WATER RESOURCES ELEMENT

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NOTE: HIGHLIGHTED GOALS ARE RECOMMENDED TO BE MOVED TO UTILITIES ELEMENT

WATER RESOURCES ELEMENT

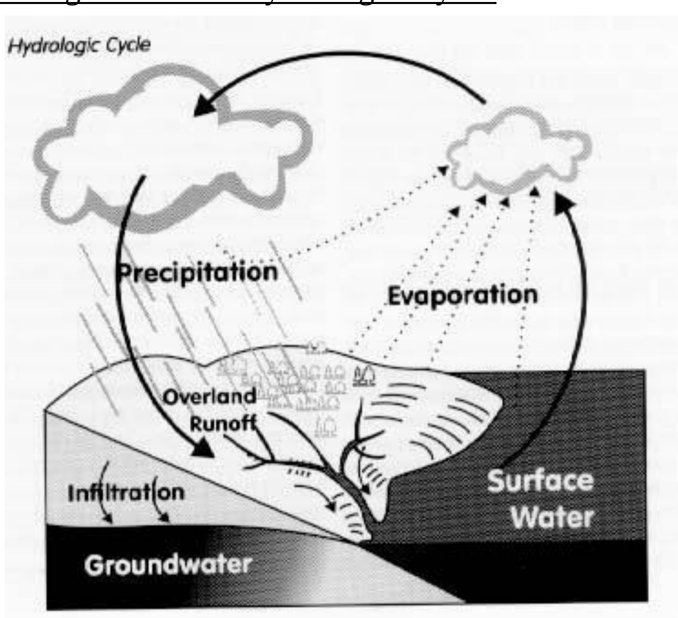
INTRODUCTION

Bainbridge Island is a quasi-enclosed environment that requires a holistic perspective to understand the interdependence among the Island's three primary water resources: *groundwater*, surface water, and *stormwater*. Although these waters are typically regulated and managed independently, they are, in nature, intimately connected. In fact, it is all the same water, simply given a different name and managed according to where it resides in the hydrologic cycle at any given time (see Figure 1).

When rain falls, rainwater that is not evaporated or taken up by plants will take one of three paths. It may infiltrate into the ground where it is called *groundwater*. It may drain directly into *streams* and harbors where it is called surface water, or it may be captured by manmade *infrastructure* such as street drains, ditches, or detention/retention ponds where it is called *stormwater*.

Rainwater that infiltrates into the ground (*groundwater*) may be pumped from wells to provide drinking water or irrigation or seep out of the ground into *streams*, springs, and harbors where it is, again, called surface water. Likewise, *stormwater* may discharge into a nearby stream or harbor and become surface water or infiltrate into the ground and become *groundwater*.

Figure 1. The Hydrologic Cycle



In order to successfully protect and manage any one of these waters, one must protect and manage all three. To address these interrelationships, a separate Water Resources Element has been developed as follows:

- General water resources management policies
- *Groundwater* protection and management ~~and protection~~ policies
- Surface water protection and management ~~and protection~~ policies
- *Stormwater* protection and management ~~and protection~~ policies
- Residential on-site sewage system policies
- Contaminated sites policies
- Public education and outreach policies

Land use Connection

In the development of policies related to the management of our Island water resources, it is important to understand the links between water resources quality and quantity and *land use*. Most water quality and habitat integrity impacts are caused by the way land was or is used. Developed land allows for rapid *runoff* and inundation of natural conveyance systems such as *wetland*s and *streams*. Rapid *runoff* can cause damage through flooding, erosion, and water-borne contamination.

In addition, *household*s create sewage which needs disposal either by a wastewater treatment plant or by residential on-site sewage systems. Wastewater treatment plants are reasonably effective at cleaning wastewater, but do not at present provide complete removal of nitrogen nor treat for contaminants of emerging concern which include, but are not limited to, byproducts of medications, recreational drugs, health and beauty products, and caffeine.

Residential on-site sewage systems can fail and cause contaminants to enter the surface water and/or *groundwater*. Even functioning systems, depending upon *density* and proximity to surface water and *groundwater*, can contribute to accumulations of nitrogen and contaminants of emerging concern in these waters.

Use of fertilizers, pesticides, and other chemicals for cropland, lawns and gardens, and vehicle and *household* cleaning and maintenance as well as improper pet and livestock waste management can add significant contamination to surface water, *stormwater* and *groundwater*.

Commercial and industrial uses, past and present, leave behind pollutants in our soils. In particular, historic *land use*s such as large row crop agriculture, lumber, petroleum, and others have left behind legacy pollutants in sediments both on upland properties and in the sediments along the bottoms of our *streams*, harbors, and nearshore areas.

Without proper coordination of the regulations that will implement policy statements, conflicting signals may be given when dealing with water resources issues. For example, a surface water problem may be resolved by efficiently collecting and removing all water from the area, whereas a *groundwater recharge* issue may require that the water be kept on-site to allow for infiltration.

Another conflict arises when infiltration of *stormwater* competes for space with on-site sewage system drainfields. There are physical limitations to the rates of infiltration and absorption based on soil types, which may make it impossible to have both of those facilities on the same site. Where development occurs in important *aquifer recharge areas*, special consideration is needed to preserve the volume of *recharge* available to the *aquifer* and to protect the *groundwater* from contamination.

A key component of ~~the~~ water resources protection and adaptive management ~~strategy~~ is adequate monitoring ~~and assessment~~ in order to assess impacts of current *land use* and effectiveness of applied management actions.

The overriding theme that runs through all of the policies and *goal*s in this element is the preservation and protection of water quality, water quantity, and ecological and hydrologic function.

Climate change

Climate change projections indicate that over the coming decades, sea level may rise up to four feet in the Puget Sound region, the ocean will become more acidic, and climatic conditions are likely to become warmer. This will result in more intense rain events during the wet season with longer, drier summers, though overall annual volume of rainfall will remain approximately the same.

Ocean acidification will likely impact aquatic species survival and assemblages in our marine areas and sea level rise will likely impact habitat and built *infrastructure* in our nearshore areas including homes, businesses, and public facilities such as roads and sewer facilities.

Wetter conditions during the wintertime will increase water availability, but may cause flooding or diminish water quality. More intense and frequent storms or heavier rainfall events can cause *stormwater* inundation and localized flooding, chronic flooding, non-infiltrated run-off, erosion and lands*LID*es. Increased intensity of rainfall may also diminish *aquifer recharge* rates as saturated soils are less able to absorb large amounts of water falling over short periods of time.

Warmer, drier conditions in the summertime will increase evaporation rates and water demand by plants, wildlife and people, and may diminish water quality. Dry conditions decrease water availability, resulting in reduced stream flow and diminished *aquifer recharge*. Warmer and drier conditions can also reduce water quality, both by increasing in-stream temperatures and by concentrating contaminants in smaller volumes of water.

~~[2] *City of Bainbridge Island Level II Assessment: An Element of the Water Resources Study*, 2000, Kato & Warren, Inc., Robinson & Noble, Inc~~

VISION

Bainbridge Island's water resources (precipitation, on the surface, and in the ground) are climate resilient and demand and quantity are adequate for all forms of life on the Island. *Aquifers* are continuously monitored and maintained above the early warning level. The water quality for most of the consumed water is monitored to ensure quality fully meets the standards for drinking water. Education on water conservation has resulted in a significant reduction in the average water consumption per *household*. The Bainbridge Island *groundwater* model is regularly updated with new data and results from model runs are used to maintain long-term *sustainability* of the Island's water resources. *Low impact development* techniques are applied to all *land use*s and redevelopment.

GOALS AND POLICIES

GOAL 1 General Water Resources

Protection of water resources is of primary importance to the Island. Therefore, the *goal* is to manage the water resources of the Island in ways that restore, enhance, and preserve their ecological and hydrologic function. ~~for present and projected *land uses*, recognizing that they are are the sole water supply and that:~~

- **Degradation of ~~*groundwater* quality and quantity~~ water resources is not allowed.**
- ~~**Water supplies and systems are efficiently utilized.**~~
- **The long-term *sustainability* of the Island's water resources is maintained, taking into account future climatic conditions and their effects on the water cycle.**
- **~~The water needs of~~ N~~n~~ew development and population growth are managed so that water resources remain adequate for the indefinite future ~~approved under the *Comprehensive Plan* are adequately met by the existing resources~~.**
- ***Groundwater*, surface water, and *stormwater* monitoring, data assessment, and reporting ~~Adequate data of the water resource~~ are current and available including future projections of availability, quality and need.**
- **Use current and future technology to maintain and protect water resources.**

General Water Resources Policies

Policy WR 1.1

The City *shall* study future climate and demand scenarios to accurately understand future water resource conditions.

Policy WR 1.2 ~~1.1~~

~~The City *shall* coordinate with other major private water purveyors, government agencies and citizens to ensure protection and preservation of water resources and to provide efficient high quality Island-wide water service.~~ *Groundwater*, surface water, and *stormwater* are resources that *shall* be protected and managed to preserve water quality and quantity, and to retain natural ecological and hydrologic function to the maximum extent practicable.

Policy WR 1.3 ~~1.2~~

~~To foster sustainable water resources, planning, protection, management, monitoring and on-going education outreach that is based on *watersheds* and natural systems *should* be provided by the City in coordination with appropriate agencies.~~ To foster sustainable water resources, planning, protection, management, monitoring and on-going education and outreach *should* be provided by the City in coordination with government agencies at all levels, drinking water purveyors, *watershed* management groups, Tribes, non-profit organizations, local integrating organizations for regional recovery and protection, and other stakeholders.

Policy WR 1.4 ~~1.3~~

The policies in this element work in tandem with the protective measures set by the City's Shoreline Management Master Program, *Critical areas* Ordinance, and any other environmental or water resources management ordinance established by the City.

Policy WR 1.5

Identify the areas of the Island that are the most vulnerable to pollution from concentrations of fecal coliforms and nitrates (for example, from septic fields, agricultural activities, or fertilizers), and monitor those areas to determine if and when preventative or restorative measures are warranted.

GOAL WR-2 *Groundwater* Protection and Management ~~Protection Policies~~

Policy WR 2.1

Recognize that the entire Island functions ~~To protect *groundwater* resources, areas identified~~ as an ~~high~~ *aquifer recharge area*. *Low impact development* techniques are essential for maintaining *aquifer recharge*.~~*should* be maintained in low impact uses~~.

~~**Discussion:**~~ Low impact uses and ~~low impact~~ less intense development are appropriate for areas with high *aquifer recharge*. Low impact uses include development for buildings, roads or parking that has a reduced area of impact on the land. Low impact uses do not depend on regular applications of fertilizers or pesticides. *Low impact development* is an environmentally-friendly approach to site development and *stormwater* management, emphasizing the integration of site design and planning techniques that conserve and protect the natural systems and hydrologic functions of a site.

Policy WR 2.2

Areas of high *aquifer recharge should* be identified and assessed as part of a *land use* application. Care *should* be taken to minimize the effect of development on these areas.

Policy WR 2.3

To ~~protect Island~~ promote efficient use of *groundwater* resources, the City *shall* encourage the ~~development and~~ expansion of public and private water systems, rather than encouraging *shall*ow or individual residential wells.

Policy WR 2.4

The City *shall* assess the impacts of proposed activities and development on the flow of springs and *streams* and levels of *wetlands* that are either sustained by *groundwater* discharge or contribute *recharge* to *groundwater*, and require an assessment of anticipated ~~by requiring a~~ hydrologic impacts ~~assessment report,~~. Activities or development may be restricted ~~and restricting the activities or development~~ ~~based on~~ if the report indicates any adverse impacts~~, and/or mitigating impacts~~.

Policy WR 2.5

The City, in cooperation with the appropriate regulatory agencies (e.g., Washington State Department of Health and the Kitsap ~~County~~ Public Health District) ~~*should*~~ will institute new wellhead protection procedures.

~~**Policy WR 2.5**~~

~~For the purpose of protecting surface and *groundwater* quality, the City Parks Department and School District *shall* develop plans to eliminate the use of biocides on their properties through the use of integrated pest management techniques. (~~

Policy WR 2.6

The City *shall* ~~promote the use of develop~~ encourage the use of integrated pest management techniques and the reduction of pesticide and herbicide use within the City boundaries.

Policy WR 2.7

Establish a stakeholder group to develop an Island-wide ~~G~~*groundwater* ~~M~~management ~~P~~plan.

Policy WR 2.8

Develop a program to strongly encourage exempt well owners to regularly monitor the quality of their well water and identify leaks using tools such as flow meters. Results *should* be self-reported to the Kitsap Public Health District.

Policy WR 2.9

Recognizing that the Island *aquifer* system is a Sole Source *Aquifer* as designated by EPA, institute an added level of development and re-development permit review to prevent or mitigate potential pollutant-generating activities associated with proposed *land use*.

Policy WR 2.10

Develop ~~an Island-wide~~ seawater intrusion prevention regulations ~~policy~~.

Policy WR 2.11

The City *shall* develop a water conservation program. ~~*should* be aggressively pursued by the City to promote the efficient use of water and to protect the resource. Water conservation programs *should* encourage the use of vegetation that prevents soil erosion, protects habitat for wildlife, retains surface water for *recharge*, and which does not require additional water during normally dry months.~~

Policy WR 2.12

Water re-use and reclamation will be encouraged to serve as a supplementary source for high-water users such as industry, parks, schools, and golf courses, as approved by the Washington State Department of Health.

Policy WR 2.13

Develop a program that encourages homeowners to explore innovative methods for recapturing and reusing surface water *runoff* and grey water, as approved by the Washington State Department of Health and the Kitsap Public Health District.

Policy WR 2.14

Maintain a comprehensive program of *groundwater* data gathering and analysis. The program *shall* include modeling, hydrogeologic and geologic studies, and monitoring of static water levels, water use, water quality, surface water flows, and acquisition of other data as necessary.

NOTE: *GOAL* 3 HAS BEEN BROUGHT OVER FROM THE ENVIRONMENTAL ELEMENT WHERE THEY WERE LABELED "*AQUATIC RESOURCES* (*GOALS* 6 & 7)"

~~*Aquatic resources*~~ GOAL ~~1~~ WR-3 Surface Water Protection and Management

~~Preserve and protect the Island's remaining *aquatic resources*.~~ Achieve no net loss of ecological functions and processes necessary to sustain *aquatic resources*[1] including loss that may result from cumulative impacts over time.

~~**Discussion**: *Aquatic resources* include marine nearshore, *wetlands*, *streams*, lakes, creeks, and associated vegetated areas.~~
Over ~~the past~~ recent decades, awareness has grown of the importance of preserving and protecting *aquatic resources* ~~particularly *wetlands*, in our natural and built environment~~. *Aquatic resources* have a number of important ecological functions, processes and values. These functions vary ~~from *wetland* to *wetland*, stream to stream~~, but include providing water quality protection, flood plain control, shoreline stabilization, contributions to *groundwater* and stream flows and wildlife and fisheries habitat. ~~*Wetlands* and *streams*~~ *Aquatic resources* also have values as natural areas providing aesthetic, recreational and educational opportunities that ~~need to~~ *should* be preserved for future generations.

~~AQ 1.1~~

~~Achieve no overall net loss of the City's remaining, regulated, *aquatic resources*.~~

~~AQ 1.2~~ Policy WR 3.1

~~Development *shall* not be approved in regulated *wetlands*, *streams*, or buffer areas, unless a property owner would be denied all reasonable use of property.~~

[1] *Aquatic resources* – Marine nearshore, *wetlands*, *streams*, lakes, creeks and associated vegetated areas.

Development *should* not be approved in regulated aquatic *critical areas* or their associated water quality buffer unless the subject property is encumbered to such an extent that application of *development regulation*s would deny all reasonable use of property.

Discussion: In some cases, buffer configurations and widths can be modified to allow normal usage of legally established lots. In other cases, the development and implementation of a habitat management plan may provide resource protection to allow development. A variance process *should* be available to accommodate development in buffer areas. Reasonable use exception *should* be reserved for development in the critical area if no other process will allow for a reasonable use of the property. A Reasonable Use Exception (RUE) is a form of variance from regulations that allows some use of a legally established lot. A reasonable use must minimize the impact to *critical areas*. The RUE process is included in the *critical areas* regulations of the Bainbridge Island Municipal Code, which implements policies of this document.

AQ 1.3 Policy WR 3.2

Require that vegetated buffers be maintained between proposed development and the aquatic resource in order to protect the functions and values of such systems. Degraded buffers *should* be restored to enhance their function. Allow Rreductions in vegetated buffers *shall* be allowed only in areas where such reductions, if consistently applied, would not result in significant cumulative impacts to *aquatic resources* and *fish and wildlife habitat*.

AQ 1.4 Policy WR 3.3

Require that buffers be retained in their natural condition wherever possible, while allowing for appropriate maintenance. Where buffer disturbance has occurred, require revegetation with appropriate species, with a preference for native species, to restore the buffers' protective values.

Discussion: Vegetated buffers facilitate infiltration and maintenance of stable water temperatures, provide the biological functions of flood storage, water quality protection and *groundwater recharge*, reduce amount and velocity of run-off, and provide for wildlife habitat.

AQ 1.5 Policy WR 3.4

Ensure that development activities are conducted so that *aquatic resources* and natural drainage systems are maintained and water quality is protected.

AQ 1.6 Policy WR 3.5

Prior to any clearing, grading, or construction on a site, all *wetland*s, *streams*, and buffer areas *should* be specifically identified and accurately located in the field in order to protect these areas during development. After construction, permanent visual markers *should* be placed around the buffer areas.

Discussion: The purpose of this policy is to educate future home owners and users of *aquatic resources* (i.e., trail users) of the boundary of the *aquatic resources*.

AQ 1.7

New development using flexible lot design *should* include any *wetlands*, *streams*, or required buffers in separate tracts or easements to remain in common ownership.

AQ 1.8 Policy WR 3.6

Herbicides and pesticides *should* *shall* not be used in aquatic resource areas *wetlands*, *streams*, and buffers areas, and *should* be discouraged in the areas that drain into them.

Discussion: Encourage alternatives to the use of herbicide and pesticide in areas adjacent to buffer areas by providing technical information and educational programs including the use of *native vegetation*.

AQ 1.9 MOVE TO *GOAL* 4

Develop a community-wide program to educate Island residents about alternatives to using and disposing of herbicides, pesticides, and other *household* chemicals to reduce impacts to marine shoreline areas, *wetlands*, *streams*, and other *environmentally sensitive areas*.

AQ 1.10 Policy WR 3.7

Prohibit Aaccess to regulated *wetlands* aquatic *critical areas* by *farm* animals *should* be discouraged. Agricultural activities within proximity of *aquatic resources should* complete a *farm* management plan addressing water quality and other natural resource protection must be in conformance with Best Management Practices.

AQ 1.11 Policy WR 3.8

Mitigation *shall* be required to compensate for unavoidable impacts to aquatic *critical areas*. Mitigation *should* be designed to achieve no net loss in functions and processes of *aquatic resources*. Restoration, creation or enhancement of *wetlands*, *streams*, and their buffers *shall* be required in order to offset the impacts of alteration of a *wetland*/stream or buffer area. Compensation for loss of *aquatic resources should* be determined according to function, acreage, type, location, time factors, and an ability to be self-sustaining.

Policy WR 3.9

Promote *watershed*-based mitigation to meet federal regulations, improve mitigation success and better address the ecological priorities demands of the island's *watersheds*.

Policy WR 3.10 MOVE TO GOAL 1

Identify the areas of the Island that are the most vulnerable to pollution from concentrations of fecal coliforms and nitrates (for example, from septic fields, agricultural activities, or fertilizers), and monitor those areas to determine if and when preventative or restorative measures are warranted.

Policy WR 3.10

Work with state and local health departments to evaluate the merits of new technologies such as greywater capture, package treatment plants and composting toilets, as alternatives to septic and sewer systems; and determine which of those systems *should* be allowed and/or encouraged to better protect the quality and capacity of the Island's ~~*groundwater*~~ surface water and nearshore environment.

Policy WR 3.11

~~The City will c~~Consider the ~~implications~~ impacts of *climate change*~~,~~ and ocean acidification, ~~and their impacts~~ when developing regulations or approving capital projects related to *aquatic resources*, including marine nearshore, *wetland*s, *streams*, lakes, creeks, associated vegetated areas and *frequently flooded areas*.

~~Wetlands~~

~~AQ 1.12~~

~~Maintain the Island's *wetlands* in their natural state by:~~

- ~~Preservation of *native vegetation* in and next to the *wetlands*.~~
- ~~Restoration of areas that have already been degraded.~~
- ~~Protection of areas that have not been disturbed.~~

~~AQ 1.13~~ MOVED TO GOAL 4

~~The City *should* make every effort to purchase or obtain *conservation easements* for significant *wetlands* and areas of the shoreline critical to natural habitat.~~

~~Streams~~

~~AQ 1.14~~

~~Maintain the Island's *streams* and creeks in their natural state by:~~

- ~~Preservation of their courses, their banks, and the vegetation next to them.~~
- ~~Restoration of areas that have already been degraded.~~
- ~~Protection of areas that have not been disturbed.~~

~~AQ 1.15~~ Policy WR 3.12

Allow stream relocation only where relocation would result in improved stream habitat ~~and~~ or when a property owner would otherwise be denied all reasonable use of the property.

~~AQ 1.16~~ Policy WR 3.13

Degraded channels and banks *should* be rehabilitated by various methods (e.g., culvert replacement, volunteer efforts, public programs or as offsetting mitigation for new development) to restore the natural function of the riparian habitat for fish and wildlife.

~~AQ 1.17~~ Policy WR 3.14

Resident and migratory ~~Anadromous~~ fish *streams* and adjacent land *should* be preserved and enhanced to ensure a sustainable fishery ~~the propagation of salmonid fish~~.

~~AQ 1.18~~ Policy WR 3.15

Require the construction of public facilities ~~necessary roads and utility corridors~~ to avoid ~~*wetland* and stream crossings and~~ encroachment into and disturbances of *aquatic resources*.

Policy WR 3.16

Maintain a comprehensive program of surface water inventory,data gathering and analysis. The program *shall* include monitoring and assessment of physical, chemical, and biological health of surface water ecosystems to include *streams*, ephemeral *streams*, lakes, *wetland*s, and marine waters. This may include water, flow, sediment, habitat, submerged aquatic vegetation, fish and shellfish tissue, aquatic species diversity and other ecosystem health indicators.

~~GOAL WR-4~~

~~Promote the maintenance, restoration and enhancement of *aquatic resources*.~~

~~AQ 1.9~~ Policy WR 3.17

~~Develop a~~ Support acommunity-wide program to educate Island residents about alternatives to using and disposing of herbicides, pesticides, and other *household* chemicals, to reduce impacts to marine shoreline areas, *wetland*s, *streams*, and other *environmentally sensitive areas*.

Policy WR 3.18

Promote and support volunteer or community-driven restoration projects.

~~AQ 1.13~~ Policy WR 3.19

The City *should* make every effort to purchase or obtain *conservation easement*s for significant *wetland*s and areas of the shoreline critical to natural habitat.

Policy WR 3.20

Permanent visual markers *should* be placed around the buffer areas of protected *aquatic resources*.

THIS GOAL MOVED TO UTILITIES ELEMENT

~~Drinking Water Service Policies~~

GOAL WR-4 *Stormwater* Protection and Management

***Stormwater* is a resource that, rather than be captured and carried away as a wastestream, *should* be protected from pollutants and retained on site to replenish *aquifers* and maintain *wetland* and summer stream flows, preserving or mimicking the natural water cycle to the maximum extent practicable.**

Policy WR 4.1

Comply with all requirements of the City's National Pollutant Discharge Elimination System Phase II Municipal *Stormwater* Permit (NPDES Permit).

Policy WR 4.2

Continue to provide ongoing opportunities for the public to participate in the decision-making process involving the development, implementation and update of the City's *Stormwater*

Management Program (SWMP) through advisory councils, public hearings, and *watershed* committees.

Policy WR 4.3

Continue to improve and maintain an education and outreach program designed to reduce or eliminate behaviors and practices that cause or contribute to adverse *stormwater* impacts and encourage the public to participate in stewardship activities.

Policy WR 4.4

Continue to identify and eliminate sources of pollutants to the City's *stormwater* drainage system through proactive field screening techniques such as effluent monitoring, system inspections and cleaning, and commercial and industrial business inspection, and through the enforcement of the City's Illicit Discharge Detection and Elimination ordinance.

Policy WR 4.5

Ensure development of, and adherence to, required public and private *stormwater* pollution prevention plans (SWPPPs) for public facilities, construction sites, and commercial and industrial landuse. Encourage the use of such plans where not specifically required.

Policy WR 4.6

Ensure development of, and adherence to, erosion and sediment control plans on all construction and development sites of any size.

Policy WR 4.7

Develop and actively enforce a strong *Low impact development* (*LID*) ordinance to require any and all methods and practices for new development and redevelopment to the maximum extent practicable and reasonable. *LID* is a *stormwater* and *land use* management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation, and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed *stormwater* management practices that are integrated into a project design.

Policy WR 4.8

Prioritize *LID*-based retrofit of public and private *stormwater* drainage systems and built assets through the inventory, management and fiscal planning process.

Policy WR 4.9

Incentivize *LID* retrofit of current built environment.

Policy WR 4.10

Use *watershed* and basin plans as a means to reduce *stormwater* impacts and *non-point source pollution*.

Policy WR 4.11

Comply with all requirements specifically identified by the City's permit for any Total Maximum Daily Load (TMDL) in which the City is a stakeholder.

Policy WR 4.12

Conduct effectiveness monitoring and assessments to continue to adaptively manage *stormwater* to ensure optimal protection.

GOAL WR-5 ~~*Sanitary sewer*~~ Residential On-Site Sewage Systems

Ensure that sewage is collected, treated, and disposed of properly to prevent public health hazards and pollution of *groundwater*, Island surface water, ~~including~~ and the waters of ~~the~~ Puget Sound~~, and to promote *recharge* of the waters of Puget Sound~~.

~~*Sanitary sewer* On-Site Systems Policie~~s

Policy ~~SSP 1.1~~

~~Properly designed and maintained on-site wastewater disposal systems that are approved by the Kitsap County Health District or the State Department of Health are a long-range solution to sewage disposal in most areas of the Island. However, there may be areas of the Island determined by the Kitsap County Health District to be unsuitable for on-site wastewater disposal systems due to site conditions (such as steep *slopes*, geological or soil conditions, lot size, or proximity to sensitive bodies of water).~~

Policy WR 5.1 ~~SSP 1.2~~

Regulations and procedures of the Washington State Department of Health and the Kitsap ~~County~~ Public Health District ~~*shall*~~ apply to all on-site disposal systems. The City *shall* work with these agencies to assure regular inspection, maintenance and repair of all *sanitary sewer* and on-site systems located on the Island.

Policy ~~SSP 1.3~~

~~Certification of adequate design and proper operation of septic systems *shall* be required prior to issuance of permits for remodeling of existing buildings.~~

Policy ~~SSP 1.4~~

~~Prior to issuance of a building permit, on-site drainfield and reserve areas *should* be identified and marked, and a protection plan *should* be approved for any building lot.~~

Policy WR 5.2 ~~SSP 1.5~~

The City *shall* request notification of all waivers or variances of Kitsap ~~County~~ Public Health ~~Department~~ District requirements, such as modification of setbacks, vertical separation, minimum lot size, reserve drainfield, etc., prior to issuance and subsequent modifications by the Kitsap Public Health District of an approved Building Site Application.

Policy WR 5.3 ~~SSP 1.6~~

~~Kitsap County Health District approved~~ A~~a~~lternative systems, such as sand filters, aerobic treatment, composting toilets, and living-systems ~~etc.,~~ *shall* be allowed when approved by the Kitsap Public Health District. ~~*should* be encouraged for sites where conventional on-site systems are not suitable or feasible.~~

Policy WR 5.4 ~~SSP 1.7~~

Regulations *shall* require coordination between the on-site septic and *storm drain*age disposal systems designs to ensure the proper functioning of both systems.

Policy WR 5.5 ~~SSP 1.8~~

The City *shall* assist the Kitsap ~~County~~ Public Health District in developing a program to require proper maintenance of all on-site waste disposal systems in order to reduce public health hazards and pollution. This program *shall* include periodic system inspection and pumping when necessary.

Policy WR 5.6 ~~SSP 1.9~~

The City and the Kitsap ~~County~~ Public Health District *should* work together on a collaborative program to fund and pursue grants or low-cost loans for low and moderate-income *household*s to repair failed septic systems. Incentivize maintenance, repair and replacement of systems for any income level.

Policy WR 5.7~~SSP 1.10~~

On-site waste disposal systems serving more than one *household should* be allowed only with assurance of proper design, operation, management and approval from the Kitsap Public Health District.

Policy WR 5.8 ~~SSP 1.11~~

The City may provide the service of operation and maintenance management for approved large on-site *sanitary sewer* systems (LOSS) or community *sanitary sewer* systems in coordination with the Kitsap ~~County~~ Public Health District.

Policy WR 5.9 ~~SSP 1.12~~

The City *should* support the Kitsap ~~County~~ Public Health District in ~~establishing~~ maintaining and improving a public education program to foster proper construction, operation, and maintenance of on-site septic systems.

Policy WR 5.10 ~~SSP 1.13~~

The City *should* support the Kitsap ~~County~~ Public Health District in developing and maintaining an ongoing inventory of existing on-site disposal systems to provide needed information for future studies.

THIS GOAL MOVED TO UTILITIES ELEMENT
~~Public *Sanitary sewer* Policies~~

THIS GOAL MOVED TO UTILITIES ELEMENT
~~*Stormwater* Management and Protection~~

GOAL WR-7 Monitoring Policies(Incorporated these in each of the sections above)

Policy WR 6.1 M 1.1

The City *should* Maintain institute a comprehensive program of water resource data gathering and analysis. The Such a program *shall* include geologic studies and monitoring of static water levels, water use, water quality, surface water flows, and acquisition of other data as necessary.

Policy WR 6.2 M 1.2

Periodic monitoring and reporting of water quality and quantity of *public water systems* is required by the Kitsap County Health District. Single units *shall* be encouraged by the City to provide well data to the Kitsap Public Utility District and the Department of Health regarding water level recordings, quality degradation, etc.

Policy WR 7.3 M 1.3 DELETE: SAME AS POLICY 5.5

The City *should* Ssupport the Kitsap County Health District in developing a program for proper maintenance of on-site waste disposal systems in order to reduce public health hazards and pollution. This program *should* include periodic system inspection and pumping when necessary.

Policy WR 7.3 M 1.4 DELETE: SAME AS POLICY 5.10

The City *should* Ssupport the Kitsap County Health District in developing and maintaining an ongoing inventory of existing on-site disposal systems to provide needed information for future studies.

GOAL WR-6 Contaminated Sites

Incorporate awareness of known contaminated sites such as former lumber treatment facilities, former fueling stations, and other pollutant-generating *land use* into all water resources management, *land use* planning, and *capital facility* management in order to remediate or clean up sites as effectively as possible, while preventing further impacts to water resources.

Policy WR 6.1

The City will assemble and maintain an inventory of contaminated sites on the Island to track site location, contaminant(s) of concern, cleanup status, and potential to impact nearby surface or *groundwater*.

Policy WR 6.2

The City will collaborate with EPA, Washington State Department of Ecology, and the Kitsap Public Health District to address contaminated site assessment and cleanup efforts within the purview of those agencies to achieve remediation/cleanup as quickly as reasonably possible.

Policy WR 6.3

The City will consult the contaminated site inventory prior to property acquisition and weigh the cost/benefit of acquiring such a property.

Policy WR 6.4

The City will make every reasonable attempt to clean-up/remediate city-owned sites that are known to be or discovered to be contaminated.

Policy WR 6.5

The City will consult the contaminated site inventory as part of development or redevelopment site plan review and take potential impacts into consideration when making *land use* decisions.

Policy WR 6.6

The City will consult the contaminated site inventory as part of capital *infrastructure* construction or maintenance.

Policy WR 6.7

The City will consult the contaminated site inventory as part of emergency management preparedness and response.

GOAL WR-~~8~~7 Public Education and Outreach

The City, in concert with federal, state, and local governments; public water purveyors; *watershed* councils; non-profits; citizens; and other appropriate entities, will continue to improve and implement a comprehensive public education and outreach program in the protection and management of all water resources.

Policy WR 7.1

Educate and inform the public about the purpose and importance of aquatic environments, their vulnerabilities, and observed status and trends in ecological health and function.

Policy WR 7.2

Educate and inform the public about expected *climate change* impacts and how these will affect the Island's water resources and their beneficial uses.

Policy WR 7.3~~PE 1.1~~

~~The City, special districts, and water purveyors will develop and implement a comprehensive public education program in water resource management and protection. The program *should* address all aspects of water conservation and *groundwater* protection, including septic system maintenance, spill management and non-point pollution impacts from *farm* animal/agricultural activities, and homeowner maintenance practices.~~
Educate the public about the characteristics of the *aquifer* system, the Island's dependency upon it, and its vulnerability to contamination (including seawater intrusion) and depletion.

Policy WR 7.4~~PE 1.2~~

~~Water conservation *should* be aggressively pursued by the City to promote the efficient use of water and to protect the resource. Water conservation programs *should* encourage the use of vegetation that prevents soil erosion, protects habitat for wildlife, retains surface water for *recharge*, and which does not require additional water during normally dry months.~~ (**Moved to *Groundwater* Protection and Management, 2.10.**)

Educate the public about EPA's Sole Source *Aquifer* Designation Program and what this designation means for the Island's *aquifer* system.

Policy WR 7.5~~PE 1.3~~

~~*Water re-use* and reclamation will be encouraged to serve as a supplementary source for high-water users such as industry, parks, schools, and golf courses, as approved by the Washington State Department of Health.~~ (**Moved to *Groundwater* Protection and Management, 2.12.**)
Educate the public about well head protection and the critical importance of restricted chemical use or storage within the protection area around wells.

Policy WR 7.6 ~~PE 1.~~4

~~The City *should*~~ Ddevelop a program that encourages homeowners to reduce *impervious surface* area and explore innovative methods for recapturing and reusing surface water *runoff* and grey water, as approved by the Washington State Department of Health and the Kitsap County Public Health District. (**Moved to *Groundwater* Protection and Management, 2.12.**)
Educate the public about Critical *Aquifer recharge areas* (or other special conservation areas) and the purpose they serve to the *aquifer* system.

Policy WR 7.7 ~~PE 1.5~~

~~The City *should* Ssupport the Kitsap County Health District in maintaining establishing a public education program to foster proper construction, operation, and maintenance of on-site septic systems.~~
Inform the public about how to report spills or illicit dumpings of hazardous waste or other pollutants and how to access information about location and status of contaminated sites.

Policy WR 7.8

Inform the public about how to find information about their well and how to properly maintain it.

Policy WR 7.9

Educate, and provide technical assistance to the public on methods to identify wasted water indoors and outdoors and practices to conserve water such as native landscaping (xeriscaping) and water use reduction or reuse.

Policy WR 7.10

Provide "how to" or "dos and don'ts" resources for streamside and shoreline landowners.

Policy WR 7.11

Provide information and guidance on water resources protection best management practices for commercial, industrial, residential, agricultural, and other *land uses* to prevent or reduce pollution. These practices include, but are not limited to, septic system maintenance; pet and livestock waste management; landscaping and gardening; *farm* plans; appropriate methods for use, storage and disposal of hazardous materials and other chemicals; on-site drainage system maintenance, and automotive care.

Policy WR 7.12

Provide and promote opportunities for citizen stewardship and involvement.

Policy WR 7.13

Provide *LID* technical guidance and workshops to businesses and contractors working on the Island.

WATER RESOURCES ELEMENT
EXISTING CONDITIONS AND FUTURE NEEDS

The following outlines the present conditions and understanding of the water resources of the Island and the future needs for restoration, enhancement, and protection of these resources.

Groundwater

Groundwater is the sole source of drinking water for Island residents, *farms* and industry on Bainbridge Island. It is found in underground reservoirs called *aquifers*. An *aquifer* is defined as a *permeable* sand and/or gravel formation that is capable of yielding a significant amount of water to a well. Wells on Bainbridge Island penetrate several distinct *aquifers* to allow withdrawal of drinking water by individual homeowners and municipal water purveyors. Most individual *household* wells penetrate to depths of less than 300 feet. Some residents are still using hand-dug wells less than 40 feet deep, completed in the *permeable* sediments known as the Vashon Recessional Outwash. *Groundwater* found at this level also feeds the base flow (summer flow) for Island *streams*. High capacity wells have been drilled as deep as 1,200 feet to find adequate marketable quantities of water for public and private water purveyors. While few in number, these wells produce a large portion of the Island's potable water. The Blakely Formation, a sedimentary bedrock formation, dominates the geology on the southern end of the Island and limits *groundwater* production in this area.

~~*Aquifer* systems on the Island have been mapped where there is sufficient geologic and hydrologic data available to define them.~~ Our understanding of the Island's water resources has been enhanced through historical studies such as the *City of Bainbridge Island, Level II Assessment*[4] prepared by Kato & Warren and Robinson Noble in 2000 and monitoring and assessments completed in the last ten years by the City's *Groundwater* Management Program. This work includes the development, improvement, and utilization of a *groundwater* model; the development of a well monitoring network; and the implementation of long-term monitoring. ~~The following information on existing conditions was drawn from the Level II Assessment by Hydrogeologists and Bainbridge Island residents Doug Dow, Russ Prior, and Mark Shaffer and is subject to change with further study. These *aquifers* are described in detail in the *Kitsap County Groundwater Management Plan*, Volumes I II, dated April 1991, and more recently in the Level II Assessment. Brief descriptions of each *aquifer* system identified are as follows:~~

Bainbridge Island has six principal *aquifers* (Kato & Warren and Robinson & Noble, 2000), the extents of which were refined in the *Conceptual Model and Numerical Simulation of the Groundwater-Flow System of Bainbridge Island, Washington* (USGS, 2011). The six *aquifers* delineated below reflect updated understanding based on the United States Geological Survey (USGS) model. Additional details about the *aquifers*, including detailed maps and discussion regarding the extent, thickness, and other characteristics, can be found in the USGS report.

Perched *Aquifer* (PA)—This *aquifer* is comprised predominantly of Vashon Advance glacial outwash (Qva). The top of the *aquifer* ranges from sea level to more than 300 feet above mean sea level [ft MSL], with a thickness of 20 to 200 feet, and is utilized predominantly by domestic wells. About 4 percent of wells are reported to be completed in this unit.

Semi-Perched *Aquifer* (SPA)—This semi-perched *aquifer* exists within *permeable* interbeds (QClpi) of the upper confining unit (QC1). The top of the *aquifer* ranges from sea level to more than 200 ft MSL, with a thickness of 10 to 50 feet. About 25 percent of wells are reported to be completed in this unit.

Sea Level *Aquifer* (SLA)—The Sea Level *aquifer* (QA1) is extensive, widely used, and mostly confined by QC1. The top of the *aquifer* ranges from -200 to 200 ft MSL, with a typical thickness of 25 to 200 feet. Fifty-three percent (53%) of wells are completed in the SLA.

Glaciomarine *Aquifer* (*GMA*)—This *aquifer* consists of water-bearing units within a thick sequence of fine-grained glaciomarine drift (QA2). The top of the *aquifer* ranges between more than -500 to -300 ft MSL, with a typical thickness of 20 to 300 feet. Several of the Bainbridge Island's production wells and at least 4 domestic wells are completed in this *aquifer*, representing about 2 percent of wells.

Fletcher Bay *Aquifer* (FBA)—The FBA (QA3) is the deepest identified *aquifer* on Bainbridge Island. Several large production wells are completed in this *aquifer* including the Fletcher Bay Well. The top of the *aquifer* ranges between more than -900 to slightly less than 600 ft MSL, with a typical thickness of 50 to 300 feet. While representing only about 1 percent of wells on Bainbridge Island, the metered KPUD and COBI FBA wells provide approximately 30 percent of the estimated total Island *groundwater* production.

Bedrock *Aquifer*—Less than 1 percent of the wells are completed in the sedimentary Blakely Harbor and Blakeley formations on the south end of Bainbridge Island.

Other wells on Bainbridge Island are either completed in water bearing zones within confining units or have an indeterminate *aquifer* completion zone.

COBI's monitoring well network is distributed across the six Bainbridge Island *aquifers* as follows: 16 in the Perched *Aquifer*, 7 in the Semi-Perched *Aquifer*, 32 in the Sea Level *Aquifer*, 5 in the Glaciomarine *Aquifer*, 9 in the Fletcher Bay *Aquifer*, and 1 in the Bedrock *Aquifer*. Aspect has updated the USGS *groundwater* model to include one new public supply well (KPUD North Bainbridge Well #10), for a total of 1,470 Group A and B public wells and exempt wells estimated to be active on Bainbridge Island.

Aquifer Concerns and Observed Conditions

There are two primary concerns in protecting an *aquifer* system. These are quality and quantity.

Quality

Seawater Intrusion

One of the most common *groundwater* quality concerns for Islands or other saltwater shorelines is saltwater intrusion, which is the movement of saltwater into a freshwater *aquifer*. Where the source of saltwater is marine water such as Puget Sound, this process is known as seawater intrusion. Seawater intrusion occurs when the saltwater/freshwater interface moves inland from offshore. Freshwater is less dense than saltwater and so freshwater will float above saltwater. It is the pressure of the overlying freshwater that keeps the interface offshore. Excessive pumping or overuse of the overlying freshwater will pull the interface toward the shoreline and possibly inland.

Some of our *aquifers* such as the *shall*ow Perched and Semi-Perched *aquifers* are, generally, not in contact with saltwater and, therefore, generally not susceptible to seawater intrusion (an exception being where these *aquifers* are present near the shoreline).

The Sea Level *Aquifer* and our deeper *aquifers* can be susceptible. How susceptible can vary from *aquifer* to *aquifer* and, even within the same *aquifer*, depending upon local conditions.

In order to monitor for potential seawater intrusion, the most common practice is to measure chloride concentration and specific conductivity in *groundwater*. The City's *Groundwater* Management Program conducts annual chloride sampling in *aquifers* or wells susceptible to seawater intrusion. The established Early Warning Level, or EWL, is a chloride concentration >100 mg/L or any 4 consecutive samples showing an increasing trend. To date, no wells in the City's monitoring network (including Kitsap Public Utility District and the City's Water Utility wells) exceeded the EWL, and no trends in chloride results were noted.

Chloride concentrations typically varied between 2 mg/L and 15 mg/L. Results in 2013 and 2014 in the Fletcher Bay *Aquifer* indicate slightly elevated chloride above historic baseline concentration, but not upward trending results. However, these *should* be monitored for continued changes.

Additionally, the City's *groundwater* model was run by USGS in 2010 and updated, recalibrated and run again by Aspect Consulting in 2016 to examine the potential for seawater intrusion under different water production (e.g., growth) scenarios. Model projections indicated no seawater intrusion. It *should* be noted that the model is designed to observe regional scale conditions, but the scale is not fine enough to assess very localized conditions such as one or two wells along the shoreline. Therefore, it is important to continue to monitor in vulnerable areas to catch potentially developing local conditions.

One example is an elevated chloride level measured in one well in the Seabold area in 2006 prior to the development of the City's *Groundwater* Management Program. As there was no established program in place at the time, there was no immediate follow up sampling/study to confirm seawater intrusion rather than a source other than seawater intrusion. Other common sources of chloride in *groundwater* include connate, or very-old, *groundwater*, septic system effluent, very hard *groundwater*, windblown sea spray, and *recharge* from irrigation, agricultural practices, and well disinfection. Chloride from any of these sources can result in elevated levels of chloride in an *aquifer* or well. Erroneously interpreting chloride concentration data without more detailed study may result in what is called a "false positive," where a test identifies a problem that does not in fact exist. That is why follow up investigation using site-specific assessments, is necessary before seawater intrusion can be confirmed. The City, the Kitsap Public Health District, and the Kitsap Public Utility District have teamed up to scope a localized, focused study in the Seabold area for potential funding in 2017.

Nitrate

According to USGS research, nitrate is the most commonly found pollutant in *groundwater* nationwide, particularly in rural areas. Nitrate levels in drinking water above EPA's Maximum

Contaminant Level (or MCL) of 10 mg/L can have serious health effects primarily for infants, but also pregnant women and individuals undergoing treatment with antioxidant medications. Nitrate converts to nitrite in the digestive track which causes a condition call methemoglobinemia which lowers the oxygen in the blood stream. In infants this is called "Blue Baby Syndrome." Brain damage, even death, can occur.

High nitrate levels in *groundwater* can also indicate the possibility that other contaminants may be present in the water such as bacteria or pesticides.

The typical sources of nitrate in *groundwater* include the application of fertilizers and pesticides, mostly from agricultural row crop *farm*ing, but commercial and *residential use* can be significant sources as well (such as lawns, parks, golf courses, ballfields, nurseries, and extensive gardens). Other sources include industrial processes and wastewaters, the land application of wastewater treatment plant sludge or bioso*LID*s, and on site septic system returns.

Although the *Groundwater* Management Program does not, at present, routinely monitor nitrate in *groundwater*, the City's consultant examined nitrate data from the Kitsap Public Health District (KPHD) as part of the 2015-2016 assessment. Nitrate data were not found to exceed EPA's MCL of 10 mg/L. Nitrate data for Group A and B public wells and exempt wells did not indicate any trends. Data submitted to KPHD for exempt wells are typically single results and are insufficient to calculate any trends. However, the maximum result during the last 15 years (2000–2014) was 5.17 mg/L in 2007. There are no apparent trends over time or geographically across the island.

Other Water Quality Concerns

Generally, *groundwater* quality on the Island is very good. However, moderate levels of iron and manganese are naturally-occurring and common. Although neither of these minerals normally exceed EPA's standards for drinking water, they can influence odor and taste and stain fixtures. Many *public water system*s and some private systems use filtration devices to remove or reduce these minerals.

Sole Source *Aquifer* Designation

In 2013, the Bainbridge Island *Aquifer* System was designated a Sole Source *Aquifer*. Sole Source *Aquifer* Designation can apply to one *aquifer* or a system of multiple *aquifers* as is the case with Bainbridge Island.

The Sole Source *Aquifer* Designation Program is an EPA program authorized under the Safe Drinking Water Act of 1974. Section 1424(e) defines a sole source *aquifer* as "the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health."

The EPA more specifically defines a sole or principal source *aquifer* as one which supplies at least
50 percent of the drinking water consumed in the area overlying the *aquifer*, and that these areas have no alternative drinking water source(s) which could physically, legally, and economically supply all those who depend upon the *aquifer* for drinking water.

The program and designation are specifically designed to protect the quality of drinking water by helping to prevent contamination of the *aquifer* system. It provides this protection by raising the level of awareness of the vulnerability of the *aquifer* system to contamination and our dependence upon the system as a drinking water supply.

Further, it requires additional EPA scrutiny of federally-funded projects. EPA inspects proposed projects for potential to contaminate the underlying *aquifer*, and, where appropriate, requires modifications and mitigations to prevent contamination.

However, this additional scrutiny applies to federally-funded projects only, and some projects such as highways and agriculture may be exempt if they meet criteria laid out in pre-established memorandums of understanding between the EPA, the Department of Transportation, the Department of Agriculture, or other agencies.

Quantity

Water Levels

The City's *Groundwater* Management Program currently monitors water levels in public and domestic wells Island-wide and in all six *aquifers*. Water level is an indicator for water quantity, and water level data are assessed against the program's early warning level, or EWL, for safe yield. The EWL for safe yield is a declining water level equal to or greater than ½ foot or more per year over a 10-year period that cannot be attributed to below average rainfall.

Individual well levels were reviewed for trends and compared against the EWL for safe yield. All wells were found to be below the EWL. Water levels in the *aquifers* did not indicate any *aquifer*-wide trends, and only two individual wells were noted for further review.

An exempt well (25N/02E-21P03) in the Sea Level *Aquifer* showed an apparent average decline of approximately 0.56 feet/year over the 8-year period of record. However, further review of the water level measurement method history showed that it changed twice over the period of record from a steel tape to a sonic water level meter and, then, back to steel tape. The results collected via sonic water level meter appeared to be inconsistent compared to the results before and after using the steel tape, a more rudimentary but more reliable measurement method. Therefore, the sonic level readings were removed from the analysis. Once removed, the remaining data were below the EWL. Water-use data were not available for the well. However, the well owner indicated to COBI that no known change in water use occurred over the period of record. Continued long-term monitoring of this well using the steel tape method, as planned by COBI, will determine if there is a significant trend in water level decline over time.

Group A system well 'Island Utility Well #1' (25N/02E-34F07) in the Fletcher Bay *Aquifer* has shown an average decline of approximately 0.49 feet/year from 2004-2014. Although this does not yet exceed the EWL, it is very close to approaching it. Therefore, further monitoring and assessment are warranted. The well is situated next to two other Fletcher Bay *Aquifer* production wells (Island Utility Well #2, Island Utility Well #4) within the same water system. Production data have not been available for these wells, which makes it unclear if declines are related to changes in water use over the period. This system has just transitioned to operation by KPUD in mid-2015, and they are now reviewing available information to understand the current conditions within that water system. Additional data review will continue as the system *infrastructure* is updated to see if additional water use, system loss, or some other factor contributed to the historical decline. No other

Fletcher Bay *Aquifer* wells monitored exhibited a similar declining trend, so it appears that this issue is specific to this well and not an *aquifer*-wide concern.

Aquifer* System *Carrying capacity

The City, as a community, has yet to fully-define or characterize a sustainable *aquifer* system. Some initial characteristics are keeping the saltwater/freshwater interface offshore and saltwater out of the freshwater supply, and maintaining a balanced water budget for the *aquifer* system in order to prevent depletion.

To help provide some baseline information about these initial characteristics and expected impacts to the system due to *climate change*, Aspect Consulting conducted a system *carrying capacity* model assessment. The *aquifer* system *carrying capacity* assessment was based on those safe-yield indicators with EWLs described above using *aquifer* water levels and chloride concentration. The on-Island *groundwater* balance for the entire *aquifer* system (water budget) was also evaluated. The *groundwater* balance components do not have EWLs, but were evaluated to provide additional context on the predicted changes in *groundwater* conditions.

Water Level Changes: The following rates of *groundwater* level change were based on comparing current and predicted *groundwater* levels in 100 years:

- The Perched *Aquifer* system showed an average 0.10 foot per year of water level decrease at 25 locations simulated across the Island;
- The Semi-Perched *Aquifer* system showed an average 0.13 foot per year of water level decrease at 12 locations simulated across the Island;
- The Sea Level *Aquifer* system showed an average 0.09 foot per year of water level decrease at 49 locations simulated across the Island;
- The Glaciomarine *Aquifer* showed an average 0.02 foot per year of water level decrease at 6 locations simulated across the Island; and
- The Fletcher Bay *Aquifer* showed an average 0.15 foot per year of water level decrease at 9 locations simulated across the Island.

The predicted *groundwater* level changes over a 100-year timeframe were less than the COBI EWLs.

Saltwater/freshwater Interface: The predictive model results indicated that, despite these slow declines, *groundwater* from the Bainbridge Island *aquifer* system flows to Puget Sound and keeps the freshwater/seawater interface at a distance from the Bainbridge Island shoreline. All wells within the Bainbridge Island shoreline maintained chloride concentrations less than 100 mg/L, and no trend in concentrations was observed based on predictive model results.

Water Budget: Though the predicted *groundwater* level declines did not appear to induce seawater intrusion, they can have impacts on other components in the system such as discharge to *streams* to help maintain summertime flows. Therefore, it is important to examine the components of the system's water budget.

Similar to a financial budget, a water budget represents a balance of inputs and outputs. If one component goes up or down, some other component(s) must go up or down to compensate.

Groundwater balance components are typically difficult to measure directly (such as *recharge* and *groundwater* underflow). Thus, this *groundwater* balance assessment relies on modeling results without actual field measurements.

Based on the 2011 USGS Report, the relationship between *groundwater* balance inputs and outputs for the Bainbridge Island *aquifer* system is shown in the following equation:

$R_{ppt} = W_{ppg} + D_{sw} + (GW_{ps} - GW_{kp})$

Where:

Inputs include:

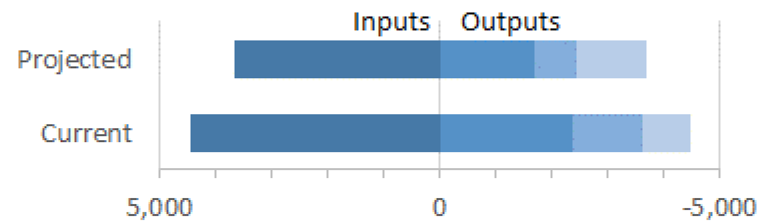
R_{ppt} is precipitation *recharge*.

Outputs include:

W_{ppg} is *groundwater* withdrawals;
D_{sw} is *groundwater* drainage to surface water (such as seeps to bluffs, creeks, *streams*, etc.); and
$(GW_{ps} - GW_{kp})$ is the net lateral *groundwater* underflow (*groundwater* flow toward Puget Sound submarine seeps (GW_{ps}) and *groundwater* flowing from the Kitsap peninsula in deeper *aquifers* (GW_{kp})).

To balance the modelled 50-percent increase in *groundwater* withdrawals and the 20-percent decrease in *recharge* due to *climate change*, the model showed projected changes in *groundwater* drainage to surface water (approximately 40-percent decrease) and lateral *groundwater* flow (approximately 24-percent decrease). Figure 6, excerpted from Aspect's technical memorandum (*Bainbridge Island Groundwater Model: Aquifer System Carrying capacity Assessment (Task 3 Scenario*), 2016) compares the water balance components under current and projected conditions, based on model results.

The Bainbridge Island *groundwater* model results showed *aquifer* storage will be reduced by approximately 11,000 million gallons between current and projected conditions, reflecting the water level decreases described above. These *groundwater* balance results *should* be carefully interpreted, considering that the limited grid resolution may not be sufficient to accurately simulate *groundwater* discharge to surface water, and that the model has not been calibrated to observed flows.



	Current	Projected
Recharge	4,456	3,660
GW underflow	-2,362	-1,673
Drainage, Surface Water	-1,261	-751
Well Pumping	-834	-1,251

Water Balance Components
(million gallons per year)

Figure 6. Current and Projected *Groundwater* Balance Components.

In this figure, well pumping (also called production) is the amount of water taken out of the system through wells (water use). The 50% increase in this component represents the expected increase in water use due to population growth.

Drainage to surface water is *groundwater* contribution to surface water features such as *wetland*s, lakes, and *streams*. The 40% reduction shown here may have an impact on maintaining summer baseflows and water temperatures. It is cautioned that the model as it is currently constructed is not specifically designed to provide an estimate as to how much stream flow will be impacted, but it could be modified to answer specific questions around this topic in future model runs.

Groundwater underflow is the amount of *groundwater* that seeps or discharges into Puget Sound at the shoreline. This value is influenced by the water levels in the *aquifers*, and the reduction shown here represents the impact from project water level decreases. The key importance to this component is that there has to be enough underflow to provide the pressure to keep the saltwater/freshwater interface offshore and prevent seawater intrusion.

Recharge is the portion of precipitation or rainfall that infiltrates the ground and reaches the *aquifer*. The estimated 20% reduction shown in the water balance accounts for *climate change* impacts.

The amount of *groundwater* underflow and discharge to *streams* is driven by the geological makeup of the *aquifer* system. Therefore, we have no direct ability to control these budget components. Rather it is the components of well pumping and *recharge* that we have more ability to directly control. We can reduce well pumping by reducing our water use through aggressive water conservation measures.

Though we cannot control precipitation patterns, we can take measures to enhance *recharge* through creative water capture and return measures (from the rain barrel scale to large scale *infrastructure*) and through protective *land use* measures such as *low impact development* and protection of *aquifer recharge areas* and other *aquifer* conservation areas.

Aquifer recharge areas

Understanding the Island's *aquifer recharge* system is important for both *groundwater* quantity and quality. *Aquifer recharge areas* have geologic and soil conditions which allow surface water infiltration, which also means they are particularly susceptible to contamination. Increasing *impervious surface*s through development reduces the amount of *recharge* available to the Island's *aquifers*. At the same time, *runoff* from *impervious surface*s in developed areas contains increased contaminants. Efforts to protect and preserve the Island's natural water supply are warranted, as the resources that would be required to clean up after contamination or to secure a new source would be prohibitive.

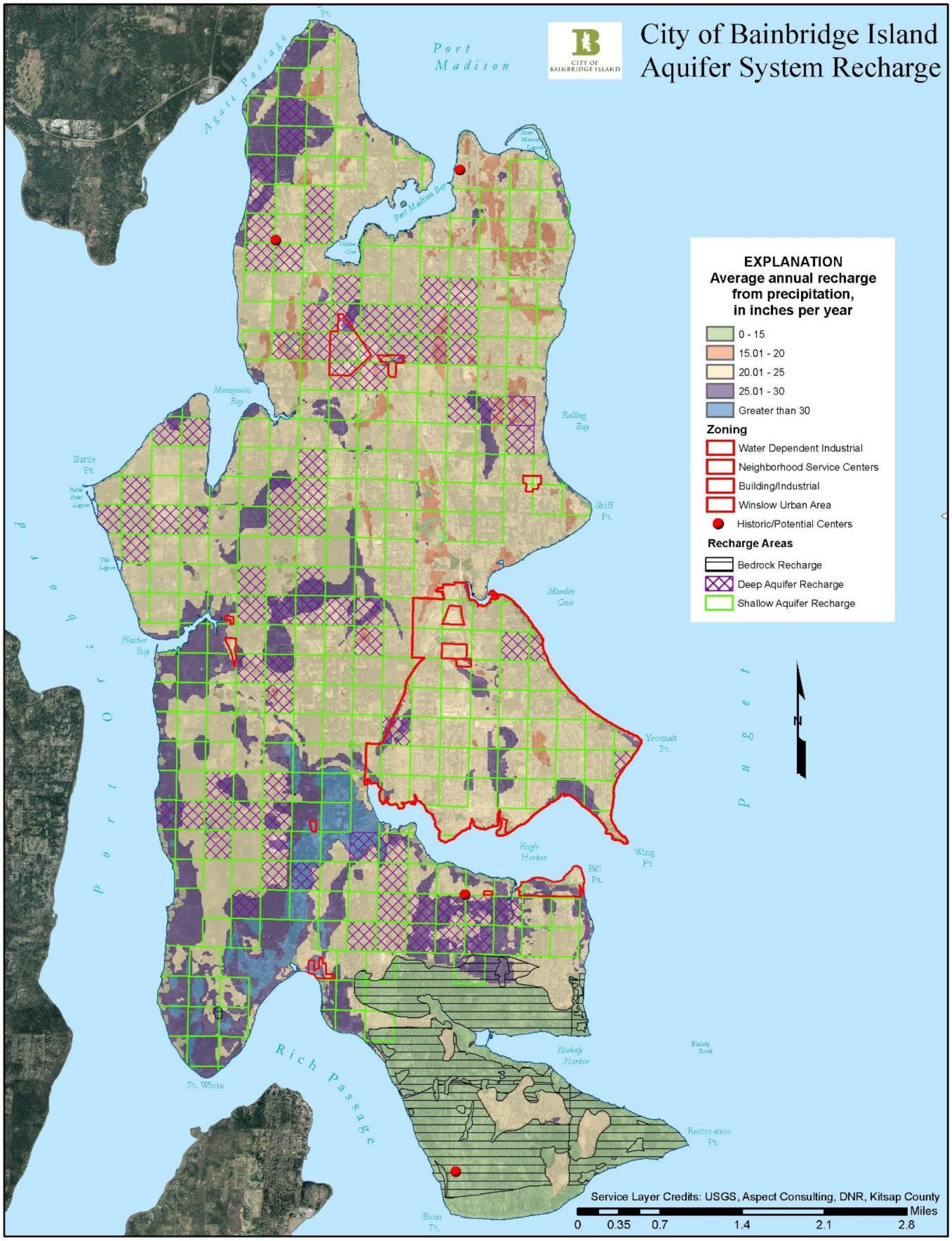
Where development overlays *aquifer recharge areas*, special considerations need to be made to preserve the volume of *recharge* available to the *aquifer* and to protect the *groundwater* from contaminates such as nitrates, biocides and heavy metals found in septic systems and *stormwater runoff*. The most extensively used *aquifer* underlies 85% of the Island and occurs under all zoning classifications.

To help the City assess *recharge* areas for special protection or designation, the model was run to determine *recharge* areas on the Island.

The Bainbridge Island model results indicate that areas across much of the Bainbridge Island area may have a critical recharging effect on *aquifers* that are sources of drinking water. Primary findings include:

- Wells in *shall*ow *aquifers* (including the Sea Level *Aquifer* and above) may withdraw water that originates as *recharge* relatively close to the well head and is younger than 100 years old. See figure below which shows the *recharge* areas for *shall*ow *aquifers* (green squares).
- Wells in deep *aquifers* (including the Glacio-Marine *Aquifer* and the Fletcher Bay *Aquifer*) may withdraw water that originates as *recharge* relatively distant from the wellhead and is greater than 100 years old. See figure below which shows the *recharge* areas for deep *aquifers* (cross-hatched area).
- Not all *groundwater* on Bainbridge Island comes from *recharge* on Bainbridge Island. Model results indicate several wells tapping the deeper *aquifers* withdraw water that originates as *recharge* from areas on the Kitsap Peninsula and is greater than 1,000 years old.

Wells in bedrock were not simulated in the Bainbridge Island model as the method of water particle tracking was not appropriate for fractured bedrock. However, the bedrock is also considered a CARA, because water supply wells have been installed at various depths in bedrock, and potable water supply is from *recharge*. Bedrock *recharge* area is shown as hatched area.


City of Bainbridge Island
Aquifer System Recharge
EXPLANATION
Average annual recharge from precipitation, in inches per year
0 - 15
15.01 - 20
20.01 - 25
25.01 - 30
Greater than 30
Zoning
Water Dependent Industrial
Neighborhood Service Centers
Building/Industrial
Winslow Urban Area
Historic/Potential Centers
Recharge Areas
Bedrock Recharge
Deep Aquifer Recharge
Shallow Aquifer Recharge
Port Madison
Agate Passage
Port Orchard
Puget
Rich Passage
Manzanita Bay
Battle Pt.
Fletcher Bay
Rolling Bay
Skiff Pt.
Murden Cove
Yeomalt Pt.
Eagle Harbor
Wing Pt.
Bill Pt.
Blakely Harbor
Restoration Pt.
Pt. White
Service Layer Credits: USGS, Aspect Consulting, DNR, Kitsap County
Miles
0 0.35 0.7 1.4 2.1 2.8

Perched *Aquifer* (PA)

The Perched *Aquifer* is a sand and gravel *aquifer* system under the major upland areas. It is found above 200 feet elevation and averages 90 feet in thickness. This *aquifer* underlies nine square miles (33%) of the Island's land surface and serves a number of domestic wells, with yields averaging 16 gpm. It is *recharge*d from leakage through overlying sediments and discharges through underlying sediments into deeper *aquifers* or through springs where the *aquifer* intercepts land surface.

[4] Subtitled *An Element of the Water Resource Study, dated December 2000*.

Semi-Perched *Aquifer* (SPA)

The Semi-Perched *Aquifer* is found under approximately 20 square miles (73%) of the land surface and averages about 30 feet in thickness. Where identified, it is found between 20 feet below and 100 feet above sea level. Approximately 25% of the domestic wells on the Island obtain an average of 19 gpm from this *aquifer*. However, uncharacteristically high yields from wells completed for Meadowmeer provide local yields over 300 gpm. The *aquifer* is *recharge*d from leakage through overlying sediments and discharges into deep cut stream valleys, deeper *aquifers*, or to Puget Sound.

Sea Level *Aquifer* (SLA)

The Sea Level *Aquifer* underlies 85% (23.5 square miles) of the Island's land surface but is noticeably absent south of Blakely Harbor where bedrock is found above sea level. The *aquifer*'s average thickness is 110 feet. It is found from 40 feet above to 230 feet below sea level. The Sea Level *Aquifer* is the Island's primary *aquifer* system, supplying water to approximately 53% of Island wells. Several of the Island's larger water purveyors obtain yields of more than 300 gpm from this *aquifer*. The average yield to the majority of (domestic) wells is 20 gpm. The *aquifer* accepts *recharge* from leakage through overlying sediment with natural discharge into Puget Sound. The City's wells at the head of Eagle Harbor are completed in the SLA.

Glaciomarine *Aquifer* (*GMA*)

The Glaciomarine *Aquifer* is the *shall*ower of the two deep *aquifer* systems present below Bainbridge Island. The data available confirms estimates of a depth of 400 to 760 feet below sea level under approximately 9.5 square miles (35%) of the Island and an average thickness of 120 feet. This *aquifer* may exist under a greater portion of the Island but lack of exploration precludes a definitive analysis. Only 2% of Island wells penetrate this fine-grained *aquifer* which yields an average of 18 gpm. Notable wells completed in the *GMA* are the City's Taylor Avenue well and the old and new wells completed at the former creosote plant site at Bill Point. *Recharge* to the *aquifer* is obtained through leakage from overlying sediments. Discharge is likely to deeper areas in Puget Sound.

Fletcher Bay *Aquifer* (FBA)

The Fletcher Bay *Aquifer* is named for a pair of wells drilled into the deep *aquifer* system near Fletcher Bay. Several other wells are also completed in this *permeable* sand and gravel formation found from 690 to 1,280 feet below sea level. Because very few wells penetrate to this depth, the extent of the *aquifer* is not well defined. The *aquifer* is believed to underlie 55% (15 square miles) of the Island, mainly in the north central area. The City obtains the majority of the drinking water for the Winslow water system from the FBA through its

Fletcher Bay and Sands Road wells. Yields from this *aquifer* average 330 gpm. Because of the depth of this *aquifer*, it has been theorized that it is connected to a similar *aquifer* identified at this depth on the Kitsap Peninsula. However, this connection has not been proven and *recharge* to the FBA can only have been assumed to originate on the Island through leakage from overlying sediments.

Hydrologic Cycle and the Water Budget

Understanding the Island's water budget requires a look at the components of the water system. These components are defined as:

- Precipitation (rain or snow);
- Evapotranspiration: the combined amount of water that evaporates directly from the surface plus the amount that is taken up by vegetation and transpired back into the air;
- *Runoff*: the amount of water that flows directly off the Island via *streams*;
- *Recharge*: the amount of water that infiltrates into the *aquifer*; and
- Discharge: well pumpage, springs, *streams* and direct discharge into Puget Sound.

Although the variability of the natural system is great, educated assessments of the individual components are commonly used to predict sustainable use of the *groundwater*.

All water entering the Island's natural water system originates as precipitation. Only a portion of the precipitation is available for *recharge* because some of it exits the system before it percolates into the ground. Water exits the system through evapotranspiration, surface *runoff* and discharge. The quantity of *groundwater* available for use is a function of the water balance: water entering the system is equal to water flowing out of the system, plus or minus the change in storage of water within the *aquifer*.

Precipitation on Bainbridge Island averages about 35 inches per year. In the absence of more precise water budget data it is generally thought that one-half to one-third of all precipitation is lost through evaporation from surface water and evapotranspiration from trees, plants and grass. It is estimated that approximately one-quarter to one-third of the precipitation is discharged to springs and stream flow or directly to Puget Sound.

The remaining precipitation infiltrates the surface sediments through direct absorption, supplemented to some extent through on-site *stormwater* infiltration, to *recharge* the Island *aquifers*. An unknown quantity of *recharge* is discharged from the Perched and Semi-Perched *Aquifer*, and to a lesser extent the Sea Level *Aquifer* providing (base) stream flow for fish and other wildlife. However, only a portion of the remaining *recharge* that reaches the major *aquifers* is available for use without serious disruption of the hydrologic system. Withdrawing too much water will cause *aquifer* water levels to decline and may cause seawater intrusion into the Sea Level *Aquifer* and deeper *aquifers*.

Hypothetical *groundwater* (*aquifer*) yield

A simplistic approach for determining the "hypothetical *groundwater* yield" is the product of the general *recharge* rate times the *recharge* area (27.5 square miles or 17,600 acres) producing a volume of water in acre feet per year. The Level II study provided a hypothetical *groundwater recharge* of 19,000 acre feet per year (afy). However, it is recognized that the sustainable yield of an *aquifer* can be more accurately determined by monitoring *aquifer*

~~water levels for many years. Such monitoring would include: flow metering of typical wells for water use or measurement of surface water diversions; well water monitoring; and stream flow monitoring. Management of the *groundwater* resources of Bainbridge Island will require balancing withdrawals from specific *aquifers* to sustainable water levels. Actual sustainable withdrawal rates are unknown.~~

~~*Aquifer recharge areas*~~

~~Springs and *streams* reflect a natural system of discharge for Island *groundwater*. All of the remaining land surface (except for portions of the southern end of the Island) serves as *aquifer recharge area*. Soil type, *slope*s, vegetative cover and *impervious surface*s significantly affect the distribution of *recharge*. The identification of *aquifer recharge areas* is important both from the standpoint of *groundwater* quantity and quality. *Aquifer recharge areas* have geologic and soil conditions which allow high rates of surface water infiltration, which also means they are particularly susceptible to contamination. Increasing *impervious surface*s through development reduces the amount of *recharge* available to the Island's *aquifers*. At the same time, *runoff* from *impervious surface*s in developed areas contains increased contaminants. Efforts to protect and preserve the Island's natural water supply are warranted, as the resources that would be required to clean up after contamination or to secure a new source would be prohibitive.~~

~~Where development overlays *aquifer recharge areas*, special considerations need to be made to preserve the volume of *recharge* available to the *aquifer* and to protect the *groundwater* from contaminates such as nitrates, biocides and heavy metals found in septic systems and *stormwater runoff*. The most extensively used *aquifer* underlies 85% of the Island and occurs under all zoning classifications.~~

~~The *Recharge* Areas Map (Figure 5) was developed by Russ Prior with assistance from Mark Shaffer, Doug Dow and Kitsap County PUD. This *recharge* map is based on a spreadsheet model produced by Robinson and Noble for the Level II Assessment (December 2000). Figure 5 identifies high, moderate and low *aquifer recharge areas* on Bainbridge Island. Generally *recharge* depends on the ease with which precipitation can move from the land surface to the *aquifer* based on the types of conditions in the area. The elements used in the Level II spreadsheet model include: amount of rainfall, surficial soil types (based on USDA Soil Survey of Kitsap County), *slope*, ground cover and water holding capacity.~~

~~*Aquifer recharge areas* have been mapped for the Island using available assessment information described in the Level II Assessment. The mapping identifies high, moderate, and low *aquifer recharge areas* in accordance with the following definitions:~~

Susceptibility	Characteristics
High	Greater than 20 inches of infiltration into the *groundwater* system per year – generally areas with high *recharge* have *permeable* surficial soils and *shall*ow *slopes*.
Moderate	Between 10 and 20 inches per year of infiltration into the *groundwater* system – includes many areas underlain by Vashon till which allows significant quantities of infiltration.
Low	Less than 10 inches per year of infiltration into the *groundwater* system – generally areas with low *recharge* have surficial soils of low *permeability* and steep *slopes*.

Source: 2000 Bainbridge Island Level II Assessment

Aquifer Concerns

The Island has many *shall*ow and deep *aquifers*, some of which may be connected vertically as well as horizontally. No data has been developed to date to determine how much water can be withdrawn from any of the Island *aquifers* without causing over-drafting. Monitoring is important to further our understanding of the Island's *aquifer* systems.

based on current water quality data, the 2000 *Bainbridge Island Level II Assessment* concluded there was no evidence of extensive seawater intrusion on the Island nor was there evidence of increasing salinity

Surface Water

The surface waters of Bainbridge Island provide aesthetic, recreational, economic, and ecological benefits to Island citizens. Boating, fishing, and shellfish harvest are important recreational and economic activities, and the Island's *streams*, lake, harbors, shorelines, and *wetland*s provide habitat for a diversity of fish and wildlife species.

The harbors and numerous coves around the Island host anchorage, moorage, marinas, boat launches, waterfront access, and swimming beaches. Eagle Harbor, specifically, hosts marinas which provide permanent moorage for live-aboards and an open water mooring and anchoring area for the Island's live-aboard community.

In addition to providing forage and habitat for salmon, otter, sea lions, and waterfowl and swimming, boating, and fishing areas for people, the majority of the Island's shorelines and adjacent nearshore areas are designated commercial shellfish growing and harvest areas by the State Department of Natural Resources. Many shoreline residents recreationally harvest shellfish such as clam and geoduck as well. The Shoreline Master Plan also regulations shellfish harvest activities.

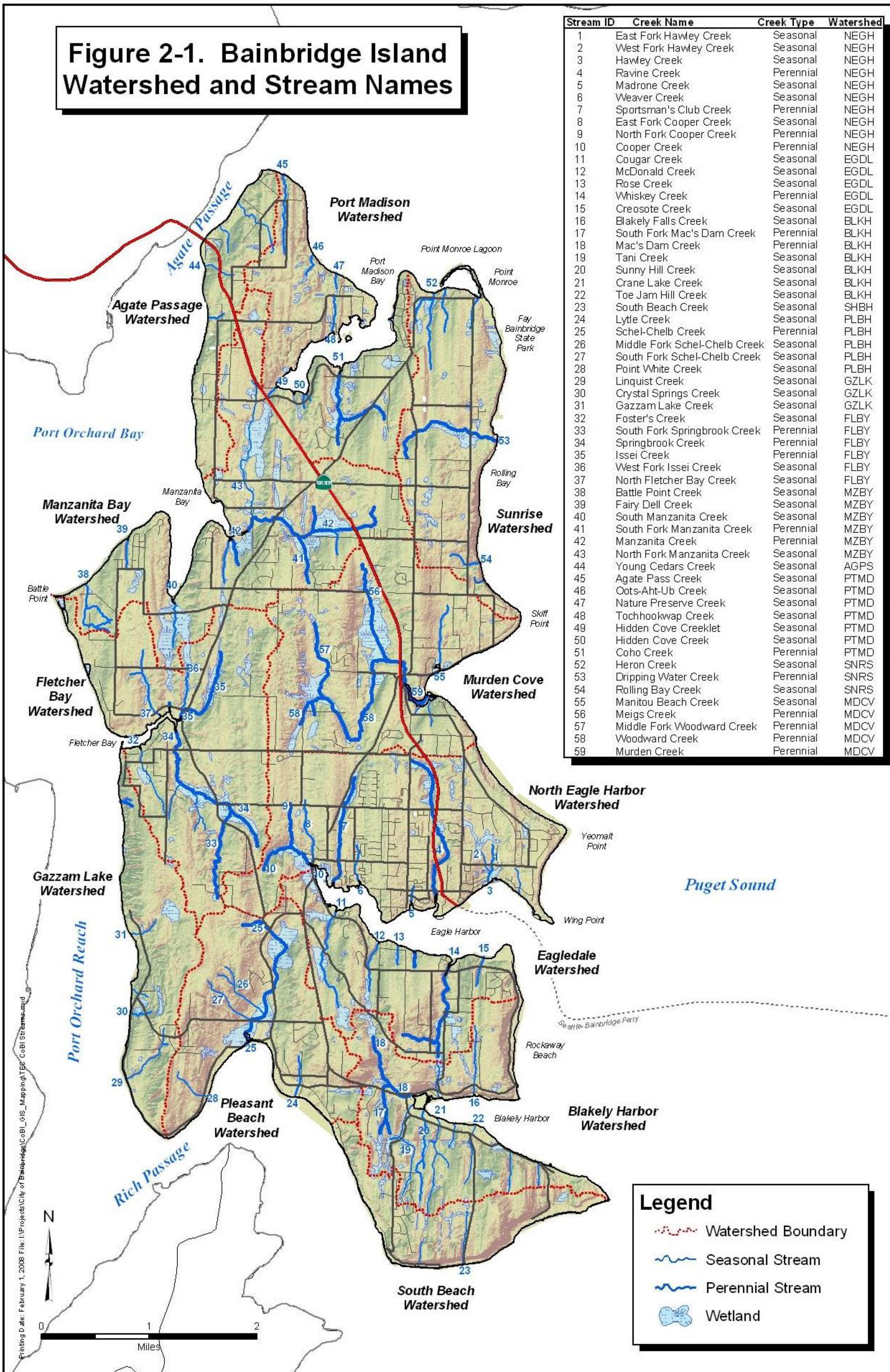
Watersheds

Surface water flows from high geographic points to lower elevations collecting in *streams* and *wetland* systems within the *watershed*s of the Island. *Watershed* boundaries are determined by Island topography where ridgelines define the boundaries.

Bainbridge Island contains twelve distinct *watershed*s with 59 seasonal and perennial *streams* that contribute fresh water to Puget Sound (see Figure 2.1 below excerpted from the Water Quality and Flow Monitoring Program Final Monitoring Plan, 2008). Five harbors, twelve estuarine *wetland*s, one lake, 1,242 acres of *wetland*, 965 acres of tidelands (between mean high and mean low tide), and 53 miles of shoreline comprise the remainder of the surface water system.

Each surface water feature serves a critical function in preserving hydrologic connectivity within the *watershed*. Recent research is finding that even those features that are seasonal such as ephemeral or intermittent *streams* and seasonally-flooded *wetland*s are critical faunal and floral habitat providers, biogeochemical processors, and connectivity corridors.

Figure 2-1. Bainbridge Island Watershed and Stream Names



Stream ID	Creek Name	Creek Type	Watershed
1	East Fork Hawley Creek	Seasonal	NEGH
2	West Fork Hawley Creek	Seasonal	NEGH
3	Hawley Creek	Seasonal	NEGH
4	Ravine Creek	Perennial	NEGH
5	Madrone Creek	Seasonal	NEGH
6	Weaver Creek	Seasonal	NEGH
7	Sportsman's Club Creek	Perennial	NEGH
8	East Fork Cooper Creek	Seasonal	NEGH
9	North Fork Cooper Creek	Perennial	NEGH
10	Cooper Creek	Perennial	NEGH
11	Cougar Creek	Seasonal	EGDL
12	McDonald Creek	Seasonal	EGDL
13	Rose Creek	Seasonal	EGDL
14	Whiskey Creek	Perennial	EGDL
15	Creosote Creek	Seasonal	EGDL
16	Blakely Falls Creek	Seasonal	BLKH
17	South Fork Mac's Dam Creek	Perennial	BLKH
18	Mac's Dam Creek	Perennial	BLKH
19	Tani Creek	Seasonal	BLKH
20	Sunny Hill Creek	Seasonal	BLKH
21	Crane Lake Creek	Seasonal	BLKH
22	Toe Jam Hill Creek	Seasonal	BLKH
23	South Beach Creek	Seasonal	SHBH
24	Lytle Creek	Seasonal	PLBH
25	Schel-Chelb Creek	Perennial	PLBH
26	Middle Fork Schel-Chelb Creek	Seasonal	PLBH
27	South Fork Schel-Chelb Creek	Seasonal	PLBH
28	Point White Creek	Seasonal	PLBH
29	Linquist Creek	Seasonal	GZLK
30	Crystal Springs Creek	Seasonal	GZLK
31	Gazzam Lake Creek	Seasonal	GZLK
32	Foster's Creek	Seasonal	FLBY
33	South Fork Springbrook Creek	Perennial	FLBY
34	Springbrook Creek	Perennial	FLBY
35	Issei Creek	Perennial	FLBY
36	West Fork Issei Creek	Seasonal	FLBY
37	North Fletcher Bay Creek	Seasonal	FLBY
38	Battle Point Creek	Seasonal	MZBY
39	Fairy Dell Creek	Seasonal	MZBY
40	South Manzanita Creek	Seasonal	MZBY
41	South Fork Manzanita Creek	Perennial	MZBY
42	Manzanita Creek	Perennial	MZBY
43	North Fork Manzanita Creek	Seasonal	MZBY
44	Young Cedars Creek	Seasonal	AGPS
45	Agate Pass Creek	Seasonal	PTMD
46	Oots-Aht-Ub Creek	Seasonal	PTMD
47	Nature Preserve Creek	Seasonal	PTMD
48	Tochhookwap Creek	Seasonal	PTMD
49	Hidden Cove Creeklet	Seasonal	PTMD
50	Hidden Cove Creek	Seasonal	PTMD
51	Coho Creek	Perennial	PTMD
52	Heron Creek	Seasonal	SNRS
53	Dripping Water Creek	Perennial	SNRS
54	Rolling Bay Creek	Seasonal	SNRS
55	Manitou Beach Creek	Seasonal	MDCV
56	Meigs Creek	Perennial	MDCV
57	Middle Fork Woodward Creek	Perennial	MDCV
58	Woodward Creek	Perennial	MDCV
59	Murden Creek	Perennial	MDCV

Land cover MOVED TO HABITAT BELOW.

Bainbridge Island encompasses an area of 17,471 acres, or approximately 28 square miles. The primary land cover is tree cover at 73%, or 12,760 acres. Grass/scrub lands, developed areas with *impervious surfaces* and other coverages comprise 15%, 11% and 1%, respectively, with combined coverage of 4,712 acres (Table 1 next page).

Land use type does not vary widely by any great degree across the island due to a low percentage of industrial or commercial land development and the lack of available or developed *farm*/range land. The island's *land use* is consequently dominated by *residential uses* (75%). Other *land uses* such as recreation land (7%), agricultural (6%), transportation corridors (6%), commercial/light manufacturing (2%), *forest land* use (2%) and public facilities (2%), make up the remainder of the *land use* as a percentage of the total acreage on the island. With a total overall population of 23,630 the greatest population *density* occurs at the towns of Winslow, Island Center, Lynwood Center and around the coastline of the island. Outside of urbanized areas, the Island is generally characterized by scattered, small communities, homes on acreage, and large parcels of undeveloped land.

Stream type

In 2014, the Wild Fish Conservancy (WFC) completed stream typing for Bainbridge Island as part of the West Sound *Watersheds*, Kitsap Peninsula (WRIA 15) Stream Typing Project.

WFC's website states, "Water typing is the state-sanctioned process of mapping the distribution of fish and fish habitat. Regulatory water type maps are used to regulate *land use* decisions adjacent to *streams*, ponds, and *wetlands*. Because existing (modeled) regulatory maps often significantly misrepresent the presence, location, and extent of fish habitat, the effectiveness of state and local government fish habitat protection regulations is compromised. More information about the water typing process and its significance is available at: http://wildfishconservancy.org/resources/maps/what-is-water-typing."

WFC classified fish and fish habitat in Island *streams* and ground-truthed regulatory maps of stream presence and location, identifying an additional # previously unknown/unmapped miles of stream on Bainbridge Island. The City is currently using WFC's updated stream data.

Stormwater

Stormwater is generated when the ground becomes saturated and rainwater drains overland to the nearest surface water body or rainfall encounters hard or *impervious surface*s and drains into manmade drainage ditches, catch basins, and pipes.

There is no question that *stormwater runoff* is the leading transport pathway of pollution into Puget Sound and its associated *wetland*s, creeks, *streams* and rivers. Not only does it carry ~~transports~~ pollutants such as trash; gas, ~~and~~ oil, and metal-laden sediment from road surfaces and parking lots~~,~~; ~~as well as residues from~~ pesticides, fertilizers, and other chemicals used in lawn care;~~,~~ ~~as well as~~ pet waste and animal waste in agricultural areas, but ~~The amount of *stormwater runoff* generated from road, roof, parking lot, and other *impervious surface*s created by urban developments can be of a higher volume than what existed in the natural state.~~ the volume of *stormwater* generated by *impervious surface*s has tremendous force and can cause erosion ~~if allowed to flow into natural drainage systems provided by~~ and damage to in-stream and *wetland* habitat.

Peak flows that follow immediately after a storm can be much greater than existed when the land was in a natural state with vegetative cover,~~. Excessive *stormwater runoff* may~~ causeing *streams* to expand and overflow~~,~~ and creating flooding conditions on adjacent lands.

Therefore, *stormwater* has long been considered, at best, a nuisance and flooding hazard to be collected and delivered downstream as quickly and efficiently as possible and, at worst, a waste stream to be collected and removed from the *watershed*. Existing land development methods and *stormwater* drainage system *infrastructure* are designed to do just that.

However, as early as the year 2000, water-starved areas of the country started to view *stormwater* as a vital resource rather than a waste stream, first by limiting its generation by reducing *impervious surface*; then, retaining and infiltrating it on site where feasible; and, lastly, protecting it from pollution, capturing it, and reusing it to the maximum extent possible. On June 16, 2015, the California State Water Resources Control Board adopted an order that provides a framework to promote integrated *stormwater* capture and reuse to improve water quality, protect local beaches, and supplement water supplies. The new [*stormwater* discharge] permit focuses on using *stormwater* as a resource and encourages *green infrastructure* and *groundwater recharge* (*Stormwater Report*, *Water Environment Federation*, *June 2015*).

The Pacific Northwest is not considered water-starved and local conditions are not nearly so dire as in California. However, *climate change* predictions suggest that local water supplies likely will see some reduction in *recharge*; rainfall patterns will further tax existing, ailing, and undersized drainage *infrastructure* and possibly diminish summertime stream flows and water quality; and warming temperatures will increase summertime stream temperatures. Therefore, local municipalities are, also, rethinking their view of *stormwater* and many have already started evaluating and planning for *climate change*, especially in *stormwater* drainage system maintenance and retrofit. In 2009, Kitsap County adopted resolution 109-2009, *Creating Kitsap County "Water as a Resource" Policy*, in which the county resolved to treat all of its waters, including *stormwater*, as a vital resource, incorporating *low impact development* and water capture and reuse into all of its landuse and utility management planning.

~~The volume of *stormwater* generated by *impervious surfaces* has tremendous force and can cause erosion if allowed to flow into natural drainage systems provided by *streams* and *wetlands*. *Stormwater* can loosen soil and stream banks in the natural drainage way causing suspended particulates to flow into other bodies of water.~~

~~Excessive *stormwater runoff* may also cause *streams* to expand and overflow, creating flooding conditions on adjacent lands. Any sedimentation will eventually drop as the water slows down and loses its force, causing siltation and the degradation of *wetlands*, particularly of salmon spawning habitat.~~

~~*Stormwater runoff* from driveways and parking lots also transports pollutants such as gas and oil as well as residues from pesticides, fertilizers, and other chemicals used in lawn care, as well as animal waste in agricultural areas. *Non-point source pollution* accumulates as water runs over hard surfaces and is carried to the nearest body of water.~~

Observed Surface and Stormwater Conditions

Department of Ecology Surface Water Quality Assessment

Every two years the State Department of Ecology (Ecology) identifies polluted water bodies and submits a list of impaired water bodies, called a 303(d) list, to the Environmental Protection Agency (EPA) for approval in accordance with the federal Clean Water Act. This assessment is based on the assumption that each water body *should* support certain designated uses. Some of these uses are swimming and boating, fish and shellfish rearing and harvest, and wildlife habitat.

Ecology designates water bodies that frequently or consistently fail to meet standards or criteria as *Impaired*. Water bodies that only infrequently fail to meet standards are classified as *Waters of Concern* or *Sediments of Concern* if the sampled matrix was sediment. These assessments use water, fish/shellfish tissue, habitat, and sediment data.

Ecology's *2012 Water Quality Assessment* determined that one stream, one harbor, two coves, one lagoon, and three Island-adjacent nearshore marine areas on Bainbridge Island were *Impaired* by one or more pollutants and were not able to provide the full recreational, habitat, and aesthetic benefits they once offered.

An additional one bay, one harbor, and 28 other Island-adjacent nearshore marine areas were identified as *Waters of Concern* and/or *Sediments of Concern* for periodic excursions beyond the allowable standard or criteria for one or more pollutants.

Ecology's proposed *2014 Water Quality Assessment* (under review by the EPA at the time of this printing), designated an additional two *streams* as *Impaired* by at least one pollutant.

Tables 2-5 on the following pages detail those water bodies classified as *Impaired* or *of Concern* according to the analyzed matrix (water, tissue, habitat, and sediment, respectively).

It *should* be noted that much of the sediment data were collected prior to 2003, some as early as the 1990's. These may not be representative of current conditions. Further, many of the identified pollutants are legacy pollutants resulting from historic *land use* such as large-scale, row-crop *farm*ing and the active lumber industry at the turn of twentieth century. The City's sediment sampling data collected in 2008 and 2013 may be more representative of current inputs to these water bodies. These data are summarized in the next section, *City Surface Water Quality Assessment*.

One example of legacy pollution is the former Wyckoff Creosote Facility located at the mouth of Eagle Harbor. Sites where sediments are contaminated by hazardous waste are regulated and managed through the Model Toxics Control Act (MTCA). Sites such as the former Wyckoff Creosote Facility, due to the complexity and size, are normally addressed through EPA's Superfund program.

However, water bodies listed on the 303(d) list require TMDLs (Total Maximum Daily Loads) where identified sources of the pollutant of concern are allocated a pollutant load reduction in order for that water body to meet criteria. Currently, the City is a stakeholder in the *Sinclair and Dyes Inlets Fecal Coliform Bacteria Total Maximum Daily Load (TMDL)*. Four of the Island's *watershed*s are captured within the TMDL drainage basin boundaries (Fletcher Bay, Gazzam Lake, Pleasant Beach, and South Beach *Watershed*s).

Table 2. Ecology Approved 2012 and Proposed 2014 Water Quality Assessment - Water

Waterbody	Parameter or Pollutant	2012	2014 (Proposed)
Eagle Harbor (Middle)	Bacteria	Impaired	Impaired
	Copper	Waters of Concern	Waters of Concern
Eagle Harbor (Inner)	Dissolved Oxygen	Waters of Concern	Waters of Concern
	Temperature		
Agate Passage - Bridge	Dissolved Oxygen	Waters of Concern	Waters of Concern
Agate Passage - Agate Point	Dissolved Oxygen	Waters of Concern	Waters of Concern
	Temperature		
Rich Passage - Pleasant Beach Cove/Pleasant Beach	Bacteria	Impaired	Impaired
	Dissolved Oxygen		
	pH	Waters of Concern	Waters of Concern
Rich Passage - Point White	Dissolved Oxygen	Waters of Concern	Waters of Concern
Rich Passage - Fort Ward	Bacteria	Waters of Concern	Waters of Concern
	Dissolved Oxygen		
	pH		
Port Orchard Passage - Lower Crystal Springs	Dissolved Oxygen	Impaired	Impaired
	Bacteria		
	Temperature	Waters of Concern	Waters of Concern
Port Orchard Passage - Upper Crystal Springs	Bacteria	Waters of Concern	Waters of Concern
Port Orchard Passage - Fletcher Bay	Bacteria	Waters of Concern	Waters of Concern
Port Orchard Passage - Battle Point	Bacteria	Waters of Concern	Waters of Concern
Port Orchard Passage - South of Rolston	Bacteria	Waters of Concern	Waters of Concern
Puget Sound (Central) - Blakely Harbor (Mouth)	Bacteria	Waters of Concern	Waters of Concern
Puget Sound (Central) - Blakely Harbor (Middle)	Bacteria	Waters of Concern	Waters of Concern
Puget Sound (Central) - Blakely Harbor (Inner)	Bacteria	Waters of Concern	Waters of Concern
Puget Sound (Central) - Murden Cove	Bacteria	Impaired	Impaired
Puget Sound (Central) - Rolling Bay	Bacteria	Waters of Concern	Waters of Concern
Port Madison Bay - Point Monroe	Bacteria	Waters of Concern	Waters of Concern
Port Madison Bay - Mouth	Bacteria	Waters of Concern	Waters of Concern
Springbrook Creek	Bacteria	Impaired	Impaired
Ravine Creek	Bacteria	---	Impaired
Murden Creek	Bacteria	---	Impaired

Table 3. Ecology Approved 2012 and Proposed 2014 Water Quality Assessment - Tissue

Waterbody	Parameter or Pollutant	2012	2014 (Proposed)
Eagle Harbor (Outer)	Benzo(a)pyrene	Impaired	Impaired
	Benzo(a)anthracene		
	Benzo[b]fluoranthene		
	Benzo[k]fluoranthene		
	Chrysene		
	Dibenzo[a,h]anthracene		
	Indeno(1,2,3-cd)pyrene		
	PCB		
Puget Sound (Central) - Rockaway	Chrysene	Impaired	Impaired

Table 4. Ecology Approved 2012 and Proposed 2014 Water Quality Assessment - Habitat

Waterbody	Parameter or Pollutant	2012	2014 (Proposed)
Puget Sound (Central) - Murden Cove	Habitat	Impaired	Impaired
Port Madison - Point Monroe Lagoon	Habitat	Impaired	Impaired

Table 5. Ecology Approved 2012 and Proposed 2014 Water Quality Assessment - Sediment

Waterbody	Parameter or Pollutant	2012	2014 (Proposed)
Eagle Harbor (Outer)	1,2,4-Trichlorobenzene	Impaired	Impaired
	1,2-Dichlorobenzene		
	1,4-Dichlorobenzene		
	2,4-Dimethylphenol		
	2-Methylnaphthalene		
	2-Methylphenol		
	4-Methylphenol		
	Acenaphthene		
	Acenaphthylene		
	Anthracene		
	Arsenic		
	Benzo(a)anthracene		
	Benzo(a)pyrene		
	Benzo(g,h,i)perylene		
	Benzofluoranthenes (b+k+j), Total		
	Benzoic Acid		
	Benzyl Alcohol		
	Bis (2-Ethylhexyl) Phthalate		
	Bioassay		
	Butyl Benzl Phthalate		
	Cadmium		
	Chromium		
	Chrysene		
	Copper		
	Dibenzo(a,h)anthracene		
	Dibenzofuran		
	Diethyl Phthalate		
	Dimethyl Phthalate		
	Di-n-butyl Phthalate		
	Di-n-octyl Phthalate		
	Fluoranthene		
	Fluorene		
	Hexachlorobenzene		
	Hexachlorobutadiene		
	HPAH		
	Indeno(1,2,3-c,d) Pyrene		
	Lead		
	LPAH		
	Mercury		
	Naphthalene		
	N-Nitrosodiphenylamine		
	PCB		
	Pentachlorophenol		
	Phenanthrene		
	Phenol		
	Pyrene		
	Silver		
	Zinc		
Rich Passage - Pleasant Beach	Benzoic Acid	Sediments of Concern	Sediments of Concern
Rich Passage - Pleasant Beach Cove	Benzoic Acid	Sediments of Concern	Sediments of Concern
Port Orchard Passage - Upper Crystal Springs	Benzoic Acid	Sediments of Concern	Sediments of Concern
Port Orchard Passage - South of Rolston	1,2,4-Trichlorobenzene	Sediments of Concern	Sediments of Concern
	1,2-Dichlorobenzene		
	Benzyl Alcohol		
Port Orchard Passage - Manzanita Bay	1,2,4-Trichlorobenzene	Sediments of Concern	Sediments of Concern
	1,2-Dichlorobenzene		
Puget Sound (Central) - Wing Point	1,2-Dichlorobenzene	Sediments of Concern	Sediments of Concern
	1,2,4-Trichlorobenzene		
	1,4-Dichlorobenzene		
	2,4-Dimethylphenol		
	Hexachlorobenzene		
	Pentachlorophenol		
Puget Sound (Central) - Rockaway	1,2-Dichlorobenzene	Sediments of Concern	Sediments of Concern
	1,2,4-Trichlorobenzene		
	1,4-Dichlorobenzene		
	2,4-Dimethylphenol		
	Hexachlorobenzene		
	Hexachlorobutadiene		
	Naphthalene		
	N-Nitrosodiphenylamine		
Puget Sound (Central) - Blakely Harbor (Middle)	1,2-Dichlorobenzene	Sediments of Concern	Sediments of Concern
	1,2,4-Trichlorobenzene		
	1,4-Dichlorobenzene		
	2,4-Dimethylphenol		
	Dibenzo(a,h) anthracene		
	Hexachlorobenzene		
	Hexachlorobutadiene		
	N-Nitrosodiphenylamine		
	Pentachlorophenol		

Commercial Shellfish Growing Area and Recreational Harvest Area Assessment

Department of Health (DOH) routine bacterial and biotoxin assessments of recreational shellfish harvest areas and commercial shellfish growing and harvest areas demonstrate a significant loss of designated uses. The entire east, north, and west shorelines are closed to recreational butter and varnish clam harvest, and the southern shoreline is closed to recreational varnish clam harvest. Only one small area around Point White is open to recreational harvest.

Most commercial shellfish growing area around the Island is open to harvest. However, two segments of commercial shellfish growing areas along Agate Passage and Crystal Springs are currently closed due to bacterial contamination in shoreline drainages to include private drains, *stormwater* outfalls, and *streams*. Point Monroe Lagoon is restricted for commercial harvest, requiring that shellfish be transplanted to approved growing area waters for a specified amount of time in order to naturally cleanse themselves of contaminates before they are harvested for market. Commercial Geoduck Tract 07850 at Restoration Point was closed four times in 2012-2013 for biotoxin. Commercial Geoduck Tract 07000 at the mouth of Manzanita Bay has been closed 14 times in the last five years for biotoxin, and is currently closed at the time of this printing.

In addition to annual commercial growing area reports, DOH publishes an annual threatened areas report to bring attention to monitoring sites where bacteria concentrations are close to exceeding the criteria. The 2015 report (based upon 2014 data) identified one monitoring site (#457) immediate outside of the north side of the mouth of Fletcher Bay as a threatened site and one site (#418) along the southern shore of Blakely Harbor as a site of concern.

Swimming Beach Assessment

The Departments of Ecology and Health's BEACH Program conducts swimming beach monitoring for bacteria during the swimming season (Memorial Day through Labor Day). Typically, bacteria levels in marine waters tends to be fairly low in the summertime. In fact, most beach closures on the Island have been associated with *sanitary sewer* spills such as the Kitsap Sewer District #7 Fort Ward spill in 2012, and the City's sewer main breaks along the north side of Eagle Harbor in 2014.

In 2015, three of the Island's swimming beaches (Fay Bainbridge Park, Joel Pritchard Park, and Eagle Harbor Waterfront Park) were monitored. Bacterial concentrations in 2015 were acceptable, and there were no beach closures in 2015.

City Surface Water Quality Assessment

In 2007, the City received a Centennial Clean Water Fund Grant from Ecology to design and implement a long-term monitoring program to assess the ecological health of the Island's freshwater (*streams* and lakes), marine water (harbors, bays, and nearshore areas), and *stormwater* discharge.

The Water Quality and Flow Monitoring Program (WQFMP) was pilot-tested in 2007-2008 and expanded to Island wide long-term status and trends monitoring in 2010. The program currently conducts routine monitoring for stream and *stormwater* chemistry, stream and nearshore sediment chemistry, rainfall, stream and *stormwater* flow, and stream biodiversity (benthic macroinvertebrates). Every five years, the program also conducts targeted storm event monitoring to assess *stormwater runoff* impacts in *streams* and nearshore marine waters.

Although the program's Final Monitoring Plan is comprehensive, staffing and funding are limited. Current monitoring gaps are *stormwater* best management practice effectiveness monitoring, lake monitoring, marine biological assessments (fish, aquatic macrophytes, phytoplankton, and benthic invertebrates), routine marine water chemistry, and freshwater and marine habitat assessments.

The program released its first edition *State of the Island's Waters* report in 2012 which summarized findings from data collected through Water Year 2011 (September 2011). Program staff are currently assessing data collected through Water Year 2015 (September 2015) and working on a second edition of the report. The following summary reflects assessments completed at the time of this printing.

Bacteria

All of the seven nearshore marine waters monitored during WY2014 targeted storm event monitoring failed to meet the state criteria for fecal coliform bacteria, while 13 (86%) of the 15 *streams* monitored on a monthly basis failed to meet the state criteria in WY2015. Given these results and the number of state listings for bacterial impairment (see Table 2 above), bacteria has proven to be the most prevalent pollutant in freshwater and marine water resources Island wide.

As described above in *Commercial Shellfish Growing Area and Recreational Shellfish Harvest Area Assessment*, commercial shellfish harvest areas along approximately twelve miles of shoreline are currently closed due to elevated bacteria in shoreline drainages, and nearly the entire Island is closed to recreational harvest of varnish and butter clams due to the biotoxins usually associated with bacteria.

Bacterial contamination is common to every season and every *watershed*, urban or rural, and its sources are as varied as the landscape itself. In rural *watershed*s, the most common sources of bacteria are failing septic systems, improperly-managed pet and livestock wastes, and wildlife. In urban *watershed*s, the most common sources are improperly-managed pet waste, improper food handling, poorly-maintained food waste receptacles, failing septic systems, poorly-maintained or failing *stormwater* drainage *infrastructure* (private and public), failing *sanitary sewer infrastructure*, and illicit cross-connections between the *sanitary sewer* and the *stormwater* drainage systems.

In marine environments, common sources of bacteria aside from discharges from upland sources are improper boat waste disposal, failing *sanitary sewer infrastructure*, and wildlife.

Nutrients

Although they are essential to all plant, human, and aquatic life, phosphorus and nitrogen concentrations, if excessive, can overstimulate growth of aquatic vegetation and algal blooms. Applying Ecology's Water Quality Index using the ratio of total nitrogen to total phosphorus, Island *streams* generally rate of low to moderate concern during the wet season and moderate to high concern during the dry season relative to other Puget Lowland *streams*. In 2013, a year of below average rainfall, most *streams* rated of moderate concern even in the wet season, and 3 *streams* reached a high level of concern. During the extreme dry period in the summer of 2015, 7 *streams* climbed to a level of high concern.

Nuisance algal blooms have increased along eastern shorelines and harbors (see Ecology's Eyes Over Puget Sound). These blooms are not only aesthetically unpleasant, but dying and decomposing algae use up aquatic life-sustaining oxygen and render aquatic habitat unusable such as in Murden Cove and Point Monroe Lagoon which are covered year-round with ulvoid macroalgae (see Table 4 above).

Though more study is needed to establish natural background levels for Island *streams* and it is well-understood that a significant amount of nitrogen-loading in Puget Sound comes from the ocean through the Strait of Juan de Fuca via tidal action, ecosystems with naturally high background levels are particularly sensitive to any additional loading from human sources.

Aside from the natural sources of nutrients from forests and *wetland*s, human inputs include agricultural and residential fertilizers, phosphate-based laundry detergents and commercial washing agents, yard waste such as grass clippings and other vegetation dumped along shorelines and *streams*, failing residential septic systems (in some cases even functioning systems), failing municipal sewer *infrastructure*, and improperly handled pet and livestock waste.

Ammonia

Ammonia is considered a priority pollutant by the EPA, since it is toxic to both humans and aquatic life. Therefore, there are established acute and chronic criteria for ammonia in surface waters. Acute criterion is the concentration of a substance at which injury or death to an organism can occur as a result of short-term exposure. Chronic criterion is the concentration of a substance at which injury or death to an organism can occur as a result of repeated or constant exposure.

Out of the 11 fish-bearing *streams* monitored on a routine basis, 8 (73%) consistently exceeded the chronic criteria, while the remaining 3 had seasonal exceedances only. During WY2014 targeted storm event monitoring, all 7 *streams* and corresponding nearshore areas monitored exceeded the chronic criteria. Murden Cove frequently exceeded the acute criteria. The cove exceeded acute criteria 14 times during the 3-year Murden Cove *Watershed* Nutrient and Bacteria Reduction Project (2013-2015).

Sediment and Metals

During rain events, sediment-laden *stormwater runoff* is a prominent pollutant on the Island. Not only does sediment cause excessive scouring and erosion, de-stabilizing *slope*s and stream banks and threatening property, but subsequent downstream deposition clogs stream bottoms, smothers fish eggs, and increases siltation rates in the Island's harbors and bays. Sediment also reduces fish's ability to find food and damages their gills as well.

Sediment-intolerant macroinvertebrate species (an important food source for fish) have diminished, some entirely, from half of the Island *streams* monitored, especially Ravine and Murden Creeks.

Equally concerning are the pollutants that sediment carries with it such as heavy metals. Though ambient or background levels of suspended sediment in *streams* and nearshore areas are generally quite low, monitoring results have shown significant increases in suspended sediment and concentrations of metals in *streams*, nearshore marine waters, and *stormwater* outfall discharge during intense rain events.

Anywhere soil is exposed to rain there is a risk of sediment-laden *runoff*. Construction sites, croplands, sand and gravel pits or accumulations, and any other cleared or grubbed land surfaces are all potential sources of sediment. Likewise, poorly-maintained parking lots, *stormwater* drainage systems, and roadways become significant sources of sediment, particularly sediment laden with heavy metals.

Metals are also carried to *streams* from uncontrolled discharges from auto washing washwater and industrial discharges.

Climate change may lead to an increase in lands*LID*e risk, erosion and sediment transport in the fall, winter, and spring seasons, while reducing the rates of these processes in the summer. Quantitative projections are limited, because of the challenge in distinguishing *climate change* impacts from factors such as development patterns and forest management.

The City collects sediment samples from select stream and nearshore sites every five years for contaminant chemistry and grain size analysis.

In-situ Physical Chemistry

Several Island *streams* and nearshore areas experience periodic excursions in pH, temperature, and dissolved oxygen. Excursions in pH are fairly rare. However, Hawley (East and West Forks), Murden, Schel Chelb, Manzanita, Springbrook, Issei, and Mac's Dam Creeks and Murden Cove suffer chronically low levels of dissolved oxygen. While most only exceed standards in the summertime, Murden and Schel Chelb Creeks exceed standards year-round.

Several *streams* that had historically maintained acceptable water temperatures year-round, have started to exceed temperature criteria during the summertime since 2012 with excursions occurring more frequently over time. These *streams* are Hawley (East and West Forks)

Sprinbrook, Schel Chelb, Linquist, Gazzam Lake, and Mac's Dam Creeks. Two nearshore areas (Eagle Harbor at Ravine Creek, and Murden Cove) frequently exceed temperature criteria as well.

Continuous temperature and dissolved oxygen sensors were deployed in three separate reaches of Murden Creek as part of the 2013-2015 Murden Cove *Watershed* Nutrient and Bacteria Reduction Project. Summertime daily maximum temperatures at all three locations exceeded the criteria with temperatures increasing and exceeding criteria more often in the downstream reach. Similarly, summertime daily minimum dissolved oxygen levels exceeded criteria at all three sites. However, upstream reaches only infrequently exceeded criteria during the summertime, while oxygen levels were significantly lower in the downstream reach and exceeded criteria year-round.

Despite observed improvements in some water quality parameters such as phosphorus and bacteria over the project period, in-stream chemistry stayed the same or worsened. This indicates that the impact is most likely habitat driven (lack of canopy cover, reduced or absent buffers, lower summertime stream flows) rather than an illicit discharge of polluted water.

These excursions in physical chemistry, especially temperature and dissolved oxygen, significantly impair these waters' ability to support aquatic life.

Flow and Land use Impacts on the Biological Community

Hydrology is perhaps the most fundamental driver of physical, chemical, and biological processes in streams and is often considered a "master variable" controlling geomorphology, substrate stability, faunal and floral habitat suitability, thermal regulation, metabolism, biogeochemical cycling, and the downstream flux of energy, matter, and biota [Power et al. 1988; Resh et al. 1988; Poff and Ward 1989; Poff 1996; Poff et al. 1997; Dodds et al. 2004](McDonough, Hosen and Palmer, 2011).

In 2015, the City contracted with King County Department of Natural Resources and Parks, Water and Land Resources Di*Vision* to conduct a stream benthos and hydrologic evaluation of the City's stream benthic macroinvertebrate data and continuous flow gauging data.

Flow data analysis showed that stream flows increase more quickly following rain events and generally have higher peaks than would be expected under forested conditions. These results were generally consistent with increasing levels of urbanization upstream of each gauge and consistent with other data collected in other Puget Sound *watershed*s.

The average Benthic Index of Biotic Integrity (B-IBI) scores spanning all years of data were very poor for Ravine Creek; poor for Issei, Murden, and Whiskey Creeks; and fair for Cooper, Manzanita, Springbrook, and Woodward Creeks. None of the eight sites investigated had average scores that showed good or excellent stream benthic communities, although two sites (Cooper and Springbrook) did have individual sampling years that had good scores. Again, these data were generally consistent with the level of development in the study *watershed*s and with data collected in other Puget Sound *watershed*s.

Five statistically significant upward or downward B-IBI component metric trends were identified at four creek sites. Two Murden Creek site metrics showed a worsening trend in species diversity and percentage of pollution tolerant species versus intolerant species. Manzanita Creek showed an improving trend in species richness and both Cooper and Issei Creek showed an improving trend in percentage of pollution intolerant species versus tolerant species.

King County also examined three additional benthic macroinvertebrate diagnostic metrics for organic pollution (i.e., animal waste including human waste), fine sediment, and metals. The Fine Sediment Sensitivity Index was generally lower at all Bainbridge sites relative to reference sites, suggesting that fine sediment inputs may be a factor in benthic impairment in these *streams*. If confirmed through evaluation of sediment conditions at these sites, the cause is unlikely related exclusively to development as some of the stream basins are relatively undeveloped. It is possible that at least in some instances, past *land use* (e.g., historical logging and *farm*ing activities) is a factor in causing excess sediment to be (or to have been) delivered to these *streams*. Any development within these basins may also be a contributing factor as well; potentially delivering fine sediment through construction and land clearing activities and through stream bank erosion resulting from increased peak flows.

All three diagnostic metrics and the flashiness hydrologic metrics indicate that Ravine Creek is suffering from multiple stressors that potentially include organic and metal pollution, geomorphic alteration, and flashier flows, all typical of an urban stream.

There was only one statistically significant upward or downward trend in these three additional metrics – an improving trend in metals-intolerant species in Issei Creek.

Habitat

As stated above in *City Surface Water Quality Assessment*, limited resources prevent the City's monitoring program from actively monitoring for freshwater and marine water habitat assessment aside from limited sediment sampling in select stream and adjacent nearshore areas (addressed above in Water and Sediment). Most of what we know about our nearshore marine habitat and freshwater habitat is based upon work by non-profit entities such as the Bainbridge Island Land Trust, the Puget Sound Restoration Fund and the Bainbridge Island *Watershed* Council and outside agencies such as Washington State Department of Fish and Wildlife (WDFW), Washington State Department of Natural Resources (DNR), Ecology, Wild Fish Conservancy, and the Suquamish Tribe. Limited *land use*/land cover information is available through aerial photography and light detection and radar (*LID*AR) technology, as well.

Land cover

Bainbridge Island encompasses an area of 17,471 acres, or approximately 28 square miles. The primary land cover is tree-cover at 73%, or 12,760 acres. Grass/scrub lands, developed areas with *impervious surface*s and other coverages comprise 15%, 11% and 1%, respectively, with combined coverage of 4,712 acres (Table 1 next page).

Land use type does not vary widely by any great degree across the island due to a low percentage of industrial or commercial land development and the lack of available or developed *farm*/range land. The island's *land use* is consequently dominated by *residential use*s (75%). Other *land use*s such as recreation land (7%), agricultural (6%), transportation corridors (6%), commercial/light manufacturing (2%), *forest land*-use (2%) and public facilities (2%), make up the remainder of the *land use* as a percentage of the total acreage on the island. With a total overall population of 23,630 the greatest population *density* occurs at the towns of Winslow, Island Center, Lynwood Center and around the coastline of the island. Outside of urbanized areas, the Island is generally characterized by scattered, small communities, homes on acreage, and large parcels of undeveloped land.

Stream type

In 2014, the Wild Fish Conservancy (WFC) completed stream typing for Bainbridge Island as part of the West Sound *Watershed*s, Kitsap Peninsula (WRIA 15) Stream Typing Project.

WFC's website states, "Water typing is the state-sanctioned process of mapping the distribution of fish and fish habitat. Regulatory water type maps are used to regulate *land use* decisions adjacent to *streams*, ponds, and *wetland*s. Because existing (modeled) regulatory maps often significantly misrepresent the presence, location, and extent of fish habitat, the effectiveness of state and local government fish habitat protection regulations is compromised. More information about the water typing process and its significance is available at: http://wildfishconservancy.org/resources/maps/what-is-water-typing."

WFC classified fish and fish habitat in Island *streams* and ground-truthed regulatory maps of stream presence and location, identifying an additional 25 previously unknown/unmapped miles of stream with 698 acres of previously unprotected habitat buffer on Bainbridge Island. The City is currently using WFC's updated stream data.

Table 1. CoBI *Watershed* Land Cover Statistics

Watershed Name /Code	*Watershed* Area (Acres)	*Watershed* Size Ranking	Breakdown of Total *Watershed* Landcover (% of Total Area)								
			Forest	*Wetlands*	**Natural**	Grass & Turf	Bare Ground	% Total Impervious Area	**Developed**	**Surface Water**	**Other**
Agate Passage / AGPS	599.96	12	79.52	2.75	**82.28**	4.25	3.08	9.17	**16.51**	**0.17**	1.04
Blakely Harbor / BLKH	1,369.73	7	87.04	1.08	**88.13**	2.25	3.62	5.75	**11.62**	**0.22**	0.04
Eagledale / EGDL	1,094.12	9	65.10	2.95	**68.04**	8.83	4.36	18.45	**31.63**	**0.33**	0.00
Fletcher Bay / FLBY	2,114.01	3	75.83	1.09	**76.92**	8.60	6.04	7.89	**22.52**	**0.56**	0.00
Gazzam Lake / GZLK	886.45	10	83.96	0.79	**84.74**	3.96	1.86	7.82	**13.64**	**1.62**	0.00
Manzanita Bay / MZBY	2,296.34	1	72.25	1.92	**74.18**	9.76	6.76	8.85	**25.37**	**0.46**	0.00
Murden Cove / MDCV	2,046.36	4	73.65	2.34	**75.99**	7.65	6.46	9.48	**23.58**	**0.43**	0.00
North Eagle Harbor / NEGH	2,184.91	2	50.64	2.46	**53.11**	8.30	10.57	26.95	**45.82**	**0.44**	0.63
Pleasant Beach / PLBH	1,437.63	5	70.66	3.00	**73.66**	6.01	6.64	13.56	**26.21**	**0.13**	0.00
Port Madison / PTMD	1,388.31	6	81.85	1.18	**83.03**	6.26	3.75	6.36	**16.37**	**0.30**	0.31
South Beach / SHBH	711.89	11	76.59	1.20	**77.79**	4.16	10.88	6.54	**21.58**	**0.63**	0.00
Sunrise / SNRS	1,342.24	8	79.08	1.92	**81.00**	4.49	6.41	7.97	**18.87**	**0.13**	0.00
TOTAL ACREAGE	**17,471.95**	-	12,760.44	333.49	**13,093.92**	1,194.76	1,089.27	1,994.28	**4,278.31**	**74.84**	**24.88**

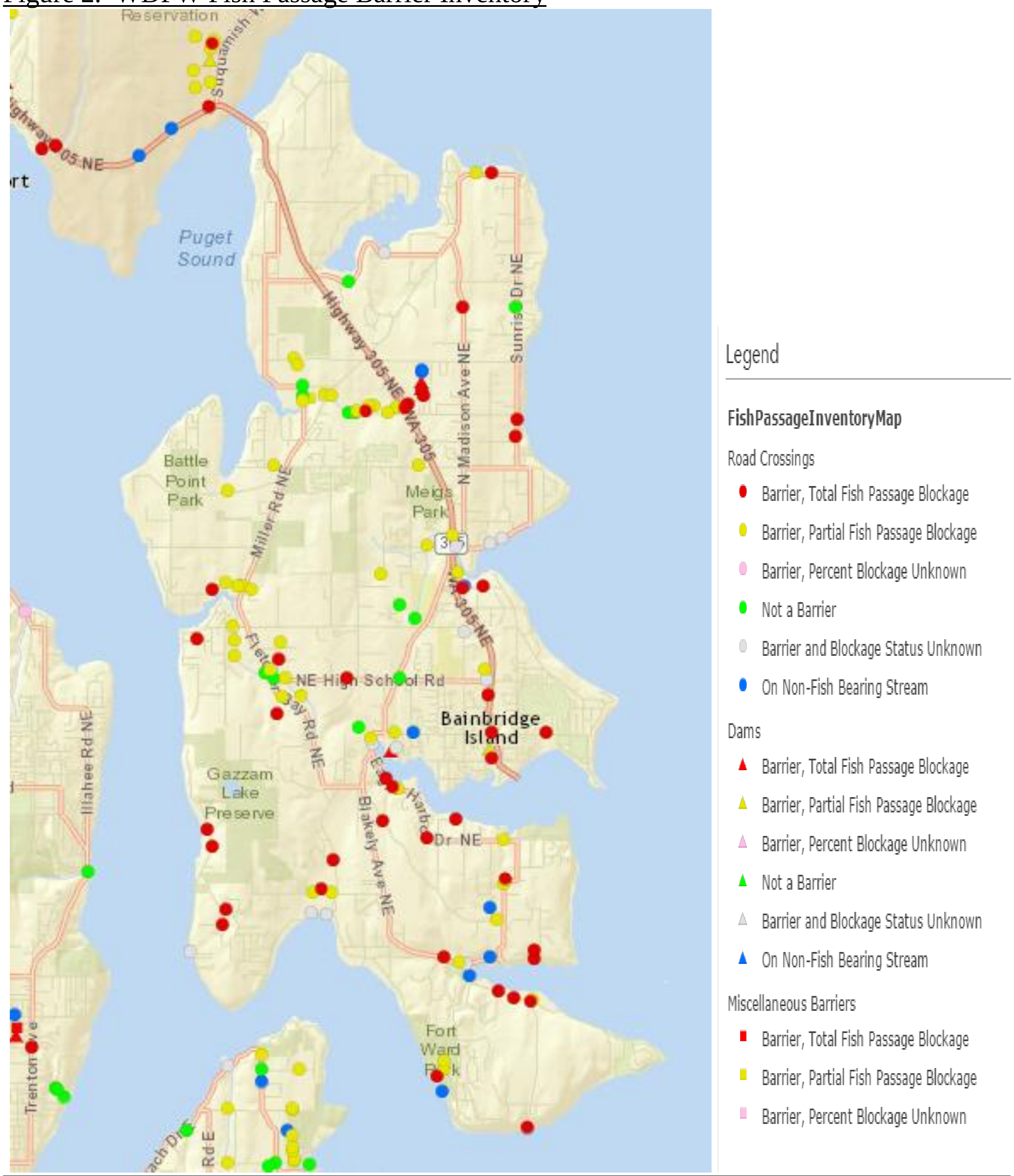
Notes:
** Statistical sources include: Battelle GIS database, CoBI GIS data, and CoBI Level II Assessment (Kato & Warren, 2000)

(Water Quality and Flow Monitoring Program – Final Monitoring Plan, COBI, 2008)

Fish Passage Barrier Inventory

In 2014 the Washington Department of Fish and Wildlife (WDFW) completed fish passage assessments on Bainbridge Island *streams*. As part of this assessment, WDFW identified 43 total passage barriers (40 road crossings and 3 dams) and 45 partial passage barriers (43 road crossings, 1 dam, and 1 miscellaneous) (see Figure 2).

Figure 2. WDFW Fish Passage Barrier Inventory



(http://wdfw.maps.arcgis.com/home/webmap/viewer.html)

WATER RESOURCES ELEMENT IMPLEMENTATION

To implement this Element, the City must take action in several ways, including regulations, program creation, and budgeting.

- Modify Aquifer Recharge Area regulations in the City's Critical Areas Ordinance, BIMC Chapter 16.20.
- Adopt stringent Low Impact Development (LID) regulations to comply with the City's NPDES permit requirements, and ensure continued aquifer recharge when development creates new impervious surfaces.
- Create a program to promote LID retrofits for existing private development and consider retrofit for public facilities.
- Develop and Island-wide Groundwater Management Plan.
- Continue data gathering, monitoring, and analysis for all City water resources.
- Continue and improve outreach programs to educate the public about water conservation and protecting water quality, including outreach to owners of exempt wells.
- Coordinate with state and local health departments to evaluate and promote new technologies that conserve and protect water resources (e.g. greywater capture, composting toilets).
- Improve coordination with the EPA, Washington Department of Ecology, and the Kitsap Public Health District to address clean-up of contaminated sites.
- The City must continue to respond to climate change scenarios in order to protect and manage its water resources.