPs per designated unit. The estimated cost for livestock exclusion fencing can vary on the animals targeted, number of gates needed and overall design. The cost for pasture renovation/grass filter strip includes liming, tilling, seeding and equipment cost.

Table 8-7. Cost Estimates for Water Quality BMPs in Agricultural Lands (King County 2015)

BMP	Estimated Cost	Unit
Livestock exclusion fencing	$10-15	Per linear foot
Solid manure handling	$500-1,000	Per large animal
Confinement areas	$500-1,500	Per large animal
Pasture renovation/grass filter strips	$300-500	Per acre

*Detailed information of numbers included in the table is on page 55 of the King County report.

8.1.1.4 Conservation Actions (acquisitions and easements)

Another important restoration activity is acquiring land for protection or placing conservation easements on land to impede development.

Table 8-8 provides costs estimates of some of King County land purchases and conservation easement acquired between 2010 and 2015. A total of 435 parcels (of several land use types) were purchased each at different prices. The estimated price per acre is the total of parcels purchased, of a certain property type, divided by the total purchasing cost. The property type indicates the reason the land was purchased, for example ecological protections (ecological), flood protection (flood), park expansion (parks), agricultural protections (farmland), and high stormwater area (stormwater). Other jurisdictions may have different approaches to land conservation through purchases or easements and use different prioritization criteria to address their basins' distinct needs (King County 2015b).

Table 8-8. Average cost estimates for land purchases and easements in King County between 2010 and 2015 (King County 2015).

Action	Property Type	Estimated price per acre (in $thousands)
Acquisition	City	$900
	Ecological	$51
	Flood	$123
	Parks	$24
	Stormwater	$822
Conservation Easements	Ecological	$10
	Farmland	$2
	Flood	$19
	Parks	$126
	Transfer of Development Rights (TDR)	$7

*Detailed information of numbers included in the table can be found on page 55 of the King County report.

Transfer of Development Rights (TDR) is a market-based mechanism that supports the voluntary transfer of development rights from areas where communities would like to discourage development to areas where new growth should be focused (Aken et al. 2008). TDR allows property owners to keep the rights to the land but limits development on that portion.

8.1.2 B-IBI Sampling and Monitoring

A key recommendation in this Implementation Strategy is to continue monitoring to support effectiveness, and status and trends evaluations.

Recent studies in King County estimate that it costs about $1,250 to $1,500 to sample one site on any given stream for about a 2-year period. This cost includes the field collection, a brief habitat survey done at the site, sample analysis, data quality control and management, and data upload. Currently the Stormwater Strategic Initiative funds two important B-IBI sampling and monitoring projects, costing a little over $600,000 over two years.

8.2 NEP Implementation Strategy Investments

Since 2016, the Stormwater Strategic Initiative Advisory Team has made funding decisions that result in on-the-ground actions. All these actions have costs associated with specific activities, and it can be informative to cost out the Implementation Strategy and/or particular results chains.

The Near Term Actions (NTA) project proposals, funded by the Stormwater Strategic Initiative, support a wide array of activities (Table 8-9). The majority of the NTAs funded are for research and monitoring. The second major project type is barriers, incentives, and technical assistance, followed by plans and planning support. Not many other funding sources are available to support project planning. National Estuary Program (NEP) funds are essential for smaller or rural jurisdictions. Stormwater projects have many other funding sources and therefore are not funded primarily with NEP.

Table 8-9. Number of Stormwater NTAs funded by National Estuary Program, by type and project cost (2016-2020)

Type of Activity	# of NTAs	NEP Funding
Research and monitoring	22	$4,711,918
Education and outreach	8	$1,212,000
Capital projects	8	$1,342,100
Barriers, incentives, and technical assistance	18	$3,715,639
Plans and planning support	15	$4,035,445
Total	**71**	**$15,547,102**

8.2.1 Cost of Inaction

In economics, everything has a cost; there is even a cost when things do not occur. The cost of inaction is a cost that occurs when an issue, like stormwater, is not addressed. A way to quantify the cost of inaction is by using avoided costs. Avoided cost originates from the assumption that functioning natural systems reduce or eliminate costs that would have been incurred in the absence of those systems (Earth Economics 2018).

8.2.1.1 Valuing the Benefits of Natural Capital

A study by Earth Economics stated that ecosystems within the Puget Sound Basin provide between $9.7 and $83 billion in benefits to people every year (Batker et al. 2010). The benefits are called ecosystem services and they are referred to as natural capital. Natural assets, such as our forests, wetlands, lakes, rivers, shorelines and Puget Sound produce economically valuable goods and services. Natural goods include fish, timber, water and agricultural products. Ecosystem services include flood protection, drinking water quality, climate stability, recreation, aesthetic value, and others.

The Earth Economics study (Batker et al. 2010) uses an economic methodology known as benefit transfer; this method essentially takes previously valued ecosystems from other similar geographies and applies them to a particular region. Even though the values used in this study did not originate in Puget Sound, they are still an important tool, especially when quantifying benefits produced by restorations actions like the ones mentioned through this B-IBI Implementation Strategy narrative.

8.3 Cost Summary

As seen throughout this section, cost estimates for B-IBI improvement are varied and site-specific. However, this section provides examples of a range of costs for different activities related to operationalizing the B-IBI Implementation Strategy.

An economic study that values ecosystem services produced by targeted B-IBI improvement actions will be a useful tool to support implementation. Valuing the Implementation Strategy can be used to prioritize implementation pathways, as well as a communication tool to encourage partners and stakeholders to take action in Puget Sound recovery.

8.4 References

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9 Adaptive Management of the Implementation Strategy

Adaptive management is a method for continuous improvement-- plan, do, check, adapt. It is based on new data, analysis, and learning. It is an integral part of planning, implementing, and accelerating Puget Sound recovery.

The Puget Sound Partnership, Puget Sound Institute, and EPA have developed a framework for adaptive management for all Puget Sound Implementation Strategies (Redman et al. 2013). This work provides guidance for the development of Progress Measures and the development of the information system that will track progress measures (including the potential revision of Vital Signs).

9.1 General Considerations to Adaptive Management of the Implementation Strategy

The Implementation Strategy drew upon the experiences and lessons learned from substantial investments in the past decade that were aimed at evaluating regulatory effectiveness, incentives and education, and developing a robust ecosystem science foundation. It is expected that these investments will continue and that new information will be incorporated into future iterations of this document. Moreover, the Implementation Strategy is grounded in assumptions describing causal relationships and the functioning of social-ecological system. These assumptions should be carefully re-evaluated as we continue to learn more. Additionally, strategies are focused on specific barriers; barriers should be evaluated to determine if they are effectively addressed by the actions and approaches described here.

9.2 Adaptive Management of the B-IBI Implementation Strategy

There are several Strategy elements that require further focus and development. Specific elements known to require future attention are listed below.

9.2.1 Working Lands Strategy

As stated in the strategy description, the Working Lands Strategy is not yet complete. During the development process, representatives of the agricultural community requested that a holistic and cross-cutting strategy be developed to address multiple ecosystem components and Vital Signs such as land use/land cover, estuaries, floodplains, salmon recovery, and B-IBI. This would improve overall management and highlight those recovery investments that support multiple benefits.

The Implementation Strategy Working Group has identified the development of a crosscutting Working Lands Strategy as a priority next step. This work has not yet started.

9.2.2 Climate Change

As described in Section 6, climate change modeling suggests that climate change will result in alterations to the timing and magnitude of rain events (and thus changes in stream hydrology) and most likely stream temperatures. Since many of the programmatic and infrastructure changes will likely last for decades, we recommend that climate change be considered as part of future B-IBI Implementation Strategy revisions.

9.2.3 Priority Actions

The Implementation Strategy development process did not generate a cohesive list of implementable actions that, if executed, would likely lead to the achievement of the B-IBI targets.

We recommend that areas of the Implementation Strategy (results chains and interim results) be prioritized for further development, and teams of relevant experts should assist in generating details on actions necessary to achieve the interim results.

The Stormwater Strategic Initiative team, in collaboration with regional partners, has already begun this aspect of adaptive management through a series of workshops that focus on individual strategy elements, and are meant to provide an opportunity for review of key assumptions and proposed approaches, while identifying priority actions that will lead to the operationalization of the overall Implementation Strategy.

9.2.4 Implementation Strategy Ongoing Review

We recommend that the information in the Implementation Strategy be reviewed and updated when new information or a new priority necessitates it. The Stormwater Strategic Initiative, in collaboration with regional partners, will host workshops to update strategy performance metrics, highlight new information, and determine if any changes are warranted. The first of these workshops has taken place and it is expected that subsequent workshops will take place every 6-12 months.

Adaptive management reviews and updates would likely not apply to the entire strategy document but rather specific elements such as the State of Knowledge Report and the Base Program Analysis. The State of Knowledge Report could incorporate new research while the Base Program Analysis could incorporate results from new studies that address program effectiveness or trials in the Puget Sound or elsewhere.

Research and Monitoring Priorities have been incorporated into a “Grand Uncertainties Matrix” and used to inform research funding associated with the National Estuary Program, the Puget Sound Partnership, and the Puget Sound Ecosystem Monitoring Program, amongst others. The expectation is that questions and uncertainties in the Grand Uncertainties Matrix will be addressed through focused investigations and that the resulting information will be incorporated back into Strategy development and planning.

9.2.5 Cross-Strategy Syntheses

The Puget Sound Institute is currently working on a cross-strategy synthesis that is meant to identify commonalities and synergies between the suites of identified strategies (see Section 4.6 for a brief presentation). The results should help coordinate work and indicate where multiple benefits can be achieved. The synthesis will include Toxics in Fish, Land Development and Cover, Floodplains, Summer Stream Flows, and Chinook. Results of this exercise should be incorporated into future revisions of this document.

9.3 Progress Measures

Progress measures are essential in understanding activities, results, and overall outcomes of our efforts to protect and restore the Puget Sound. The B-IBI Vital Sign indicator is one such measure. It is valuable in providing an integrated measure of stream biological condition, but does little to inform on short or intermediate-term activities or ecosystem response. A suite of measures is typically needed. The selection of progress measures related to B-IBI is described below.

9.3.1 Selection Process for Activity Progress Measures

The Puget Sound Partnership is leading an effort to develop progress measures to provide information on Puget Sound recovery (see Puget Sound Partnership Delta project memorandum titled, "Task 3A: Purpose and Use of Progress Measures.") The purpose is to provide a suite of measures addressing the Vital Signs, and aligned with Implementation Strategies, which 1) provide information on the natural and human drivers affecting the Vital Signs, and 2) support adaptive management. Three types of progress measures have been defined:

- Activity Progress Measures: track the actions (project and program implementation, etc.) which are meant to improve a Vital Sign;
- Intermediate Progress Measures: track the changes in, and provide an opportunity to improve our understanding of, the drivers that cause changes to the Vital Signs; and
- Outcome Progress Measures: track the changes in the condition of Puget Sound ecosystem and/or human wellbeing.

Each of the measures occupy a different aspect of the Puget Sound reporting framework, as illustrated by Figure 9-1.

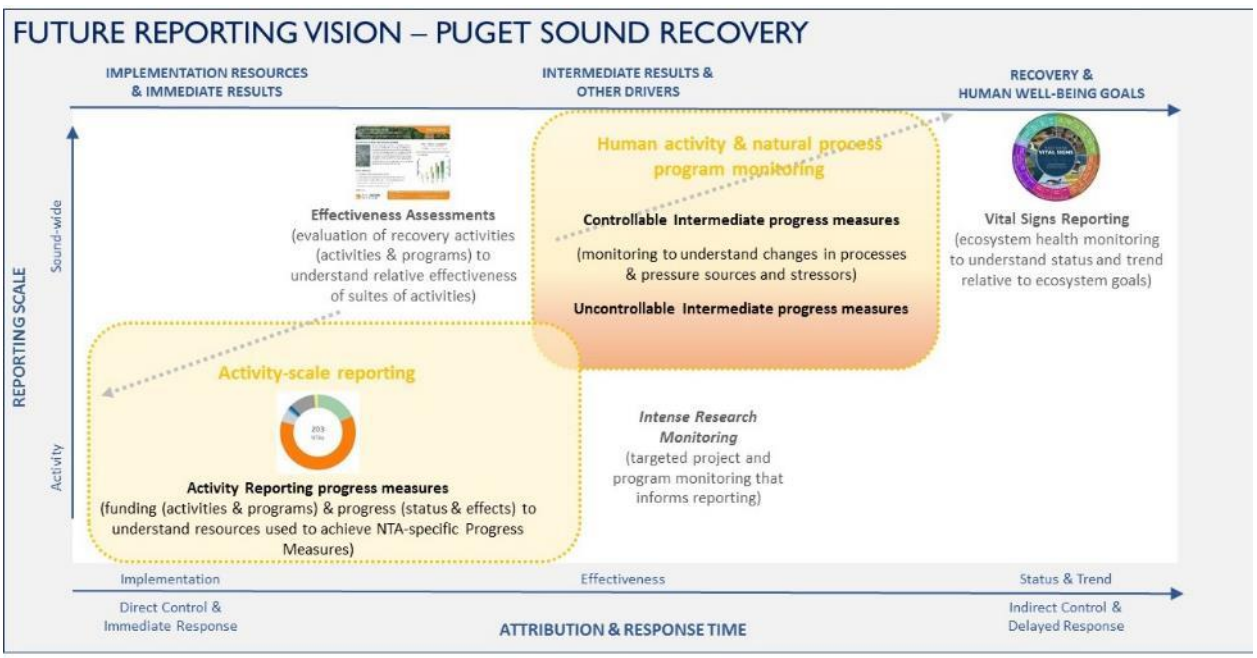


Figure 9-1. The relationship and differences between the activity measures, intermediate measures, and outcome measures (in this case, the Vital Signs).
The y-axis presents the scale of reporting, from localized (activity) to regional. The x-axis presents the extent of control (direct to indirect), attribution, and response time (immediate to long term). Activity progress measures focus on the smallest scale, with the highest level of control.

The current effort focuses on identifying a set of Activity Progress Measures under each Implementation Strategy. The first step to identifying suitable activity progress measures is to review potential activities under the each of the B-IBI strategies, and then to determine a measure to track the extent and magnitude of implementation (e.g., number of BMPs, acres treated). A set of potential measures were identified in the workshop, hosted by the Puget Sound Partnership in August 2018. Additional measures were identified by the B-IBI Core Team. The set of potential activity measures were screened by comparing each to a set of criteria that describe the characteristics of a quality activity progress measure. The characteristics include:

- Attribution: there is a demonstrated link between the progress measure and an eventual change in the Vital Sign.
- Direct Control: the progress measure changes as a result of an activity performed as part of the strategy implementation
- Reliable: activity measures should change in predictable and consistent ways. It should be possible to get predictable and reproducible data describing the progress measure.
- Understandable: the meaning of changes in the progress measure should be clear even to those not directly involved in the work. They can be used in communication and storytelling.
- Feasible: the cost and time to gather information and report results should not pose a substantial burden on a project.

The screening process identified a set of potential activity progress measures. A subset of these were brought forward (Table 9-1).

To improve our ability to compile and compare monitoring efforts across programs and projects, a standard terminology for progress measures was developed. All activity progress measures should include, at a minimum, the following information:

- Progress Measure Name: A short description of what is being measured, preferably including the units of measurement (e.g., Miles of Roads Swept);
- Objective: Desired future state of the progress measure. It should be quantitative, measurable, with a discreet time line. A Vital Sign Target is a specific example of an objective; and
- Metric: A clearly defined standard of measurement.

Progress measures will be incorporated into the Puget Sound Info website to facilitate reporting and evaluation of progress towards recovery.

9.3.2 Proposed B-IBI Progress Measures

Four progress measures are proposed for the B-IBI Implementation Strategy – three activity measures and one intermediated progress measure (Table 9-1). Data for activity progress measures would be provided by implementing partners, while data for the intermediate progress measure may be collected through a focused regional or cross-jurisdictional effort. Most of the measures are cross-cutting; the data (or a subset of the data) collected and reported for a particular recovery goal will also be valuable information for progress towards another recovery goal. While these are a good starting point, focused effort should be dedicated to ensuring that progress measures are sufficiently comprehensive, and accurate to the Implementation Strategy.

Table 9-1. Proposed progress measures for the B-IBI Implementation Strategy

Progress Measure Name	Unit	Description	Notes
Value of Stormwater-related Incentive Programs	$	A key strategy element is to increase the amount of incentive programs available that would directly lead to an increase in stormwater retrofits and habitat protection and restoration activities on private lands. This progress measure will track the value of the incentives utilized/distributed.	The value of incentives is a cross-cutting performance measure.
Area Treated by Stormwater BMPs	Acres	This represents the amount and type of developed land treated by stormwater best management practices (BMPs). Land use type and BMP type are sub-categories of information that will be collected.	The treated area is typically calculated during the BMP design phase. The values from this progress measure can be used to calculate the volume (gallons) of runoff treated and the amount of toxics removed or prevented from flowing into streams.
Area of Restored Riparian Habitat	Acres	Riparian areas provide critical habitat for many species, contribute nutrients to aquatic food webs for salmon, and slow the flow of water which reduces soil erosion and flood damage. Restoring the condition of degraded riparian areas improves ecosystem services. Riparian plantings provide natural land cover for habitat and reduce water temperatures by shading the stream. Due to the significant loss and degradation of riparian areas throughout Puget Sound, it is critical that degraded riparian areas are improved to restore ecosystem services that benefit species and people. Activities to restore or improve riparian habitat could include revegetation projects and riparian restoration associated with shoreline infrastructure removal projects.	This is a cross cutting measure designed for salmon. IDT identified riparian areas as key for stream health. Could focus on a subcategory of project area (for lowland streams).
Percent of Puget Sound Covered by Stormwater Utility Fees	%	Stormwater utility fees have been identified as a stable and equitable source of stormwater funding. This measure will represent the fraction of impervious area covered by a stormwater fee.	This is a proposed measure. Would like to normalize according to a land use measure (percent impervious) that is meaningful in terms of runoff.

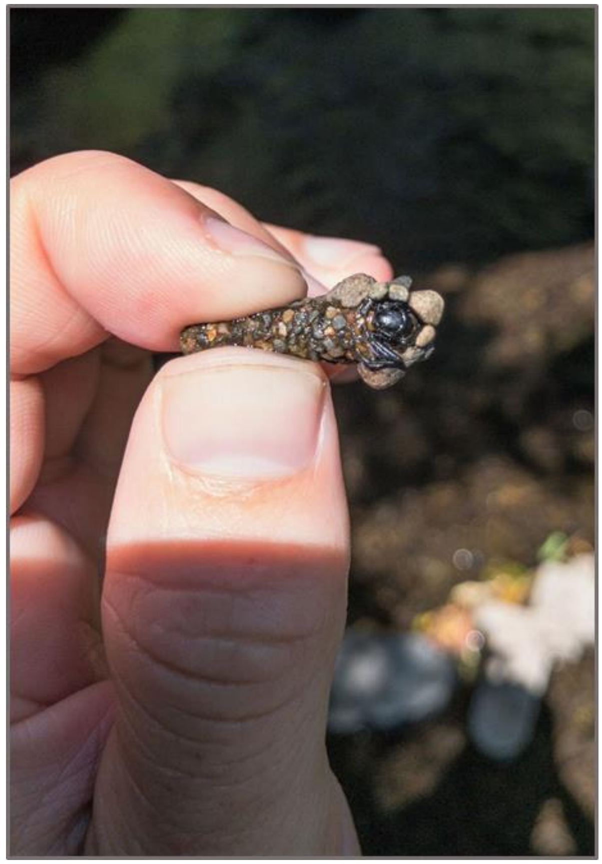
9.4 Further Consideration – Vital Sign Revision Project

The Puget Sound Partnership has launched the Vital Signs Revision Project update the set of Puget Sound Vital Signs and indicators. This revision effort is building on the existing foundation and experience gained over the last 10+ years to define an updated set of Vital Signs and indicators which will carry recovery forward past 2020. The Vital Signs and indicators have become central to planning and management for Puget Sound recovery and so their revision might expand and or redefine the scope of efforts.

The revised Vital Signs were presented to the Leadership Council in June 2020 and accepted as proposed. B-IBI was maintained as an indicator for Freshwater Quality while the previous indicators were replaced with “water temperature in streams and rivers” and “nutrient concentration in streams and rivers.” Reporting on these new indicators has not yet begun. Since both of these measures describe potential stressors that can affect benthic invertebrates, it is reasonable to expect that future adaptive management exercise will incorporate them into evaluation and analysis.

10 Conclusions

The Puget Sound region is expected to receive nearly two million more residents over the next 30 years. This presents one of the most substantial risks to Puget Sound recovery efforts. We are not currently prepared to accommodate projected growth and maintain B-IBI scores. If we intend to protect "excellent" streams, and restore "fair" streams to "good" condition, much investment and effort will be needed. We will not achieve our recovery goals based on the status quo.



The B-IBI Implementation Strategy aims to build a strategy for freshwater quality that is multi-faceted, multi-disciplinary, and applicable at a Puget Sound regional scale. This type of planning is rare, and represented a tremendous opportunity to develop a shared vision to confront commonly understood challenges. Through a shared vision, the region will have more opportunity to coordinate and focus efforts for stream recovery and protection. This strategy is not final. However, it does represent a step forward in regional coordination and an important aspect of adaptive ecosystem-based management.

This Implementation Strategy tackles some of the largest restoration and protection challenges for Puget Sound recovery and is intended to create a pathway for meaningful, measurable progress toward ecosystem recovery goals.

10.1 Key takeaways and next steps

Land use challenges are common to nearly all components of Puget Sound recovery. This Implementation Strategy has implications for land use planning, stormwater management, and riparian and hydrologic restoration activities. Work on this strategy should be done in conjunction with the other strategies that address similar pressures and stressors.

Realizing these strategies will be a substantial challenge, and will require significant shifts in the way we interact with the environment, manage growth, and address the cumulative impacts of development. It will require resources, coordination, and political will.

The publication of the B-IBI Implementation Strategy is a starting point. We expect to build more detail about achieving important interim results. We will need to coordinate implementation, and to realize our full potential, we must mobilize the Puget Sound recovery community including local practitioners and elected officials. This Implementation Strategy document and the related systems, processes, and participants that led to its formation are working to build on it, implement recommendations, and accelerate recovery.

At its core, this Implementation Strategy addresses two fundamental questions:

How can we manage growth to protect important ecosystem functions?

***How do we mobilize limited resources to accomplish restoration at a scale adequate to repair ecosystem functions previously impacted by human development and land-use practices*?**

This gives us a framework to answer these questions but it does not make the hard choices, does not do the work, and does not push forward the bold initiatives that will be necessary. Those tasks are left to all of us.