SENSITIVE HABITAT INVENTORY AND MAPPING (SHIM)

Mill Creek and Bellevue Creek
Kelowna, British Columbia

Inventory Summary Report



Prepared For:
THE CITY OF KELOWNA

Prepared By:
ECOSCAPE
Environmental Consultants

February, 2006

File No. K05003

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Kyle Hawes, R.P.Bio.
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1.0 INTRODUCTION

Ecoscape Environmental Consultants (Ecoscape) was retained by the City of Kelowna (CoK) to complete Sensitive Habitat Inventory and Mapping (SHIM) on Mill Creek and Bellevue Creek occurring within the city limits. The following report summarizes the inventory findings, which have been provided to the CoK and the Community Mapping Network (www.shim.bc.ca) in digital GIS format.

1.1 Project Background

As resource development and human populations increase in British Columbia, pressures for all resources and services have accelerated. Rapid growth has often overwhelmed the ability of local planners to manage land and preserve sensitive habitats (Mason and Knight, 2001). This has resulted in the loss or degradation of aquatic and riparian habitats that are critical for fish and a diverse wildlife assemblage. Thus, there is an urgent need to develop better methods to conserve and protect and reclaim these habitats.

Sensitive Habitat Inventory and Mapping (SHIM) is a standard for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia. SHIM attempts to ensure the collection and mapping of reliable, high quality, current, and spatially accurate information about local freshwater habitats, watercourses, and associated riparian communities.

SHIM is designed as a land-planning, computer-generated interactive GIS tool that identifies sensitive aquatic and terrestrial habitats. It is intended to provide community, stewardship groups, individuals, regional districts and municipalities with an effective low cost delivery system for information on these local habitats and associated land uses.

SHIM has numerous applications and can:

- Provide current information not previously available to urban planners, to allow more informed planning decisions and provide inventory information for Official Community Plans;
- Assist in the design of stormwater/runoff management plans;
- Monitor for changes in habitat resulting from known disturbance;
- Identify and map potential point sources of pollution;
- Help guide management decisions and priorities with respect to habitat restoration and enhancement projects;
- Assist in determining setbacks and fish/wildlife-sensitive zones;
- Identify sensitive habitats for fish and wildlife along watercourses;

- Provide a means of highlighting areas that may have problems with channel stability or water quality, and require more detailed study;
- Provide baseline mapping data for future monitoring activities; and,
- Map and identify the extent of riparian vegetation available and used by wildlife and fisheries resources.

1.2 Project Objectives

The objectives of the project were to:

- Inventory and map Mill Creek and Bellevue Creek within the Kelowna city limit, their associated riparian habitats, and watercourse and important fisheries habitat features;
- Provide the basis for accurately mapped baseline data that can be integrated into local mapping and planning initiatives; and,
- Augment and potentially enhance local land use planning maps and/or specific site or detailed planning surveys.

The primary functions of SHIM are to:

- Identify sensitive habitats and resources within local communities;
- Integrate property boundaries, land parcels, and road networks with locations of sensitive resources to facilitate Official Community Plans and Development Permit applications;
- Work within an interactive Geographical Information System (GIS) to provide useful map products for analysis and effective communication;
- Facilitate updating and exchange of information; and,
- Establish partnerships with provincial and municipal governments, stakeholders, and the public to protect and manage aquatic habitats and associated functions (i.e. riparian communities and linear corridors etc.).

By combining resource information from a variety of sources the goal is that SHIM will provide a robust baseline inventory (cataloguing the stream and all natural and anthropogenic features occurring within and long it) for improving integrated resource management and planning within the City of Kelowna.

2.0 SCOPE OF WORK

The primary scope of work was based on the Request for Proposal (City of Kelowna, September 30, 2005) and further built upon and supported by Ecoscape's extensive experience with SHIM and its primary objectives, and included the following:

- Pre-field interpretation (using digital orthophotos) of subject watercourses;
- Field inventory (conforming to SHIM Standards and Methodology) on Bellevue Creek and Mill Creek beginning at their confluence with Okanagan Lake, extending upstream to the City Limit. The approximate SHIM stream length of Bellevue Creek and Mill Creek was 6.6km and 23.3km respectively.
- Process field data as per SHIM standards; and,
- Provide standard SHIM deliverables to the City of Kelowna and subsequently to the Community Mapping Network (CMN) for publication in the SHIM atlas.

3.0 METHODOLOGY

Field inventory and data processing and data deliverables conformed to the SHIM Standards (Mason and Knight, 2001), which can be reviewed in full at http://www.shim.bc.ca/methods/SHIM_Methods.html .

3.1 Centreline Survey

Kyle Hawes, R.P.Bio. was the principle surveyor and completed all field survey elements with the assistance of a field technician (Walter Hawes).

The stream centerline was mapped along the center of the bankfull (not floodplain) width. The creeks were stratified into a series of successive sections (segments), each possessing and being characterized by different attributes or biophysical characteristics (i.e., hydraulic class, channel characteristics, substrates composition, and riparian class etc.). The stream segmentation and associated attributes was the fundamental unit of the centerline survey with point features providing a more quantitative measure of relative disturbance/modification, and aquatic habitat quality/complexity (i.e. area abundance of deep pools/spawning substrates/coarse woody debris measure etc.).

The field inventory was completed during Kokanee-egg incubation periods. Therefore measurements and GPS logging of suitable spawning habitat occurred adjacent to these areas using offset points to mitigate the potential disturbance to Kokanee spawning redds, which may have been present in suitable substrates.

The section of Mill Creek from the upstream end of the Kelowna International Airport to the city limits was surveyed in 2002 by the Regional District of Central Okanagan, conforming to SHIM standards. This data was shared by the Regional District for incorporation in to the CoK SHIM streamline.

The data dictionary (SHIM_2002) was updated to include a Level of Impact Rating (Appendix A). A zero (0) to six (6) scoring system was developed to evaluate respective stream segments in terms of their degree of disturbance, where a stream segment not being recently modified (natural) received a score of 6 (nil), and a stream segment being highly modified on both banks/channelized/ditched, etc. received a score of 0 (both_banks_high). A rationale was then provided explaining the score assigned each segment.

Table 1 provides a complete list of features and corresponding attributes that were recorded using the Trimble Geo Explorer (GPS) and SHIM Data Dictionary.

Table 1. Overview of watercourse and habitat attributes to be collected using the SHIM Data Dictionary (Module 3, Mason and Knight, 2001). The complete data dictionary can be found in Appendix A.

Survey Component	Main Attribute	Detailed Feature Collected
Stream Centre Line	Stream Reference Information	Name; Watershed Code; Date; Time; Survey Conditions; Surveyors
	Stream Segment Points	Start; Stop; Reach Break; Elevation; Representative Photographs
	Stream Segment Class	Stream Section; State of Section (i.e. natural/modified/channelized); Dominant Hydraulic Type
	Segment Characteristics	Section Gradient; Fish Spawning; Canopy; Access; Gravel
	Segment Substrate Attributes	Dominant Substrate Type; Compaction
	Segment Channel Attributes	Widths (wetted, bankfull), Depths (wetted, bankfull)
	Segment Instream Cover	% Total Cover; % by Feature/Cover Type (large woody debris/deep pool/over stream vegetation etc.)
	Segment Riparian Attributes	Left and Right Bank Riparian Class (vegetation association; structural stage; bank slope; material etc.)
		Segment Summary Description
Watercourse and Habitat Features	Culvert Attributes	Type-Material; Condition; Barrier; Size; Baffles
	Obstruction Attributes	Type-Material; Barrier; Size; Photo
	Stream Discharge Attributes	Point of Discharge; Type-material; Size
	Erosion Feature	Type of Erosion; severity; exposure; material
	Fish Habitat Attributes	Type of Habitat (Spawning/rearing/cover); Size; Slope; Photo
	Enhancement Areas	Type of Enhancement; Potential or existing enhancement
	Wildlife Observations	Type of Observation; Wildlife species; Photo
	Wildlife Tree Attributes	Type of Tree; Size; Location
	Near Waterbody Attributes	Type of Waterbody (spring/side channel/pond etc.); Size
	Wetland Attributes (Polygon feature)	Wetland Type-Class; Photo
	Photograph Location	Location; Direction.
	Level of Impairment	Score 0 (natural) – 6 (severely impaired); Rationale
	Enhancement Opportunity Rating	0 (Nil) – 4 (Very High); Rationale

3.2 Top of Bank Survey

Watercourse (lake, pond, stream and wetland) location and extent are critical for providing information to help determine the extent of protection to which a water course should be entitled. Determining the correct location of a stream, functionally (hydrologically) connected watercourses and wetlands, and their associated top of banks (TOB) is a necessary prerequisite for delineating Fisheries Sensitive Zones (FSZ). FSZs are an

essential planning component in defining the Streamside Protection and Enhancement Area for development adjacent to a stream.

The top of bank was defined using the following criteria as recognized by the Ministry of Environment and Department of Fisheries and Oceans Canada:

i) The point closest to the boundary of the active floodplain of a stream where a break in the slope of the land occurs such that the grade beyond the break is flatter than 3:1 at any point for a minimum distance of 15 metres measured perpendicularly from the break;

ii) For a floodplain area not contained within a ravine, the edge of the active floodplain of a stream where the slope of the land beyond the edge is flatter than 3:1 at any point for a minimum distance of 15 metres measured perpendicularly from the edge; or,

iii) The first significant break in a ravine slope where the break occurs such that the grade beyond the break is flatter than 3:1 for a minimum distance of 15 metres measured perpendicularly from the break, and the break does not include a bench within the ravine that could be developed.

3.3 Data Logging and Processing

GPS settings were in accordance with Resource Inventory Committee Standards to ensure the collection of spatially accurate data. The coordinate system used was North American Datum 83, 11 north.

Field (GPS) data were post processed (differentially corrected) in the office using base stations situated both in Penticton (SOPAC, Dominion Radio Astrophysical Observatory), and Kettle Falls, Washington (USFS, Colville National Forest).

Data dictionary tools designed for ARC View 3.x were employed to process the data and to export the data into ESRI shapefiles.

3.4 Quality Assurance Quality Control

The Resource Inventory Committee and SHIM methodology (Mason and Knight, 2001) provide specific requirements for quality assurance and quality control. These standards such as GPS settings/precision, logging intervals, and data management and deliverables were followed throughout the project.

4.0 RESULTS

The following section summarizes the inventory data base. Bellevue Creek and Mill Creek are discussed separately in respective subsections. Refer to the attached figures (maps) and corresponding summary pages for segment attributes and representative photos. The processed data from the centreline survey (Stream_line) and feature data has been included in Appendix B. In addition, this (data) can be found in digital format accompanying the complete inventory catalogue, which includes all point features, attributes, and representative photos (intended for use in a GIS platform). Furthermore, the reader is encouraged to refer to the Community Mapping Network, SHIM atlas (www.shim.bc.ca).

4.1 Bellevue Creek

Within the City of Kelowna, Bellevue Creek extends about 6.62 km from its terminus at Okanagan Lake upstream to the Kelowna city limits. The creek was divided into 25 segments (Figures 1-7). Components of stream segment attributes are discussed in Section 4.1.1 and watercourse and habitat features are analyzed and summarized in Section 4.1.2.

4.1.1 Stream Centreline Survey

The following subsection summarizes components of the centreline survey, which can be found in Appendix B (Stream_line data).

4.1.1.1 Stream Primary Character

Over 4.2 km (64%) of Bellevue Creek has been channelized and modified within the Kelowna city limit (Table 2). Natural stream segments account for about 36% of the SHIM stream length. With the exception of Segment 8, all natural segments occur within and upstream of the Bellevue Creek Canyon adjacent Crawford Estates. Despite being involved in the Okanagan Mountain Park forest fires (August 2003), these segments have still been classified as 'natural' where salvage logging has not occurred. The exceptions were Segments 20 and 23, where intense salvage logging rendered these segments as 'modified'.

Table 2. Bellevue Creek summary of Primary stream character. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Segments	Primary Character	Length (m)	Percentage of stream
1,2,3,4,5,10,11,12,13,14,15,16,17	Modified – Channelized	2927	44%
6,7,9,20,23	Modified – non channelized	1301	20%
8,18,19,21,22,24,25	Natural	2391	36%

4.1.1.2 Stream Channel and Hydraulic Character

Stream segments within the Kelowna city limit can be clustered into three (3) groups based on stream channel character, hydraulic class, geomorphic setting, and anthropogenic setting:

1. Urban/channelized (Segments 1-17),
2. Bedrock canyon/cascade (Segments 18-22), and
3. Natural floodplain (Segments 23-25) (Table 3).

Collectively, the urban/channelized group of segments represents about 54% of the SHIM stream length. Approximately 81% of the this lower 3.6 km of creek has been channelized. The average stream gradient was about 4% with an average constructed channel width, at normal highwater level, of about 9.7m.

The bedrock canyon/cascade group of segments represents about 21% of the SHIM stream length. Moving upstream, the gradient rises from 7% to greater than 45%. Two (2) waterfalls (Crawford Falls), each over 9-m in height, occur in Segment 21 representing a natural barrier to fish migration (Table 4).

A natural floodplain setting remains upstream of Crawford Falls. Occurring over 1.6km, nearly ¼ of Bellevue Creek, within the City of Kelowna, remains as natural floodplain. Despite the catastrophic fires and salvage logging, these areas have a high capability of regenerating to the late seral and climax Red-listed riparian/floodplain associations that existed before the fires. The average channel width in floodplain areas was over 15m. The well defined floodplain valley, averaging 90-m in width, does not appear to be recently active. However, numerous relic channels and boulder and cobble debris were observed across the broad valley, which continues upstream of the city limit. Any of these channels could again become active in the event of a log jam and subsequent channel avulsion.

Table 3. Bellevue Creek stream channel summary. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

		Gradient (%)				Stream Channel			Floodplain Width [a]			
Segments	Segment Group	Ave.	Min	Max	Percent Channelized	Mean Bankfull Width (m)	Min (m)	Max (m)	Left [b]	Right [b]	Length (m)	Percent of Stream
1-17	Urban/ Channelized	4.4	2.0	7.0	81.46%	9.66	6.50	17.5	0.00	0.00	3594	54.29%
18-22	Bedrock Canyon	15.0	7.0	45.0	0%	8.08	7.40	9.00	0.00	0.00	1407	21.25%
23-25	Natural floodplain	6.0	5.0	7.0	0%	15.50	10.00	20.00	65.00	16.00	1619	24.46%

a. The average width of the natural floodplain valley above Crawford Falls (Segments 21 and 22) is approximately 90-m.
b. Respective left and right bank floodplain widths were approximated from the SHIM top of bank of current stream channel.

Table 4. Bellevue Creek summary of hydraulic character. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Segment	Segment Group	Hydraulic	Length (m)	Percent of Creek
1-12	Urban/Channelized	Riffle	2133	32%
13-17	Urban/Channelized	Cascade	1461	22%
18-20 and 22	Natural Bedrock Canyon	Cascade/Pool	1166	18%
21	Natural Bedrock Canyon	Falls	241	4%
23-25	Natural floodplain	Riffle/Pool	1619	24%

4.1.1.3 Instream Habitat Cover/Complexity

Total and relative instream cover is a field estimate of the type and amount of in-channel cover available to fish. Total cover represents the total percentage of the wetted area of respective segments occupied by cover. The relative abundance (%) of cover types (e.g., deep pool, large woody debris etc.) is an estimate of the distribution (of respective cover types) within the total cover estimate.

Total cover through the urban/channelized group of segments averaged about 28% over the 3.6 km combined segment length (Table 5). Boulders were the predominant cover, accounting for 87% of total cover. Deep pools, generally associated with large boulders, accounted for 10% of total cover. The quality of boulder cover is limited by severe channelization and aggrading and extreme low flow events and scarcity of residual pools. Based on field observations and previous inventories (EBA, 2002)[1], the coarse streambed substrates are primarily providing cover for prickly sculpin (*Cottus asper*) and small resident and juvenile rainbow trout (*Oncorhynchus mykiss*).

Total cover increases to about 48% in the canyon where natural stream channel character remains. Boulder cover is predominant comprising 69% of the total cover. However, deep pool cover, and large and small woody debris are more prevalent accounting for 16%, 10%, and 5% of the total cover respectively. Total cover was less in natural floodplain areas estimated at 34% of the total wetted area. Boulder cover still accounts for the majority of instream cover (78%) with a slightly reduced relative abundance of residual pools (12%). The relative abundance if coarse woody debris was generally unchanged from that observed in the canyon. However, as fire induced snags continue to fall into the creek, the relative abundance of coarse woody debris is likely to increase.

[1] EBA Engineering Consultants Ltd. 2002. Instream and riparian restoration of Bellevue Creek at Stonybrook Road.

Table 5. Bellevue Creek summary of instream habitat/cover. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Segments	Setting	Combined Segment Length (m)	% Total Cover (Average of combined segments)	Percentage of Total cover by Cover Type [a]						
				B	DP	IV	LWD	OV	SWD	UC
1-17	Urban/Channelized	3594	28%	87%	10%	0%	1%	1%	2%	0%
18-22[b]	Natural Bedrock Canyon	1407	48%	69%	16%	0%	10%	0%	5%	0%
23-25	Natural floodplain	1619	34%	73%	12%	0%	10%	0%	5%	0%
		6620	34%	78%	12%	0%	6%	0%	3%	0%

a. Cover codes: B=boulder; DP=deep pool; IV=instream vegetation; LWD=large woody debris; OV=overstream vegetation; SWD=small woody debris; UC=undercut bank

b. Segment 21 consists of two water falls and steep cascade (>30%) and is therefore not considered frequented by fish and is a barrier to upstream fish migrations.

4.1.2 Watercourse and Habitat Features

The following section summarizes feature data collected and nested within the line segments. All features were measured and recorded individually and provide a more robust and quantitative measure of watercourse impairment and habitat quality.

4.1.2.1 Modifications

Nearly all (>99%) recorded modifications (artificial structures/features) occurred in the urban/channelized group of segments (Table 7). Channelization involving channel straightening and excavation accounted for over 90% (2.93km) of recorded modifications. Constructed retaining walls and riprap accounted for over 5% of combined left bank modifications and nearly 8% of combined right bank modifications. The balance of modifications, being less than 1%, included bridges and water withdrawals.

Table 6. Summary of artificial features/modification occurring along Bellevue Creek. Features and values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Segment Group	Combined Segment Length (m)	Type	Left Bank						Right Bank					
			Length (m)	Percent of length	Total (m)	% of total length of modifications	% of combined segment length by section	% of SHIM stream length	Length (m)	Percent of length	Total (m)	% of total length of modifications	% of combined segment length by section	% of SHIM stream length
Urban/ Channelized	3594	Bridge	43	1.37%	3135	99.96%	87.23%	47.36%	43	1.33%	3235	99.74%	90.01%	48.87%
		Garbage/Pollution		0.00%					10	0.31%				
		Channelization	2927	93.37%					2927	90.48%				
		Bank Stability	165	5.26%					255	7.88%				
Bedrock Canyon	1407	Water Withdrawal	0	0.00%	0	0.00%	0.00%	0.00%	7	100.00%	7	0.22%	0.50%	0.11%
Natural Floodplain	1619	Bridge	1	100.00%	1	0.04%	0.08%	0.02%	1	100.00%	1	0.04%	0.08%	0.02%
Total	6620		3136					47%	3243					49%

4.1.2.2 Discharges

Ten discharges from permanent structures were identified. Three (3) of these were flowing during the field inventory despite no measurable precipitation occurring in at least three (3)

days prior to the field inventory. The clear, cool, colourless flows observed from each of these pipes may indicate interaction of the piping with groundwater flows or intercepted tributaries.

4.1.2.3 Erosion

Bank stability has been largely mitigated by the extensive channelization and diking using the coarse boulder/cobble alluvium. Within the Kelowna city limit, approximately 3% of the streambank (by length) is subject to instability and erosion. On the right bank, the cumulative severity of erosion is roughly 300m^2. On the left bank two (2) large landslides have elevated the cumulative severity to over 2800m^2 of bank erosion. The most prominent of landslides occurs at the downstream end of the canyon below Crawford Estates. A groundwater discharge, possibly originating at Jacksmith Lake, occurs near the top of the ravine slope, day-lighting from a more porous layer in the stratum. This discharge is likely the underlying cause of instability, which may have been exacerbated by the loss of vegetation during the Okanagan Mountain Park Fire.

4.1.2.4 Fish Habitat

The predominance of boulders in the majority of segments precludes a reliable cumulative measure of boulder habitat by individual feature. The reader should thus refer to Section 4.1.1.3 for an estimate of relative instream boulder cover. Table 7 summarizes important fish habitat features (excluding boulders) with respect to quantity and relative abundance within the three (3) segment groups. The reader should be advised that when considering spawning habitat, only visually prominent gravel deposits were recorded as important potential spawning habitat features. This measure does not consider the relative abundance of gravel in respective stream segments. Although not recorded as features, the small and patchy distribution of gravel, generally associated with large boulders, may be providing spawning habitat for small resident rainbow trout.

Table 7. Summary of significant habitat features/structures. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits. Segment 21 was excluded from this analysis since it represents a barrier to upstream fish migration (waterfalls). Fish presence-non detection upstream of Segment 21 was not ascertained.

Segment Group	Combined Segment Length (m)	Type	Length (m)	Percent of total length of Segment Group
Urban/Channelized	3594	Deep Pool	27.0	0.75%
		Small Woody Debris	9.5	0.26%
		Spawning Habitat	3.0	0.08%
Natural/Ravine	994	Deep Pool	27.9	2.81%
		Large Woody Debris	45.4	4.57%
		Small Woody Debris	18.5	1.86%
		Spawning Habitat	31.0	3.12%
Natural/Floodplain	1791	Large Woody Debris	21.5	1.20%
		Small Woody Debris	2.5	0.14%

4.1.2.5 Obstructions/ barriers

Table 8 presents the current obstructions that occur on Bellevue Creek within the City limit relative to their distance from Okanagan Lake. The two (2) waterfalls (Crawford Falls) and associated steep cascade and debris comprising Segment 21 are permanent natural fish migration barriers. Rainbow trout were visually observed to the bottom of Segment 21 over 4.5km upstream of Okanagan Lake. However, no fish were visually observed upstream of the waterfalls and, unless introduced by humans, upstream segments are not likely frequented by fish.

Table 8. Bellevue Creek summary of obstructions/barriers to upstream fish migration. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Type	Barrier	Length (m)	Width (m)	Depth (m)	Height (m)	Slope (m)	Distance upstream from Okanagan Lake (km)
Log Jam	Yes	2.50	7.10	0.30	1.30	90	4.20
Falls	Yes	0.00	0.00	0.00	9.00	90	4.57
Persistent Debris	Potential	0.00	4.50	0.30	1.20	0	4.62
Falls	Yes	0.00	0.00	0.00	18.00	90	4.78
Velocity Barrier	unknown	7.50	3.00	0.01	0.00	30	4.95
Dam	Yes	0.00	5.50	0.25	1.15	0	5.90
Falls	Yes	3.50	5.00	0.70	3.00	0	6.08

4.1.2.6 Restoration/Enhancement Features

Fifteen enhancement features were documented on Bellevue Creek consisting of 12 rock wiers, two (2) upstream log deflectors, and one (1) boulder cluster. Seven (7) of the rock wiers were partially collapsed. The remaining features appeared to be satisfying their intended functional objectives, primarily in the creation/maintenance of residual pools. Section 4.1.4 provides a brief discussion with respect to potential enhancement opportunities and constraints, based on SHIM field inventory.

4.1.3 Stream Impact Summary

Ecoscape developed and appended a Level of Impact rating to the data dictionary (Appendix A). This simple rating system was designed with the intent on providing a more measurable parameter in monitoring and evaluating habitat restoration and future conservation efforts on Bellevue Creek and associated riparian and floodplain communities. The raw data and rationale for respective segment scores can be found in Appendix B within the Stream_line data. Weighted scores for respective SHIM impact ratings were obtained by dividing the cumulative length of segments receiving the same SHIM impact rating by the total SHIM stream length to obtain a fractional abundance (% of SHIM stream length). This value was then multiplied by the respective SHIM Score (0-

6) equaling the weighted score. The sum of weighted scores was then divided by the maximum attainable score (6)[2] and transformed into a percentage value.

The sum of the weighted scores (Table 9) for Bellevue was 2.99, nearly 50%. This near failing grade reflects the degree of channelization and loss on riparian habitat that has occurred over Bellevue Creek within the City limits (See also Tables 2 and 3).

Table 9. Bellevue Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 6.62 linear km of creek within the Kelowna city limits.

Segments	SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
19,21,22,24	Nil	6	1366	20.64%	1.24
8,9,18,25	1_bank_low	5	1138	17.19%	0.86
7.0	1_bank_mod	4	210	3.18%	0.13
4,6	1_bank_high	3	373	5.64%	0.17
10,14,16,23	Both_banks_low	2	1481	22.38%	0.45
2,3,5,11,12,20	Both_banks_mod	1	993	15.00%	0.15
1,13,15,17	Both_banks_high	0	1057	15.97%	0.00
				Weighted Score	3.0
				Stream Grade	50%

4.1.4 Opportunities and Constraints – Overview

Opportunities to restore instream habitats through the urban/channelized group of segments are limited by the degree of channelization and, furthermore by extremely low mid to late summer flows. Surface flows often cease during this period with very few residual pools available to provide refuge for fish. However, resident rainbow trout were observed nearly to the base of Crawford Falls (Segment 21) approximately 4.5 km upstream from Okanagan Lake.

Several groundwater discharges and springs were identified during the field inventory. These contributions of cool water may be critical in sustaining residual pools for resident fish when much of the creekbed is dry. Recognizing the lack of residual pools, due to channelization and persistent aggrading, viable enhancement opportunities may include the strategic placement of boulder wiers, proximal to groundwater discharge areas, to help mitigate aggrading and to maintain additional residual pools.

Climate change and the continued watershed level impairments such as increased imperviousness and loss of floodplain areas may further impact on groundwater recharge in turn further reducing base flows during dry summer months. Despite the catastrophic fires and salvage logging, the floodplain that exists upstream of Crawford Falls has a high capability of regenerating to the late seral and climax riparian/floodplain associations that

[2] A combined weighted score of 6 would be attained if all segments were natural with no measurable human disturbance on either the right or left bank.

existed before the fires. This cottonwood ecosystem is Red-listed within the British Columbia and furthermore, is considered one of the most important native habitat types in North America. These floodplains soak up and retain water creating enormous underground reserves, which supplement stream flows with cool water during the summer months. Therefore to help sustain the long-term viability of Bellevue Creek, key management strategies should focus on the conservation of remaining floodplain areas. Not only will this benefit aquatic organisms, but also the rich diversity of wildlife that depend on these ecosystems during part or all of their life histories.

4.2 Mill Creek

Within the City of Kelowna, Mill Creek extends about 23.3 km from its terminus at Okanagan Lake upstream to the city limits to the north of Old Vernon Road. The creek was divided into 74 segments (Figures 8-26). Components of stream segment attributes are discussed in Section 4.2.1 and watercourse and habitat features are analyzed and summarized in Section 4.2.2.

4.2.1 Stream Centreline Survey

The following subsection summarizes components of the centreline survey, which can be found in Appendix B (Stream_line data).

4.2.1.1 Stream Primary Character

Within the Kelowna city limits, nearly 21 km (89%) of Mill Creek has been modified to some degree (Table 10), with the balance (11%) remaining natural, not having been recently disturbed. The combined length of modified, non channelized segments totaled over 13 km, while that of segments more severely altered (channelized, ditched, and culverted) totaled nearly 7.5km.

Table 10. Mill Creek summary of Primary stream character. Values shown below are based on SHIM field inventory and analysis of 23.3 linear km of Creek within the Kelowna city limits.

Segments	Primary Character	Length (m)	Percentage of Stream
1,2,4,6,8,11,12,26,29,39,41,43,44,48,50,52,54,56,64,67,68	Channelized	5502	24%
63,74	Culvert	217	1%
61,62,65,66	Ditch	1679	7%
3,5,7,9,10,13,14,15,16,17,18,19,20,21,23,25,27,28,30,31,32,33,34,35,36,38, 42,45,46,47,49,53,55,57,58,59,60,72,73	Modified	13438	58%
22,24,37,40,51,69,70,71	Natural	2486	11%

4.2.1.2 Stream Channel and Hydraulic Character

The existing channel character and substrate composition has been influenced by anthropogenic factors such as channelization and removal of instream structures, such as large woody debris. In addition, beaver are playing a significant role in stream-channel character, with over 3 km of the SHIM streamlength documented as physically altered by beaver in the form of dams and ponds. A run/glide hydraulic character predominates Mill Creek accounting for nearly 40% of the SHIM streamlength. Riffle-pool character accounts for about 31%, while very slow moving slough / pond, influenced by beaver together account for about 29% of the SHIM streamlength. The average channel gradient was just over 1% with a maximum observed segment gradient of 3%.

4.2.1.3 Instream Habitat Cover/Complexity

Total and relative instream cover is defined in section 4.1.1.3. Within the Kelowna city limit, about 57% of Mill Creek had an estimated total percentage of the wetted area occupied by cover of less than 20% (Table 11). About 30% of the SHIM stream length had an estimated percent total cover of less than 11% of the wetted area. Deep pools were the predominant cover type estimated to account for 50% of all instream cover followed by over stream vegetation and large woody debris accounting for about 15% and 13% respectively. A more quantitative assessment of important fish habitat features can be found in Section 4.2.2.4.

Table 11. Mill Creek summary and distribution of instream cover/habitat complexity. Values shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of Creek within the Kelowna city limits.

% Total Cover	Combined Segment Length (m)	Percentage of SHIM Stream Length	Percentage of Total cover by Cover Type [a]						
			B	DP	IV	LWD	OV	SWD	UC
0-10%	6981	30%	6%	43%	11%	9%	13%	7%	11%
11-20%	6255	27%	9%	39%	2%	8%	21%	17%	3%
21-30%	2815	12%	2%	26%	5%	22%	27%	9%	10%
31-40%	1676	7%	12%	49%	0%	14%	13%	5%	7%
41-50%	329	1%	15%	70%	0%	0%	10%	0%	5%
51-60%	1085	5%	1%	60%	0%	7%	21%	8%	4%
61-70%	328	1%	1%	15%	0%	49%	15%	15%	5%
71-80%	1560	7%	0%	52%	10%	7%	17%	6%	8%
81-90%	1776	8%	2%	67%	0%	17%	5%	6%	3%
>90%	517	2%	1%	69%	0%	20%	5%	5%	0%
	23322		4%	50%	3%	13%	15%	8%	5%

a. Cover codes: B=boulder; DP=deep pool; IV=instream vegetation; LWD=large woody debris; OV=overstream vegetation; SWD=small woody debris; UC=undercut bank

4.2.2 Watercourse and Habitat Features

The following section summarizes feature data collected and nested within the line segments. All features are measured and recorded individually and provide a more robust and quantitative measure of watercourse impairment and habitat quality.

4.2.2.1 Modifications

Artificial features (modifications) along Mill Creek had a cumulative linear measure of over 7.5 km on the left bank and 7.4 km on the right bank (Table 12). Thus modifications occur over about 32% of the SHIM streamlength. Channelization and retaining walls together accounted for about 91% of all artificial features, occurring over 6.9 km on the left bank and 6.7 km on the right bank.

Table 12. Mill Creek Summary of artificial features/modifications. Features and values shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of creek within the Kelowna city limits.

	Left Bank			Right		
Type	Length (m)	% of total length of modifications	% of SHIM stream length	Length (m)	% of total length of modifications	% of SHIM stream length
Bridge	558	7.36%	2.39%	558	7.53%	2.39%
Channelization	4144	54.68%	17.77%	4144	55.95%	17.77%
Dam/floodgate	21	0.28%	0.09%	21	0.28%	0.09%
Livestock crossing	0	0.00%	0.00%	9	0.12%	0.04%
Other	53	0.70%	0.23%	63	0.85%	0.27%
Pipe Crossing	12	0.16%	0.05%	12	0.16%	0.05%
Retaining Wall/Rip Rap	2791	36.82%	11.97%	2599	35.10%	11.15%
	7578		32.49%	7406		31.76%

4.2.2.2 Discharges

A discharge includes any substance that enters a watercourse via an artificial structure (i.e., pipe), whether it is a contribution of clean cold water from a spring, or pollution from a sewage outlet or storm drain.

A total of 97 discharges were documented along Mill Creek during the field inventory (Table 13). Seventy storm drains were recorded with an average diameter of 320mm and a maximum observed discharge pipe diameter of 1360mm. Several outlets were discharging high turbidity flows during the inventory period. Furthermore, on one occasion, an outlet (about 100-m downstream of Dilworth Drive) began discharging very turbid flows while that feature was being measured and recorded by the field crew, despite the absence of precipitation.

Table 13. Summary of discharges identified on Mill Creek. Features shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of Creek within the Kelowna city limits.

Type	Count	Mean Diameter (m)	Min Diameter (m)	Max diameter (m)	Number flowing during survey
Agricultural Runoff	2	0.15	0.10	0.20	1
Other	9	0.34	0.01	0.80	6
Pollutant	1	0.40	0.40	0.40	1
Septic Effluent	1	0.40	0.40	0.40	1
Storm Drain	70	0.32	0.06	1.36	13
Tile Drain	14	0.13	0.03	0.30	6
	97	0.30	0.03	1.36	28

4.2.2.3 Erosion

Within the Kelowna city limit, approximately 11% of both the left and right bank are unstable and subject to erosion (Table 14). Removal and/or lack of riparian vegetation were observed as the primary factor contributing to bank erosion with channelization and encroachment as secondary associated factors. Mass wasting was most prevalent in stream segments occurring through rural (in particular the Marshall Feedlot) and industrial/commercial properties where little has been done to mitigate for encroachment, removal of riparian vegetation, and subsequent erosion.

Table 14. Summary of bank erosion recorded along Mill Creek. Values shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of Creek within the Kelowna city limits.

Left Bank				Right Bank			
Length (m)	Average Height (m)	Area (m^2)	Percent of SHIM stream length	Length (m)	Average Height (m)	Area (m^2)	Percent of SHIM stream length
2664.30	1.08	2586.74	11.42%	2558.80	1.01	2355.89	10.97%

4.2.2.4 Fish Habitat

Deep pools were the predominant habitat feature type observed and recorded on Mill Creek (Table 15). Deep pool features were those that had an assessed residual pool depth[3] of about 0.25 m. Deep pools occurred over 2.6 km (11.3%) of Mill Creek within the Kelowna city limit, accounting for 67% (area abundance) of all habitat features recorded. Greater than 45% of all deep pool features were attributed to beaver activity. The combined length of segments physically influenced by beaver was roughly 3 km. Over this combined segment length, the average of total instream cover was 83%. Deep pools, created upstream of the dams, accounted for about 70% of the total cover (in these segments).

Spawning habitat, identified by the presence of suitable gravel, occurred over 745 linear metres (3.2%) of the SHIM stream length. The relative abundance of suitable spawning habitat, accounting for nearly 11% of the combined measured area of habitat features, is

[3] Residual pool depth is the depth that the pool would have if the stream stopped flowing.

largely attributed to past habitat enhancement initiatives involving the addition of such gravel.

Table 15. Summary of habitat features. Values shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of Mill Creek within the Kelowna city limits.

Type	Combined Length (m)	Mean Width (m)	Combined Area (m2)	Mean wetted Depth (m)	Percent of SHIM stream length	Relative area Distribution
Deep Pool	2634.4	3.4	12236.2	1.0	11.30%	67.0%
Spawning Habitat	745.8	2.3	1954.3	0.1	3.20%	10.7%
Over Stream Vegetation	355.7	3.4	1315.2	0.6	1.53%	7.2%
Small Woody Debris	259.3	4.1	1090.8	0.5	1.11%	6.0%
Large Woody Debris	229.6	4.4	1041.7	0.6	0.98%	5.7%
Undercut Bank	116.6	0.9	148.9	0.5	0.50%	0.8%
Instream Vegetation	66.0	1.9	124.5	0.1	0.28%	0.68%
Other	49.0	6.0	356.5	9.1	0.21%	1.95%
	4456.4		18267.9		19%	

4.2.2.5 Obstructions/Barriers

Obstructions included all features that had the potential to prevent the normal passage of fish during all or part of the year. In addition, for the purpose of this assessment, obstructions may also represent features that have the potential to become a flood hazard.

Within the Kelowna city limit, 32 beaver dams, one (1) natural debris jam, and one (1) concrete wier/dam were recorded on Mill Creek. Fifteen of the beaver dams were identified as fish barriers fish during all or part of the year, with the remainder having the potential to become an obstruction (depending on the intensity of beaver activity).

4.2.2.6 Restoration/Enhancement Features

Over 130 enhancement features or complexes of features (i.e., wiers, LWD, spawning gravel) were recorded on Mill Creek with a combined linear measure of over 1000m. Table 16 provides a summary of recorded restoration/enhancement features. Upon reviewing Table 16, the reader should appreciate that enhancement work, if done well, will over time become less noticeable. Therefore, it is possible that some features, becoming naturalized, may not have been recorded during the inventory. Although not indicated in Table 16, spawning habitat enhancements (imported gravel) occurred over 200m (linear measure) of Mill Creek. All occurrences of suitable spawning gravel were recorded as a habitat feature (Section 4.2.2.4) rather than an enhancement feature. Comments were included in the data base identifying, where possible, whether respective spawning habitat features were naturally occurring or part of an enhancement.

Table 16. Summary of stream restoration/enhancements on Mill Creek. Values shown below are based on SHIM field inventory (fall, 2005) and analysis of 23.3 linear km of Mill Creek within the Kelowna city limits.

Type	Count	Length (m)	Average Width (m)	Area (m^2)	Percent of Enhancement Count	Percent of Enhancements by Area	Percent of SHIM streamlength
Log/Rock Wiers	54	96	4	382	41.54%	16.19%	0.41%
LWD Placement	13	199	2	572	10.00%	24.21%	0.85%
Other	1	6.00	0.40	2.40	0.77%	0.10%	0.03%
Rock/Boulder Placement	33	70	2	213	25.38%	9.03%	0.30%
Side Channel/Pools	9	91	6	562	6.92%	23.78%	0.39%
Bank revetments (bioengineering)	20	393	1	630	15.38%	26.69%	1.68%
	130	854.00	3.09	2360.99			

4.2.3 Stream Impact Summary

Within the Kelowna city limit, only about 11% of Mill Creek remains natural. Overall, the cumulative severity of stream channel and riparian alteration, disruption, and destruction is defined by the SHIM impact Rating criteria as low to moderate severity on both banks. The sum of weighted SHIM scores equaled 1.8 (out of 6) receiving a stream grade of 30%. The naturalization of highly modified stream segments, over time, in conjunction with intensive restoration and enhancement initiatives over much of the SHIM streamlength has lessened the impact rating. Nevertheless, 22 segments, accounting for 25% of the SHIM streamlength, still received an impact score of 0 being highly modified on both banks. Nine (9) of these segments occur through the Kelowna International Airport.

Table 17. Mill Creek level of impact summary. Values shown below are based on SHIM field inventory and analysis of 23.3 linear km of Creek within the Kelowna city limits.

Segments	SHIM Impact Rating	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
24,40,70,71	Nil	6	1140	4.89%	0.29
15,20,22,35,37,51,69	1_bank_low	5	2027	8.69%	0.44
13,17,21,23,46,59	1_bank_mod	4	1659	7.11%	0.29
9,19,25,27,28,30,33,36,38,42,45,47,53,55,57,58	Both_banks_low	2	5566	23.87%	0.48
3,5,7,10,14,16,18,26,29,31,32,34,43,44,49,50,52,54,73	Both_banks_mod	1	7121	30.53%	0.31
1,2,4,6,8,11,12,39,41,48,56,60,61,62,63,64,65,66,67,68,72,74	Both_banks_high	0	5808	24.91%	0.00
				Weighted Score	1.8
				Stream Grade	30%

4.2.4 Opportunities and Constraints – Overview

Considerable efforts have been invested into restoring and enhancing the function and productive capacity of Mill Creek. Over 130 habitat feature enhancements (i.e., wiers, backwaters, spawning habitat) were documented. However, during the field inventory it became apparent that water quality problems may be a primary factor encumbering efforts to restore productive capacity.

Ninety seven discharges, including 70 storm drains were recorded over the 23 km SHIM streamlength. Many of these pipes were observed discharging high turbidity flows during minor rain or snow events. In addition, some were observed discharging literally muddy flows when no precipitation had occurred in at least 24hrs prior. These persistent sources of sediment and potential non-point-source pollution may be negating efforts to restore the proper functioning condition of Mill Creek including that of spawning habitat capacity. For instance, persistent turbid streamflows lead to siltation of suitable spawning gravel, which may result in suffocation and entombment of spawning redds.

Many of the disturbed and modified stream segments, riverine wetlands, and riparian associations have a high capability to regenerate in conjunction with remedial efforts such as bank stabilization and riparian planting. For instance, riverine communities and functionally connected marshes occurring adjacent the Marshall Feedlot, despite their current impairments, have high capability to regenerate and be conserved as a rich and diverse riverine and wetland complex.

Beaver play an integral role in the dynamics of natural aquatic and riparian ecosystems. Dams can provide critical habitat for fish and hold back water during dry summer months. However, the displacement / extirpation of natural predators from the urban landscape may favoured beaver populations and upset the natural ecosystem balance resulting in a proliferation of dams. Furthermore, mitigated freshet flows (Mill Creek Diversion) may have reduced the stream's seasonal ability to temporarily blow-out beaver dams and flush streambed substrates. More intensive management of beaver populations within Mill Creek should be investigated.

5.0 CONCLUSION

The preceding report has summarized detailed field inventory data collected on Bellevue Creek and Mill Creek within the Kelowna City Limits. The collection and management of data was in conformance with the SHIM methodology, which is a standard for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia.

The 2005 inventory has resulted in the development of an up-to-date and robust catalogue of watercourse and habitat features occurring on Bellevue Creek and Mill Creek, which has numerous applications and can be used by community, stewardship groups, individuals, regional districts and municipalities, and senior regulatory agencies. In maintaining the integrity of this SHIM database, periodic field inspections should be carried out to update watercourse and habitat feature mapping.

6.0 CLOSURE

The inventory that has been summarized within this report was commissioned by and prepared for the City of Kelowna. The collection, processing, and management of data (attached within Appendix B) has conformed to SHIM standards. No other warranty is made, either expressed or implied.

Questions or inquires pertaining to SHIM methodology, data, and this summary report should be directed to the undersigned.

Respectfully Submitted,
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