Three

Existing Conditions and Problems in Kirkland's Watersheds

3.A Overview of City Watersheds

The city of Kirkland contains ten watersheds covering over 6,700 acres. Approximately 6,500 acres drains in small streams that flow directly to Lake Washington (Figure III.1 and Table III.1). A much smaller part of the city (less than 300 acres) drains to the Sammamish River, which also flows to Lake Washington. Forbes Creek, Juanita Creek, and Moss Bay are the three largest watersheds, making up three-quarters of the entire city; however, only the Forbes Creek and Moss Bay watersheds are entirely within the City's jurisdiction. Most of the Juanita Creek watershed is located in unincorporated King County. One of the other relatively large watersheds, Yarrow Creek, is mostly within the City of Bellevue's jurisdiction. The greatest opportunity for addressing issues in the city's watersheds exists in those located solely within Kirkland's jurisdiction, as the City has more control over the types of activities and rate of growth within its boundaries. At the same time, regional cooperation can produce results in watersheds that span two or more jurisdictions.

Kirkland's watersheds generally drain to three types of receiving waters: (1) small, moderately sloping streams, including Juanita, Forbes, and Yarrow Creeks, and small unnamed streams in the Moss Bay watershed; (2) large wetland complexes, such as the Heronfield wetlands in Juanita Creek watershed; and (3) Lake Washington. Currently, Juanita and Forbes Creeks support anadromous[3] and resident fish populations, including coho salmon and cutthroat trout (The Watershed Company. 1998). Historically, Juanita creek also supported sockeye salmon populations (Williams et al. 1975). Yarrow and Carillon Creeks also support limited fish populations of coho salmon and/or cutthroat trout. Table III.2 provides a summary fish populations in Kirkland streams.

The city's stormwater is conveyed in constructed open channels (ditches) and pipes to the receiving waters, with a little under half of the conveyance being in pipes. Drainage from the smaller watersheds that flow directly to Lake Washington off the steep western slopes of the city is primarily piped. Open channels are difficult to maintain in these areas because of the steep topography and associated erosion problems. Piped flow is also more prevalent in the more developed areas in the city, including the commercial centers of the South Juanita Slope, Moss Bay, and Kirkland Slope watersheds.

The mapped soil and geologic characteristics in much of Kirkland inhibit the infiltration of surface water. The predominant soils in the City are in the Alderwood series and are considered soil type C, moderately fine to fine textured soils that have a layer which impedes the downward movement of water. Alderwood soils are not very deep (20 to 40 inches) and generally located on upland terraces over glacial till, a geologic material that has very low permeability. All but three of Kirkland's watersheds consist mostly of Type C, Alderwood-associated soils. Soils in the Juanita Bay area are in the Indianola series and are considered soil type A; deep, well- to excessively-drained sands and gravels having high infiltration potential. These soils are generally associated with streams, as is the case here with its presence in the vicinity of Juanita creek. Kitsap soil, associated with glacial lake deposits, are present in the Yarrow Bay area. These D type soils are generally made up of clay and have very low infiltration potential. The predominant soil types for each watershed are listed on Table III.1. New techniques now available should be applied in Kirkland to update existing soils maps.

[3] Anadromous fish include species, such as Pacific Salmon, that spend part of their life history in fresh water and part in salt water.

TABLE III. 1 Summary of Watershed Characteristics

	Juanita In City	South Juanita Slope	Forbes	Kirkland Slope	Moss Bay
Basin Size (acres)	1428.95	287.29	1836.78	210.52	1487.37
% of Total City Acreage	20%	4%	26%	3%	21%
Miles of open channel/Miles of pipe (>1 means more open channel than piped)	6.82/4.09 = 1.67	0.32/0.53 = 0.6	9.49/4.64 = 2.05	0/0.02 = 0	4.75/6.43 = 0.74
% Impervious Surface – Existing	48%	41%	34%	37%	43%
% Impervious Surface – Buildout (estimate based on zoning)	49.33%	44.23%	38.45%	37.89%	46.4%
Predominant Soil Type	A	C	C	C	C
Top 3 Zoning Categories (% of total basin acreage in each zoning category)	31% LDR 14% COM 12% OFF	66% LDR 12% COM 12% HDR	70% LDR 10% P/O 9% MDR	86% LDR 13% P/O 0.5% COM	60% LDR 8% MDR 7% IND 7% P/O (tied)
Current Fish Usage	Yes – anadromous and resident	No	Yes – anadromous and resident	No	No
Historic Fish Usage	Yes	No	Yes	No	Unknown
Comments	Approx 2/3 of basin area in unincorporated King County				

Soil Type Key:

A = deep, well- to excessively-drained sands and gravels having high infiltration potential

B = moderately deep to deep, moderately fine to moderately coarse-textured soils with moderate infiltration potential

C = moderately fine to fine textured soils that mostly have a layer which impedes downward movement of water

D = soils that have very low infiltration rates including clay and soils with a permanent high water table or hardpan

Zoning Key:

LDR = Low Density Residential
MDR = Medium Density Residential
COM = Commercial
OFF = Office
IND = Industrial
INS - Institutional
P/O = Park/Open Space

TABLE III. 1 Summary of Watershed Characteristics *cont.*

	Houghton Slope A (NW College Creek)	Carillon	Houghton Slope B	Yarrow In City	Sammamish In City
Basin Size (acres)	376.63	105.71	134.38	579.28	293.33
% of Total City Acreage	5%	2%	2%	8%	4%
Miles of open channel /Miles of pipe (>1 means more open channel than piped)	0.81/1.94 = 0.42	0.31/0.11 = 2.85	0.32/0.89 = 0.36	4.33/0.67 = 6.49	0.03/0.23 = 0.15
% Impervious Surface – Existing	43%	37%	38%	26%	36%
% Impervious Surface – Buildout (estimate based on zoning)	46.09%	40.32%	43.22%	26.95%	39.45%
Predominant Soil Type	C	A	C	D	C
Top 3 Zoning Categories (% of total basin acreage in each zoning category)	56% LDR 21% MDR 14% INS	56% LDR 22% MDR 9% COM	78% LDR 10% MDR 10% COM	57% LDR 30% P/O 11% OFF	80% LDR 7% COM 5% HDR
Current Fish Usage	No	Possible	No	Possible	No
Historic Fish Usage	No	Possible	No	Yes	Unknown
Comments				Most of basin in Bellevue	Most of basin in Redmond

Soil Type Key:

A = deep, well- to excessively-drained sands and gravels having high infiltration potential

B = moderately deep to deep, moderately fine to moderately coarse-textured soils with moderate infiltration potential

C = moderately fine to fine textured soils that mostly have a layer which impedes downward movement of water

D = soils that have very low infiltration rates including clay and soils with a permanent high water table or hardpan

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The mapped soil and geologic characteristics in much of Kirkland inhibit the infiltration of surface water. The predominant soils in the city are in the Alderwood series and are considered soil type C, moderately fine to fine textured soils that have a layer which impedes the downward movement of water. Alderwood soils are not very deep (20 to 40 inches) and are generally located on upland terraces over glacial till, a geologic material that has very low permeability. All but three of Kirkland's watersheds consist mostly of type C, Alderwood-associated soils. Soils in the Juanita Bay area are in the Indianola series and are considered soil type A; deep, well- to excessively drained sands and gravels having high infiltration potential. These soils are generally associated with streams, as is the case here with its presence in the vicinity of Juanita Creek. Kitsap soils, associated with glacial lake deposits, are present in the Yarrow Bay area. These type D soils are generally made up of clay and have very low infiltration potential. The predominant soil types for each watershed are listed on Table III.1. New techniques now available should be applied in Kirkland to update existing soils maps.

The volume, duration, and frequency of surface water reaching the city's receiving waters is directly related to impervious surfaces and the underlying soil and geologic conditions. Unmitigated impervious surfaces cause more water to run off into the city's natural and constructed drainage system more quickly, resulting in flooding and degradation of stream habitat. Additionally, impervious surfaces, such as roadways, contribute pollutants to surface water, impacting beneficial uses. Currently, 39% of the city's surface area is covered by impervious surfaces, including roads, parking lots, and rooftops. Juanita Creek, Moss Bay, and Houghton Slope A watersheds have the highest percentage of impervious surfaces. Yarrow Creek and Forbes Creek watersheds have the lowest percentage of impervious surfaces (26% and 34%, respectively), and a high percentage of land use in these basins is low-density residential and parks and open space. Overall, the single largest land use in the city of Kirkland consists of single-family residences (58% of total acreage).

In the future, land use zones are expected to remain similar to what they are today; however, there is the potential for significant future development and redevelopment of commercial and residential properties as discussed in Appendix B. There are approximately 400 acres of vacant land available for new development, and older residential communities have already been experiencing redevelopment as large lots are subdivided and smaller homes are torn down and replaced with larger ones. Based on an analysis of current zoning regulations, there could be an overall increase of 3% in impervious surface area if the available land is built out to its full developable potential.

3.B Problems

Surface water problems in the city today are largely a result of uncontrolled flows from impervious surfaces. Much of the development in the city occurred prior to realization of the negative impacts that development and associated impervious surfaces could have on water resources. As Kirkland has developed and impervious surfaces have increased, stormwater flows have increased in volume, frequency, and duration. Hydrologic modeling results for Forbes Creek show an increase in peak flows from predeveloped to existing conditions (see Appendix C for complete hydrologic modeling results). The modeling also shows a decrease in base flow because of less infiltration and subsequent groundwater recharge (Figure III.2). The effects of increased high flows are evident in the Juanita Creek and Forbes Creek stream channels. Active channel downcutting and bank erosion is present in many reaches and can be partially attributed to higher, more frequent flows (Parametrix 2004). Furthermore, ordinary urban activities such as driving, washing cars, and applying garden chemicals contribute pollutants to surface water. Although current design regulations will lower the impact of future development and redevelopment, existing development and new development that is smaller than thresholds for requiring control (for example replacement of an existing single-family house with a larger single-family house) will continue to cause flooding, water quality, and aquatic habitat problems if left unchecked. These problems are very much interrelated; however, for clarity, they are discussed separately below.

Erosion and sedimentation problems are related to each of the three main surface water issues: flooding, water quality, and aquatic habitat. Erosion and sedimentation in stream channels has compromised or clogged surface water infrastructure, resulting in flooding problems. Additionally, fine sediment from in-stream erosion, construction-related runoff, hillslope failures, and other erosive mechanisms contributes to poor water quality conditions in the city's streams. Aquatic habitat is also affected by erosion and sedimentation through the removal of in-stream habitat structures as streams experience downcutting or bank erosion, and spawning gravels are buried by sediment.

Flooding

Flooding is no longer a widespread problem in Kirkland, but in the handful of places where it does occur, it is a public safety and property damage issue for the residents and motorists affected. Table III.3 lists flooding problems that have been identified by Kirkland Surface Water Utility personnel. Capital improvement projects are being recommended to address these problems, as discussed in Chapter V.B.

Nuisance flooding occurs in the autumn because of clogged catch basins resulting from heavy leaf fall. Flooding also occasionally occurs due to the deposition of sediment and other types of debris in catch basins. This type of flooding occurs throughout the City and is usually easily addressed by City maintenance personnel. Maintenance crews greatly lower the frequency of this type of problem through street sweeping, and cleaning and retrofit work, but there are still localized problems during high-intensity rain events.

Flooding in Kirkland also occurs from increased erosion associated with higher, more frequent volumes of runoff, both adjacent to and within stream channels. Most of the streams in the City have narrow or non-existent riparian zones, and little space exists to allow for natural overbank flooding. The proximity of structures to streams reduces the potential for connectivity between the active channel and adjacent floodplain. As a result, active erosion is occurring on many of the City's stream channels as they adjust to accommodate larger, more frequent flows resulting from increased impervious surfaces.

Table III.2 List of Flooding Problems

Location	CIP Number	Flooding Problem
NE 95th at 126th Avenue NE	FO-03	The east branch of Forbes Creek backs up upstream from NE 95th Street during storms, and minor road and residential flooding occurs.
124th Avenue NE in the vicinity of NE 100th Place	FO-13	Culvert on 124th Avenue NE has inadequate capacity to handle flows during large storm events. Water backs up and causes residential flooding.
Totem Lake Boulevard at 119th Avenue NE	JU-9	Totem Lake Boulevard floods during mid-large storm events. Flooding occurs several times a year.
Business Park on Post Office Creek	UMB-2	Business park floods during storm events, due to undersized culvert and reduced channel conveyance.
108th Avenue NE Roadway Drainage	FO-01	During heavy rains, minor roadway flooding occurs because of inadequate curb cuts to convey stormwater away from roadway.

There is the potential for an increase flooding as Kirkland's existing stormwater infrastructure ages. Many pipes and structures are at or beyond the age of their expected life, and may cause flooding if/as they fail or become clogged with roots. There also are likely to be pipe capacity problems in some areas due to a cumulative increase in flows from development that doesn't meet the minimum threshold requirements for providing flow control. In addition to inadequate pipe capacity, the aging infrastructure is prone to root intrusion and pipe failure and has the potential to cause more flooding problems.

In areas of active channel erosion (downcutting or bank erosion), infrastructure can be compromised, resulting in flooding and habitat-related problems. Examples of this kind of problem and the associated capital improvement projects to address them include (1) the erosion of culvert footings for a bottomless culvert located on Forbes Creek, upstream of Forbes Creek Drive (CIP FO-05), and (2) bank erosion and slumping that has exposed a storm drain outfall pipe on Juanita Creek near NE 120th Place (CIP JU-10). Associated with increased erosion, is the increased sediment deposition that occurs downstream.

Sediment deposition reduces channel conveyance and fills in culverts and pipes, reducing capacity and causing flooding. City maintenance personnel are continually addressing sedimentation issues at the Cochran Springs Creek culvert at Lake Washington Boulevard (CIP CO-01). Erosion and sedimentation problems also have a significant impact on aquatic habitat as will be discussed in the Aquatic Habitat section.

Water Quality

Water quality is degraded in the Juanita Creek and Forbes Creek watersheds, where monitoring and sampling has been conducted since 1997 (see Appendix D water quality monitoring data for Juanita and Forbes creeks). The poor water quality in Kirkland's watersheds is typical of urban areas and has affected beneficial uses such as contact recreation (swimming and wading) and fishing in Lake Washington and has contributed to degraded habitat for aquatic organisms, including salmonids.

Both Juanita and Forbes Creeks are on the draft 2004 Washington State Department of Ecology 303(d) (Ecology. 2004) list for waters with impaired water quality. Both creeks have elevated levels of fecal coliform, high temperatures, and low concentrations of dissolved oxygen. The previous 303(d) listing for these creeks, published in 1998, was only because of elevated fecal coliforms. Yarrow Creek was also on the 1998 303(d) list for fecal coliforms. A fecal coliform RNA analysis completed by King County Department of Natural Resources in 1998 determined that the primary sources of fecal coliforms at Juanita Beach were ducks and geese. An RNA analysis has not been completed for Forbes Creek; however, a plan to conduct fecal coliform RNA analysis for Forbes Creek is included in Appendix E.

Pollutants from nonpoint sources, such as landscaping chemicals and fertilizers, wastewater from washing and cleaning, pollutants from motor vehicles, fine sediments from roadways and construction activities, and animal waste have primarily contributed to the degradation. Point sources of pollutants, such as waste from failing septic systems, petroleum and chemical spills, and inappropriate connections to the drainage system also contribute to degraded water quality. An indirect source of water quality impairment is the lack of high-quality riparian vegetation surrounding Kirkland's streams. Poor riparian vegetation quality and quantity adjacent to Juanita and Forbes Creeks have contributed to elevated temperatures. Surface water quality problems in Kirkland have not been ranked according to which pollutants or issues are of greatest concern. A first step in allocating resources would be to prioritize the pollutants of interest and corresponding measures to improve water quality conditions.

In addition to the increase of pollutants entering Kirkland's streams from nonpoint and point sources, the pollutant concentrations present in the surface water are higher than they might otherwise be if there were more opportunities for attenuation by vegetative filtering, infiltration, or constructed water quality treatment facilities. The high percentage of impervious surfaces in the city reduces the amount of surface water that naturally infiltrates into the soil and ground, filtering out pollutants and recharging the groundwater. Instead, surface water (and pollutants) is quickly routed to catch basins and pipes, limiting contact with vegetation that can filter out pollutants prior to reaching more sensitive receiving waters. In areas where surface water is conveyed in open ditches prior to discharging to stream channels, some pollutant filtering is probably occurring. The city's existing stormwater system has few water quality treatment facilities because it was mostly constructed prior to the establishment of current surface water regulations that require water quality treatment. All of these factors contribute to the poor water quality in Kirkland's streams.

The City is obligated to maintain and improve surface water quality under the federal Clean Water Act, as was discussed in Section II.C., Regulatory Framework.

Aquatic Habitat

Aquatic habitat within Kirkland's streams has been impaired by a variety of conditions resulting from urbanization (see Appendix F for a complete summary of stream conditions on Juanita and Forbes Creeks). Figure III.3 gives an overview of aquatic habitat problems. In general, the limiting factors for properly functioning physical habitat conditions observed on both Juanita and Forbes Creeks include (1) increased frequency of high flows, (2) increased sediment mobility, (3) lack of riparian vegetation, (4) lack of large woody debris (LWD), and (5) lack of channel complexity (Parametrix, 2004). These factors have implications for anadromous and resident salmonids, including coho salmon and cutthroat trout, and have likely contributed to reduced fish populations observed in Juanita, Forbes, and Yarrow Creeks. It is unknown whether other Kirkland watersheds, including Carillon and Moss Bay, ever supported significant populations of fish. Current fish usage in these watersheds has not been observed (Watershed Company. 1998). Kirkland's smaller watersheds located on the steep slopes above Lake Washington (South Juanita Slope, Kirkland Slope, and Houghton Slopes A and B) never supported historic fish populations (Williams et al. 1975).

Fish passage barriers located on Forbes Creek limit viable spawning and rearing habitat (Parametrix. 2004). Several of the barriers are located on reaches lower in the watershed, significantly reducing the habitat available to migrating fish. There are no fish passage barriers located in the Juanita Creek watershed within the City's jurisdiction, based on the recently completed Stream Inventory and Habitat Evaluation Report for Juanita, Forbes, Yarrow and Cochran Springs Creeks (Parametrix. 2004).

Active channel downcutting and bank erosion is present in many reaches and can be partially attributed to higher, more frequent flows (Parametrix. 2004). The erosion is detrimental to fish populations for a number of reasons. In addition to the local habitat degradation where erosion occurs, channel downcutting and bank erosion also compromise built structures, including culvert crossings, which can create barriers to fish passage. Active erosion in one part of the channel invariably causes sedimentation in another part of the channel or at the channel outlet in Lake Washington. Deposition of fine sediment has created fish passage problems on Forbes Creek and filled in spawning gravels on Juanita Creek, reducing the availability of dissolved oxygen to buried salmon eggs and decreasing their viability.

FIGURE III.3 Map of Aquatic Habitat Problems (see end of section)

Channel bank erosion is also related to bank modification. A high percentage of Kirkland's streams are located on private property where homeowners have armored stream channels, cut back vegetation, or otherwise modified the streambanks. While bank armoring may be effective in reducing erosion locally, it often has the unintended consequence of causing more erosion in another location. Additionally, lack of vegetation can increase bank instability, resulting in erosion (Booth and Reinelt. 1993).

Riparian vegetation provides many habitat functions, including (1) supply of LWD to stream channels, (2) shade to keep water temperatures low, (3) filtration of pollutants, (4) supply of nutrients to aquatic organisms, and (5) cover from predators such as birds. The riparian vegetation is variable on both Juanita and Forbes Creeks. In general, publicly owned portions of Forbes Creek are forested and in good condition, whereas publicly owned land on Juanita Creek has limited riparian cover. Privately owned land on both creeks is generally in poor condition, with limited, lower-quality vegetation. The loss of riparian vegetation adjacent to Kirkland's streams has contributed to degraded aquatic habitat conditions, including lack of LWD and high water temperatures.

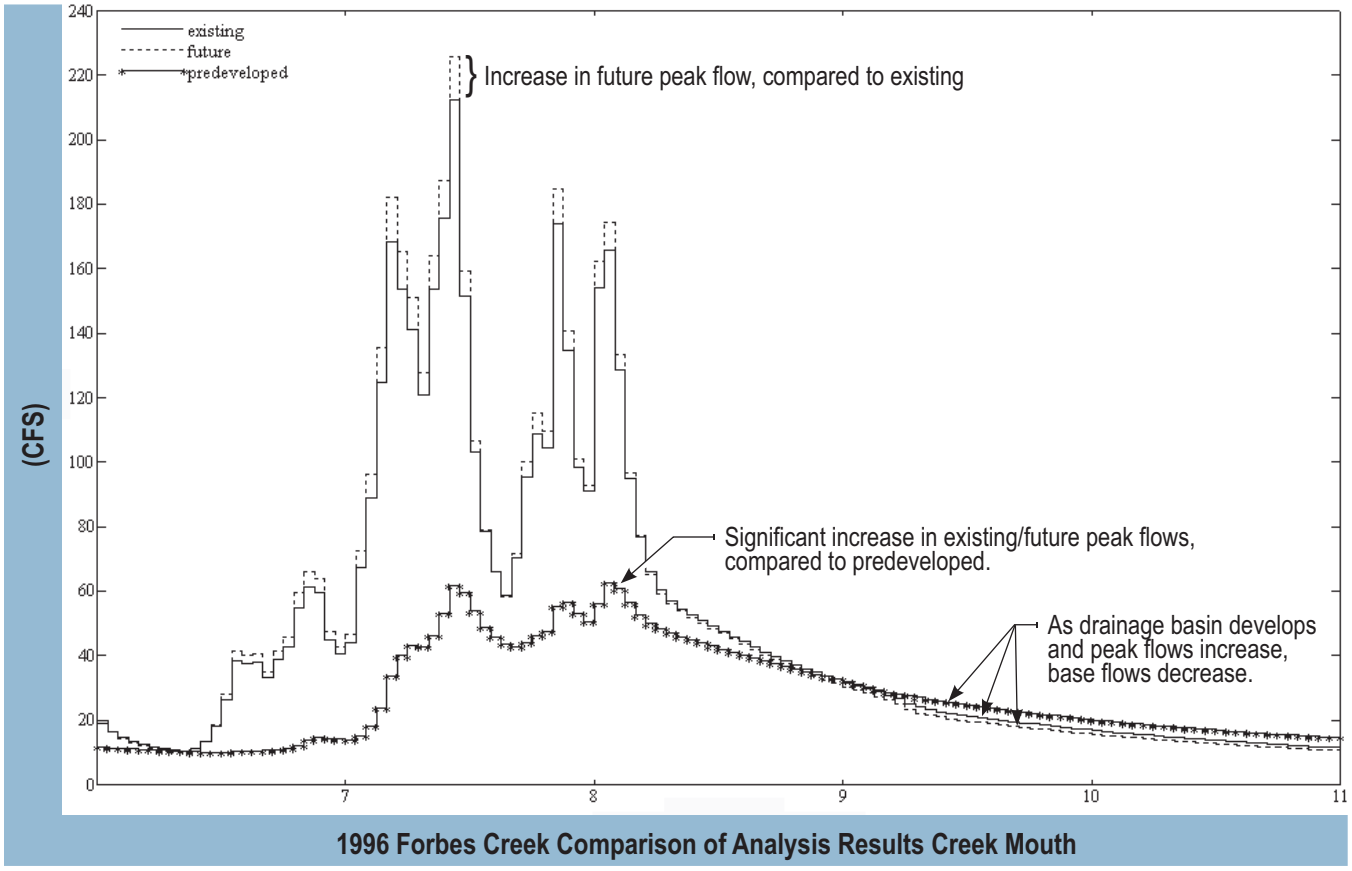
A direct effect of stream channel erosion and deposition and decreased quality and quantity of riparian vegetation is the loss of in-stream channel complexity. Fish species need variable in-stream physical habitat conditions to meet their needs at different points in their life history, including pools, riffles, spawning gravel, and overhanging riparian cover. The presence of LWD helps create channel complexity through pool formation, sediment retention, and channel grade control. Both Juanita and Forbes Creeks have minimal LWD and low pool frequency.

Other factors contributing to the degradation of aquatic habitat in Kirkland's streams include stream channels that have been piped and degraded water quality. Stream channels have been piped in some areas, eliminating fish habitat and/or access to upstream habitat. An example of this is Forbes Creek through an office complex just upstream of the Burlington Northern Santa Fe railroad crossing. As discussed above, degraded water quality is a problem in Kirkland's fish-bearing streams. Benthic macroinvertebrates have been monitored at several stations on Juanita and Forbes Creeks using the Benthic Index of Biotic Integrity (B-IBI). B-IBI scores are a measure of the general health of the in-stream invertebrate community and can be used as an indicator of overall habitat quality. The data collected between 2001 and 2003 indicate poor habitat quality on all sites sampled (see Appendix G for B-IBI monitoring data for Forbes and Juanita creeks).

Table III.3 Fish Populations in Kirkland Streams

Watershed	Resident Fish Population	Anadromous Fish Population	Historic Fish Population	Comments
Juanita Creek	Yes	Yes	Yes	Largest variety of fish populations of any creek in Kirkland
South Juanita Slope	No	No	No	Mostly pipe system
Forbes Creek	Yes	Yes	Yes	Many blockages (I-405), resident trout east of I-405
Kirkland Slope	No	No	unknown	Mostly piped system
Moss Bay	No	No		Short stretches of open channel exist (Everest Creek) but are separated from Lake WA by long piped sections
Houghton Slope A	No	No		NW College Creek
Carillon Creek	Possible at mouth	Possible at mouth (limited)		Water district property is headwaters
Houghton Slope B	No	No		3 small drainages, mostly piped
Yarrow Creek	Yes at mouth	Yes at mouth (limited)		LK WA Boulevard culvert is a blockage

FIGURE III. 2 Forbes Creek Reach 1 - Predeveloped, Developed, and Future Developed Flows



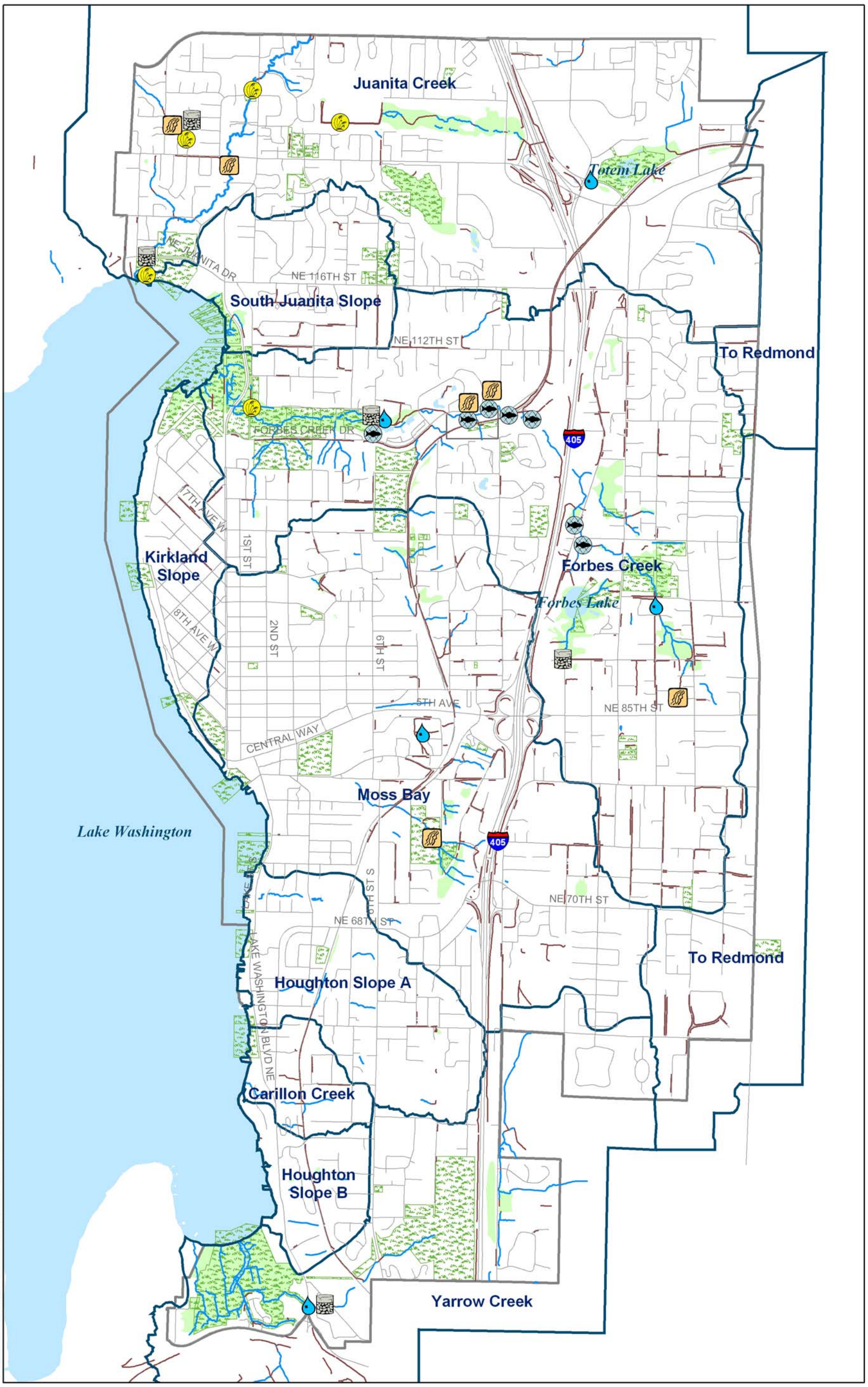
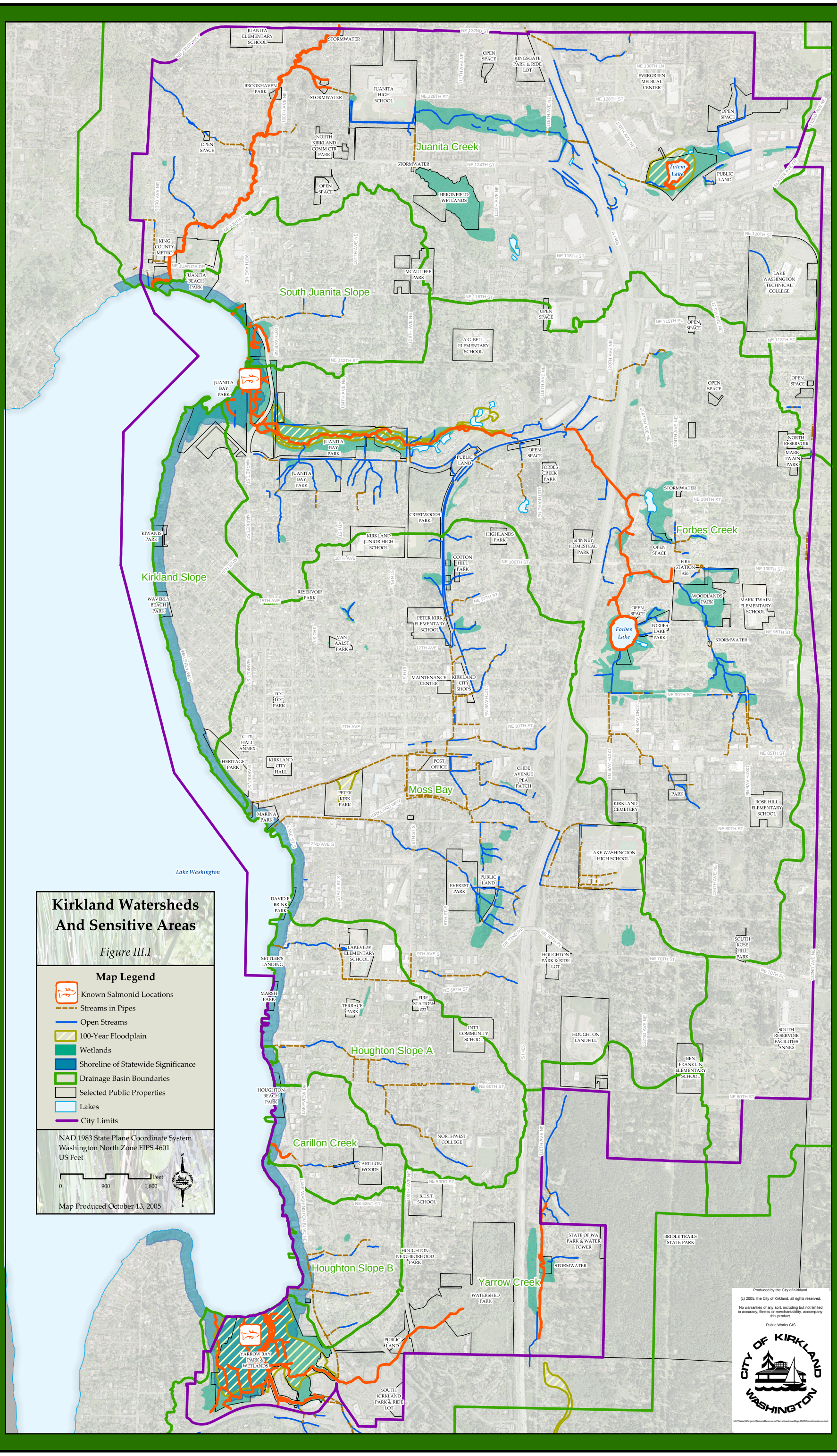


Figure III.3
Locations of Aquatic Habitat Problems


Kirkland Watersheds
And Sensitive Areas
Figure III.1
Map Legend
Known Salmonid Locations
Streams in Pipes
Open Streams
100-Year Floodplain
Wetlands
Shoreline of Statewide Significance
Drainage Basin Boundaries
Selected Public Properties
Lakes
City Limits
NAD 1983 State Plane Coordinate System
Washington North Zone FIPS 4601
US Feet
0
900
1,800
Feet
Map Produced October 13, 2005
Juanita Creek
South Juanita Slope
Kirkland Slope
Forbes Creek
Moss Bay
Houghton Slope A
Carillon Creek
Houghton Slope B
Yarrow Creek
Lake Washington
Totem Lake
Forbes Lake
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