PRIORITIZATION OF AND REHABILITATION CONSIDERATIONS FOR FISH MIGRATION IMPEDIMENTS IN LOWER FRASER RIVER

Prepared for:

Fraser Salmon and Watersheds Program
Vancouver BC

March 2009

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March 2009

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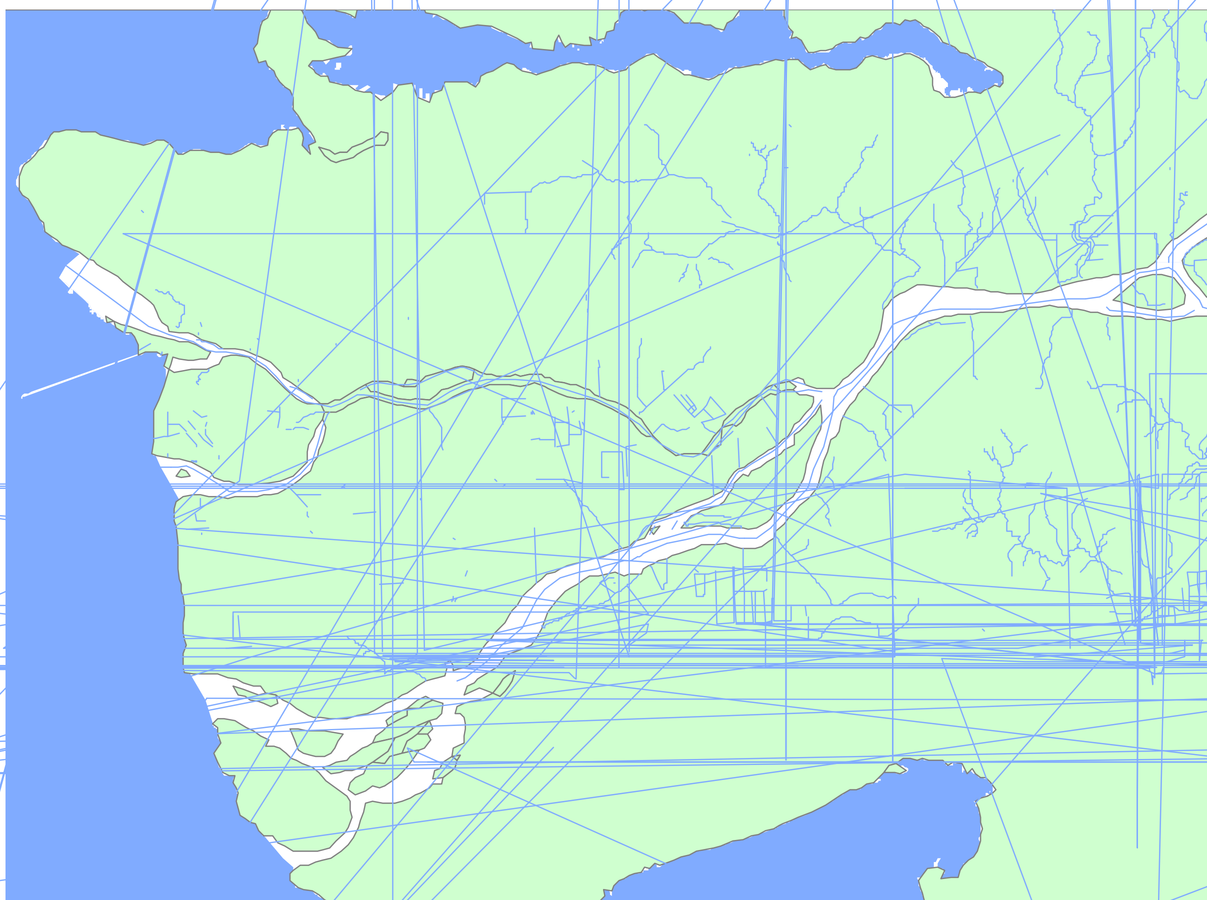
1 INTRODUCTION

1.1 Project Background

Man-made structures have [redacted] access to critical habitats [redacted] improvements to the numerous flood box structures [redacted] opportunity to improve or re-establish salmon migration into Fraser River [redacted] and wetlands.



Improving access to the remaining lower Fraser River tidal channels, wetlands, marshes and tributaries is considered an important component in the recovery of lower Fraser salmon populations. In addition to salmon use of Fraser River tributaries for spawning, rearing and overwintering, tidal channels, wetlands and marshes have been found to act as important natal and non-natal rearing habitats for juvenile salmon, particularly sockeye, Chinook, chum and coho (Levings et al. 1995; Murray and Rosenau 1989; Levy and Northcote 1982). These rearing areas provide refuge from predators and an opportunity for fry to grow larger and stronger before entering the ocean.

The Fraser River is tidal for about 115 km upstream from its mouth (Levings et al. 1995). Given the importance of freshwater tidal systems to salmon fry rearing, there are many existing ones that are productive and require protection, others that should be rehabilitated or enhanced, and still others that present an opportunity for creation of tidal habitats. The overall goal of re-connecting tidal channels is to restore natural physical processes (tidal and riverine flooding) and characteristics, functions, and biological responses to each potential project site. Restoration of natural estuarine processes will result in the recovery of estuarine habitat for a wide variety of fish, wildlife, and other organisms. Chinook, sockeye, chum and coho salmon are the most dependent on estuarine rearing habitat but other salmonids will benefit from the rearing and overwintering habitats in the re-connected tidal channels.

1.2 Project Goals and Objectives

The primary goals of the project are to identify man-made impediments or barriers (i.e., culvert or flood box) to salmon migration in selected tributaries to the Fraser River west of Brunette River and to recommend rehabilitation alternatives for each high priority culvert or flood box structure. The specific objectives of this project were:

1. Compilation of fish population, habitat assessment and structure impediment data in up to 15 Fraser River tributaries west of Brunette River,
2. Development of a prioritized list of stream sites where man-made impediments to fish migration should be rehabilitated or replaced,
3. Rehabilitation alternatives and recommendations for high priority sites where impediments to migration have been identified.

2 STUDY AREA

Initially, the extent of the lower Fraser area under consideration in this project included the Fraser River mainstem and its tributaries, sloughs and wetlands west of Brunette River. Several sites west of the Brunette River were also investigated, with more detailed work being completed on a high priority site at McLean Creek (City of Coquitlam).

3 METHODS

The activities for this project proceeded in the following order:

1) Existing fish population and habitat assessment data for up to 15 lower Fraser River tributaries where culverts or flood boxes are known to be impeding salmon migration were compiled. The web-based SHIM database and existing BC MOE database (7 Dec 2000) on flood boxes were used as primary sources for determining the locations of and existing information on flood boxes in the lower Fraser. Assessment data included information collected by Pacific Streamkeepers using 'Streamkeepers Module 1, Introductory Stream Habitat Survey (DFO)' (http://www.pskf.ca/mod01/index.html), published reports, Fish Wizard (http://www.fishwizard.com/), Fisheries Inventory Summary System (FISS) (http://a100.gov.bc.ca/pub/fidq/fissSpeciesSelect.do;jsessionid=fa9b308810f8858d488f0e628a594ff6458c6c356e4e8e1367edeabdba1fe5f3.e3uMah8KbhmLe3uKc34Mbh8Lay1ynknvrkLOlQzNp65In0), and additional habitat assessment data collected in the field through this project.

2) Additional information on migration impediments, such as culverts, flood boxes, and pump stations, was based on A. Thomson (unpubl. data) or from measurements taken during field-based habitat assessment surveys. Information included:

- length, height, width or diameter of the culvert or flood box,
- culvert gradient,
- height of outlet drop,
- flap gate type and observed operation,
- pump type and operational concern.

3) Investigated sites were prioritized for more detailed feasibility assessments. Priorities were based on: current structural and operational conditions that warrant and allow for changes to the floodbox and/or pump structures or their operation, nature of impediment to migration (i.e., velocity barrier, excessive outlet drop, flap gate type or operation, pump type or operation, etc.), salmon species and other salmonids affected, relative importance of stream to salmon, and type, condition and length of habitat available upstream of the barrier/impediment.

4) In order to evaluate the value of salmon habitat upstream of the potential impediment, subsampling of the anadromous sections of the high priority sites was required to obtain habitat data. Habitat survey data were co

Musqueam Fisheries Technicians and streamkeepers within the Musqueam Ecosystem Conservation Society (MECS) worked with LGL to identify impediments to fish migration and conduct the field assessments.

5) Water resource engineers evaluated floodbox and pump station operational regimes and recommended operational or structural alternatives to improve fish passage. For each of five high priority sites, water resource engineers also identified constraints to construction and approximate costs for the installation of a self-regulating tidal gate.

6) A report was prepared that compiled and summarized all of the existing and field assessment information, described operational characteristics for several floodbox and pump station sites, and provided estimated costs for installation of a self-regulating tidal gate at each high priority site.

4 DESCRIPTION OF IMPEDIMENT SITES

4.1 Site Assessment and Characterization

Thirteen channels and sloughs and a total of 15 floodbox structures were investigated in this study. The watercourse sites included: Chillukthan Slough, Crescent Slough, 96th Street Canal, 80th Street and River Road Canal, Fleetwood Creek, 168th Street Canal, 176th Street Canal, McLean Creek, Spencer Creek, Chester Creek, Mandale Slough, Matsqui Slough and McLennan Creek (Table 1). The sites were located in the Municipalities / Cities of Delta, Surrey, Coquitlam, Maple Ridge, Mission, and Abbotsford. All potential fish migration impediment sites investigated were floodboxes with either side or top hinged flapgates. The flapgates were constructed of cast iron, steel, aluminum or wood. An assessment of the likely effect of tides on their operation (i.e., opening and closing) found that some gates were completely submerged at low tides while others were not submerged even at moderate tides. Fish migration, either upstream or downstream, at all of these sites was considered impeded and would be dependent on favourable combinations of tides, Fraser River water levels and watercourse discharges. In addition, 13 of the 15 floodbox structures had pump stations of which only four were fish friendly. Fish friendly pumps greatly improve the survival of downstream migrating fish.

4.2 Fish Distribution and Habitat

Coho (CO) and cutthroat trout (CT) were the dominant salmonids found within the investigated sloughs, man-made canals and streams (Table 2). Additional salmonids found included Chinook (CH), chum (CM), kokanee (KO), sockeye (SK), and pink salmon (PK), and rainbow trout (RB), steelhead (ST), anadromous cutthroat trout (ACT), and Dolly Varden charr (DV). Based on brief habitat assessments, all sites would provide rearing and overwintering habitat for resident salmonids and the freshwater rearing phases of anadromous salmonids. Suitable spawning habitat for salmonids is also available in 10 of the 13 watercourses. Significant habitat area exists upstream of the impediments, with channel lengths ranging from 1.5 to 18.54 km and channel widths of 0.9 to 10 m. In general, habitat condition is considered to be fair to good, although more information is required on water quality (i.e., seasonal dissolved oxygen, water temperature, and water chemistry). Under existing conditions, habitat use by salmon of the 13 sloughs, canals and streams is generally limited (i.e., low habitat use currently). We believe this may be due primarily to the poor access to these habitats and if access is improved the potential use of these habitats would improve to moderate or high.

4.3 Site Priorities for Detailed Feasibility Assessments

Based on our assessment, there are five sites that should be examined in the short term as they are currently under-utilized by salmon and offer an opportunity for significant habitat gain for salmon, particularly rearing and overwintering habitat. These sites include Chillukthan Slough, Crescent Slough, Fleetwood Creek, 96th Street Canal, and McLean Creek (Table 2). Determination of site priorities was assessed based on: current structural and operational conditions that warrant and allow for changes to the floodbox and/or pump structures or their operation, nature of impediment to migration (i.e., velocity barrier, excessive outlet drop, flap gate type or operation, pump type or operation, etc.), salmon species and other salmonids affected, relative importance of stream to salmon, and type, condition and length of habitat available upstream of the barrier/impediment.

It is important to note that due to project scope and budget, the assessments and analyses completed for this report were not exhaustive. Priorities that we have stated are based on the information that we examined and on the 13 watercourses we investigated. Inherent in our recommended priorities is the understanding that further assessments for these and other sites should be completed prior to implementing improvement measures. With further recommended assessments, priorities could easily change. For example, a higher priority may be determined for gates that are an older style that impede both inmigration and outmigration, or a lower priority would be assessed for sloughs or canals with significant water quality concerns.

As a preliminary step, we completed more detailed investigations and analysis on five higher priority sites identified above. These detailed investigations included:

1. Identifying channel and habitat characteristics, land use impacts, potential water quality impacts, and other fisheries constraints,
2. Current operational regimes at the floodboxes to determine the likelihood of gate openings during specific migration times for salmon fry, smolts and adults, and
3. Preliminary assessments to determine the feasibility and approximate cost of replacing an existing flapgate with a self-regulating tidal gate.

These detailed assessments and analyses follow below.

Table 1. Summary of floodbox and culvert specifications, and likelihood of structure as a fish migration impediment (reproduced from A. Thomson unpubl. data).

Site	Floodbox ID	Location Description	Flapgate Hinge	Construction Material	Spring Present	Forced closed	Tidal Closure	Culvert Gradient (%)	Culvert Length (m)	Culvert Age	Culvert Material	Culvert Shape	Culvert Diameter (m)	Has Backwater Weir?	Upstream Migration Impediment	Downstream Migration Impediment	COMMENTS
Chillukthan Slough	DE-FP-004 (east)	Chilluktan Slough, runs through the middle of Ladner	Side mount	Wood or wood metal composite	No	No	Rarely or never submerged during low or moderate tides	0 to 0.9		25+ years	Concrete	Square	approx. 2m x 2m	Yes	Before stoplogs inserted- unlikely After stoplogs inserted - very likely	Oct - May; no May-Oct: limited	three pairs of wooden side mounted flap gates, two pump stations
	DE-FP-012 (west; Manson Pump Stn)							0 to 0.9					approx. 2m x 2m		Before stoplogs inserted- unlikely After stoplogs inserted - very likely	Oct.-May: no May - Oct.: limited	four sluice gates, no flap gates
Crescent Slough	DE-FP-003 (West)	Crescent Slough at River Rd. Local name "Green Slough floodbox" West end of the Slough.	Side mount	Wood or wood metal composite	No	No	Rarely or never submerged during low or moderate tides	0 to 0.9	20+ m	unknown	Concrete	Rectangular	approx. 2m x 2m	No	Before stoplogs inserted- unlikely After stoplogs inserted - very likely	Oct.-May: no May - Oct.: limited	two pairs of wood side mounted flap gates
	DE-FP-006 (East)	Crescent Slough at 6200 River Rd. Local name "McDonald" pumping station; East end of the Slough.	Side mount	Wood or wood metal composite	No	No	Rarely or never submerged during low or moderate tides	0 to 0.9	20+ m	unknown	Concrete	Rectangular	approx. 2m x 2m	No	Before stoplogs inserted- unlikely After stoplogs inserted - very likely	Oct.-May: no May - Oct.: limited	one pair of side mounted flap gates
96th St Canal	DE-FP-007	One kilometre west of Cougar Canyon Ditch (Interceptor ditch) along Fraser R. "Gravel Ridge" pumping station	Side mount	Wood or wood metal composite	No	No	Rarely or never submerged during low or moderate tides	0 to 0.9	10 to 19 m	25+ years	Concrete	Square		No			two pairs of aluminum side hinged flap gates; 20 cm drop at gates at low tide
80th St and River Rd Canal	DE-F-005	80th Street and River Road - Local name "Tasker"	Side mount	Wood or wood metal composite	No	No	Rarely or never submerged during low or moderate tides	0 to 0.9	20+ m		Wooden stave	Rectangular					two pairs of side hinged flap gates
Fleetwood Creek	SU-FP-022	36R - Between 64th Ave. and 168th Street. Serpentine R.	Top mount	Cast iron	No	No	Tidal influenced	0 to 0.9			Corrugated pipe	Round	1.22	No	Definite	When pump off: no When pump on: yes	existing fish friendly pump
168th Street Canal	SU-F-137	39L - Between 168th Street and 176th Street. Serpentine R.	Side mount	Cast iron Aluminium	Yes	No	Tidal influenced	0 to 0.9		New	Corrugated pipe	Round	1.22	No	During highwater periods in Serpentine	During summer: Likely Other times: unlikely	aluminum side hinged flap gate; gate opens well when positive head diff. exists
176th Street Canal (Law Ditch Creek & Magnan Creek)	recently replaced	At 176th St immediately N of Fraser Highway on left bank	Two top mount; One side mount	Cast iron	No	No	Tidal influenced	0 to 0.9		New	Concrete		Varies	Uncertain	Unlikely	Unlikely	structure replaced & now has fish friendly pump and adult fishway
McLean Creek	PC-FP-020	Just north of the PoCo border along the Pitt River. In the North Deboville Dyking Dist.	Top mount	Cast iron	No	No	Always fully or partially submerged during low or moderate tides	0 to 0.9	20+ m	10 to 25 years old	Concrete	Round	0.91 estimate.	No	Definite	Definite	four cast iron flapgates; Pump station operated by BC MoE
Spencer Creek	MR-FP-003	At confluence of Spencer Cr and Kanaka Creek	Top mount	Cast iron	No	Yes	Always fully or partially submerged during low or moderate tides	0 to 0.9	10 to 19 m	25+ years	Concrete	Rectangular	2.2 x 0.9	No	Likely	Definite	Kanaka Creek rises faster than Spencer so floodbox action does not work. Fish go thru . pumps instead.
Chester Creek	MI-FP-001	Chester Creek pumpstation	Top mount	Cast iron	No	No		0 to 0.9	10 to 19 m	10 to 25 years old	Concrete	Rectangular	1.8 by 1.8	No	Likely	Not likely (leave before gates shut)	Pump chewing juveniles during d/s migration is more an issue than inmigration; manual winch used to open flapgate; annual coho & chum fry / smolt salvage
Mandale Slough / Lane Creek / Mandale Creek	MI-FP-003	Top end of Lane Slough, just west of Mission bridge.	Top mount	Wood or wood metal composite	No	No	Always fully or partially submerged during low or moderate tides	2 to 5	10 to 19 m	25+ years		Round		No	Definite	Not likely	Manual winch used to open flapgate
Matsqui Slough / Clayburn Creek	AB-FP-005	Matsqui Slough pumping station - all four floodboxes	Side mount	Steel	No	No	Always submerged regardless of high and low tides	0 to 0.9	20+ m	25+ years	Concrete	Rectangular	2.1 x 2.3	Yes			Four identical floodboxes exist at this pumping station; Pump station has "fish friendly" suction pump that has been tested to pass fish safely but the test was inconclusive. Requires reevaluation.
McLennan Creek	AB-FP-001	Glenmore Rd and Fraser River - both floodboxes	Side mount	Steel	No	No	Always submerged regardless of high and low tides	0 to 0.9	20+ m	25+ years	Concrete	Rectangular	2.1 X 2.3	Yes			Two identical floodboxes at this site; fish friendly pump

Table 2. Floodbox and fish habitat characteristics in watercourses where impediments to fish migration were found. Priority for continuing with a more detailed feasibility assessment is identified for each floodbox structure.

Site	Location (UTM)	Municipality	Flood Structure ID	Nature of Impediment to Migration	Other Constraints	Salmonid Species (Potential)	Salmon Habitat Type	Habitat Length (km) Upstream of Impediment	Condition of Habitat	Habitat Use Existing (Potential)	Priority for Detailed Feasibility Assessment
Chillukthan Slough	10 U 493722 5437818	Delta	DE-FP-004 (east)	Flap Gate, Pump	Water Withdrawal, High Summer Temps,	CT, CO, (CH)	Rearing, Overwintering	4.8	Fair-Good	Low (High)	High
	10 U 490568 5435871	Delta	DE-FP-012 (west; Mason Pump Stn)	Flap Gate, Pump	Water Withdrawal, High Summer Temps,	CT, CO, (CH)	Rearing, Overwintering		Fair-Good	Low (High)	Medium
Crescent Slough	10 U 494757 5439080	Delta	DE-FP-003 (West)	Flap Gate, Pump	Water Withdrawal, High Summer Temps,	CT, (CO), (CH)	Rearing, Overwintering	7.61	Fair-Good	Low (High)	High
	10 U 496446 5441810	Delta	DE-FP-006 (East)	Flap Gate, Pump	Water Withdrawal, High Summer Temps,	CT, (CO), (CH)	Rearing, Overwintering		Fair-Good	Low (High)	Medium
96th St Canal	10 U 503118 5444467	Delta	DE-FP-007	Flap Gate, Pump		CT, (CO), (CH)	Rearing, Overwintering	7.65	Fair-Good	Low (High)	High
80th St and River Rd Canal	10 U 499872 5443727	Delta	DE-F-005	Flap Gate	High Summer Temps, Water Quality?	(CO), (CH)	Rearing, Overwintering	<2	Fair	Low (Moderate)	Low
Fleetwood Creek	10 U 516140 5442014	Surrey	SU-FP-022/023	Flap Gate	Low Summer Flows	CO, CT	Spawning, Rearing, Overwintering	2.78	Good	Moderate (High)	High
168th Street Canal	10 U 517742 5442164	Surrey	SU-F-136/137	Flap Gate		CO	Rearing, Overwintering	1.5	Fair-Good	Moderate (Moderate)	Low
176th Street Canal (Law Ditch Creek & Magnan Creek)	10 U 519249 5443088	Surrey	SU-F-154	Flap Gate		CO, CT, RB	Spawning, Rearing, Overwintering	5.62	Fair-Good	Moderate (Moderate)	Low
McLean Creek	10 U 521282 5458804	Port Coquitlam	PC-FP-020	Flap Gate, Pump	Water Withdrawal, High Summer Temps,	CO, CT	Spawning, Rearing, Overwintering	3.02	Good	Low (High)	High
Spencer Creek	10 U 530725 5449912	Maple Ridge	MR-FP-003	Flap Gate, Pump	High Summer Temps, Water Quality?	CO, CT	Spawning, Rearing, Overwintering	3.49	Fair-Good	Low (Moderate)	Low
Chester Creek	10 U 544421 5444554	Mission	MI-FP-001	Flap Gate, Pump		CM, CO, CT	Spawning, Rearing, Overwintering	5.15	Fair-Good	Moderate (High)	High
Mandale Slough / Lane Creek / Mandale Creek	10 U 549863 5441714	Mission	MI-FP-003	Flap Gate, Pump		CO, CH, CM, CT	Spawning, Rearing, Overwintering	4.06	Fair	Low (Moderate)	Medium
Matsqui Slough / Clayburn Creek	10 U 549579 5439978	Abbotsford	AB-FP-005	Flap Gate, Pump		CO, CH, CM, ACT, CT, DV, KO, PK, ST, SK, RB	Spawning, Rearing, Overwintering	18.54	Good	Moderate (High)	High
McLennan Creek	10 U 548081 5439607	Abbotsford	AB-FP-001	Flap Gate, Pump		CO, CT, RB	Spawning, Rearing, Overwintering	5.34	Good	Moderate (High)	High

5 DETAILED ASSESSMENT OF PRIORITY SITES

5.1 Fish Species Composition and Habitat Characteristics

Coho have been found in Chillukthan Slough, 96th Street Canal, Fleetwood Creek, and McLean Creek and would likely be present in Crescent Slough and 96th Street Canal with improvements to fish access (Table 3). Cutthroat trout have been found in all locations except Chullikthan Slough. Currently, the sloughs and canal are dominated by non-salmonids such as threespine sticklebacks.

Chillukthan and Crescent Sloughs would be characterized as very low gradient glides with average channel widths of 9-10 m and depths of 0.9-1.5 m (Table 4). Water levels and flows are relatively stable throughout the year and provide perennially wetted habitat for fish. The sloughs would be used as rearing and overwintering habitat for coho and as early spring rearing habitat for Chinook fry. As a very low gradient glide and with a predominance of fines, spawning habitat for salmon is considered as poor. Cover is provided by the deeper pool / glide habitats with some sections having ample overhanging vegetation. The sloughs are located within agricultural and urban land uses so impacts on fish and fish habitat associated with these land uses are prevalent. These impacts include water withdrawal, loss of riparian vegetation, channelization and dyking, and water quality impairments.

Habitat in 96th Street Canal is comprised of primarily riffles and glides in the lower reaches with beaver ponds in the upstream reaches. The canal would be characterized as low gradient with average channel widths of about 3.5 m and depths of 0.2-0.5 m in the riffles and glides (Table 4). Due to its connection to Burns Bog, the canal exhibits a natural hydrograph throughout the year and provides perennially wetted habitat for fish. The canal would be used primarily as rearing and overwintering habitat for coho with potentially some utilization by Chinook fry as rearing habitat in early spring. Fines predominate and consequently spawning habitat for salmon is considered poor. Some measure of cover is provided by the tannic coloured water with some sections also having ample overhanging vegetation. The lower reach of the canal is located within urban and industrial land uses while the upper reaches are within Burns Bog. The impacts in the lower reaches include loss of riparian vegetation, channelization and dyking, and water quality impairments.

Fleetwood Creek is comprised of riffles, pools and glides with primarily shallow glides in the reaches between Serpentine River and Fleetwood Park. The creek within the Park would be characterized as moderate gradient (1-4%) with average channel widths of about 0.9-3.0 m and depths of 0.3-1.0 m (Table 4). The creek provides perennially wetted habitat for spawning, rearing and overwintering of coho and cutthroat trout. Fines and gravel predominate and spawning habitat for salmon is considered good. Boulder and large wood debris (LWD) together with overhanging vegetation provide ample, good quality cover. The lower reach of the creek is located within agricultural pastures while the upper reaches are within Fleetwood Park. The impacts in the lower reaches include loss of riparian vegetation, channelization and dyking, and water quality (i.e., high temperature, low dissolved oxygen) impairments.

McLean Creek is comprised of primarily glides in the lower reaches with riffles, pools and glides in the upstream reaches. The creek would be characterized as moderate gradient (1-4%) with average channel widths of about 3.0-5.0 m and depths of 0.5-1.5 m (Table 4). Cutthroat trout have been caught in the creek and although only juvenile coho have been found, the habitat is suitable for spawning, rearing and overwintering of coho. Fines and gravel predominate and spawning habitat for salmon is considered good. Boulder and large wood debris (LWD) together with overhanging vegetation provide ample, good quality cover. The lower reach of the creek is located within an agricultural area while the upper reaches are within an urban land use. The impacts in the lower reaches include loss of riparian vegetation and channelization and dyking. Water quality impairments have not been determined to date.

Table 3. Species composition for high priority fish migration impediment sites.

Watercourse	Species	Comments	Reference
Chillukthan Slough	coho	present	Municipality of Delta - Environment Dept.
	peamouth chub	present	Habitat Wizard / FIDQ / FISS
	threespine stickleback	present	Habitat Wizard / FIDQ / FISS
Crescent Slough	cutthroat	present	Habitat Wizard / FIDQ / FISS
	black crappie	present	Habitat Wizard / FIDQ / FISS
	brassy minnow	present	Habitat Wizard / FIDQ / FISS
	carp	present	Habitat Wizard / FIDQ / FISS
	goldfish	present	Habitat Wizard / FIDQ / FISS
	peamouth chub	present	Habitat Wizard / FIDQ / FISS
	prickly sculpin	present	Habitat Wizard / FIDQ / FISS
	threespine stickleback	present	Habitat Wizard / FIDQ / FISS
96th St Canal	coho	potentially present	Coast River Environmental Services Ltd. (2006)
	cutthroat	present	
	threespine stickleback	present	
Fleetwood Creek	coho	present	SHIM map of Fleetwood Creek, Habitat Wizard / FIDQ
	coho	fry & 1+	FISS report; Coast River Environmental (1998); Envirowest (1993)
	cutthroat trout	fry & adults	Habitat Wizard / FIDQ / FISS; Coast River Environmental (1998); Envirowest (1993)
	threespine stickleback	present	Coast River Environmental (1998)
McLean Creek	coho	juveniles present	North Fraser Salmon Assistance Project Trapping unpublished data 2002
	cutthroat	present	Scott Resource Services Inc. 1999
	threespine stickleback	present	North Fraser Salmon Assistance Project Trapping unpublished data 2002

Table 4. Summary of habitat characteristics for five high priority fish migration impediment sites.

Watercourse	Channel Width (m)	Channel Depth (m)	Channel Type	Perennial or Ephemeral	Habitat Type	Predominant Substrate	Spawning Gravel Quality	Instream Cover	Overhanging Vegetation	Surrounding Land Use	Water Extraction Occurring	Riparian Removal	Channelization / Dyking	Water Quality	Fisheries Potentials / Constraints	Previous Enhancement / Rehab work	Reference
Chillukthan Slough	9-10	0.9-1.5	glide	perennial	R, OW	fines	poor	fair: deep pool	fair	agriculture, urban	yes	Impact present	Impact present	Impact present	Water quality[2], Spills, Vegetation[3]	Ladner Pond (1988)[1] Rip Rap Rock Work (1999)[4], Riparian (1999)[5], Biophysical Inventory / Assessment (1999)	Fisheries Project Registry Stream Classification Database FISS Report
Crescent Slough	9-10	0.9-1.5	glide	perennial	R, OW	fines	poor	fair: deep pool	poor	agriculture, urban	yes	Impact present	Impact present	Impact present	Water quality[8], Flow Regime[9], Habitat[10]	Ladner Marsh Tidal Flushing (1992)[6] Ladner Marsh Wetland Stewardship (1999)[7] Biophysical Inventory / Assessment (1983, 1996-1997, 1999)	Fisheries Project Registry Fisheries Project Registry; Stream Classification Database Coast River Environmental Services Ltd., (2006) FISS Report
96th Street Canal	3.5	0.2-0.5	riffle, glide, beaver ponds	perennial	R, OW	fines, gravel	fair	fair: tannic coloured water	fair	urban, industrial	no	Impact present	Impact present	Impact present	Habitat[17]		Coast River Environmental Services Ltd., (2006)
Fleetwood Creek	0.9-3.0	0.3-1.0	riffle, pool, glide	perennial	S,R,OW	gravel, cobble	good	good: boulder, LWD	fair	agriculture, urban, park	no	Impact present in lower reach	Impact present in lower reach	Impact present in lower reach	Water Use/diversion[12], Flow Regime[13], Spawning Habitat[14]	Fleetwood Creek Restoration (1996-1999)[11] Flow Control (1994)[15], Biophysical Inventory Assessment (1993&1994)[16]	Fisheries Project Registry FISS Report
McLean Creek	3.0-5.0	0.5-1.5	riffle, pool, glide	perennial	S,R,OW	fines, gravel	good	good: boulder, LWD	fair	agriculture, urban	yes	Impact present	Impact present	unknown	Habitat[18]		Stream Classification Database

Habitat Type: S-spawning, R-rearing, OW-overwintering

[1] Activities include: Enhancement / Restoration - Lake Wetland or Estuary Restoration / Enhancement

[2] Typical degraded urban stream

[3] Vegetation sporadic and sparse all along bank of the slough

[4] Slope stabilization done at upstream end of culvert

[5] Planting and hydroseeding of the compensatory riparian vegetation at upstream end of culvert

[6] Activities include:1) Water quality / quantity enhancement 2) restore fish passage / barrier modification / obstruction removal 3) Lake wetland or estuary restoration / enhancement and 4) riparian restoration / enhancement

[7] Activities include: Biophysical survey / Habitat Inventory - Detailed Mapping / Monitoring

[8] Slough inhabited by coarse fish species and forage fish which have wide tolerance limits for a variety of environmental conditions

[9] Ditches draining the surrounding agricultural lands forms tributaries of Crescent Slough

[10] Survey indicates that resident fish are quite mobile and may use different portions of the slough at different times during the year

[11] Activities include: 1) Spawning habitat or off-channel restoration / enhancement 2) restore fish passage / barrier modification / obstruction removal 3) riparian restoration / enhancement

[12] Historical maps indicate that immediately downstream of 76th Ave culvert this creek previously flowed to the southwest and joined the drainage ditch paralleling 160th St. Portions of the old creek bed contain sections of potential spawning habitat; Appears that flows from two drainages south of the 76th Ave that used to feed the creek have been diverted and directed east to the 168th street alignment. The extra flow would have increased the discharge and flushing in the creek slower ditched portion increasing its value as salmonid habitat

[13] Flow of creek enters Serpentine River through 2 culverts with top mounted flap gates - only fish passable during higher flows when flap gates open

[14] Short section of medium quality spawning gravels observed between 60 and 120 meters downstream of 76th Avenue culvert in present channel

[15] Fish friendly screw pump installed

[16] Bioinventory provides details on habitats, fish presence and potential enhancement opportunities

[17] Potential rearing/overwintering habitat for coho

[18] Potential rearing/overwintering habitat for Pitt River coho and chinook

5.2 Operational Regimes

5.2.1 Fleetwood Creek

Facility Description

Fleetwood Creek pumping station consists of a single 1.09 m^3/s capacity screw pump and two 1.22 m diameter parallel floodboxes mounted with a top-mounted cast iron flapgate. The pump was installed in mid 1990's to address localized flooding of agricultural land. The floodboxes predate the pump installation.

Facility Operation

Fleetwood Creek pumping station lies in the Serpentine River lowlands. The Serpentine River is dyked in the vicinity of the confluence of the Serpentine River and Fleetwood Creek. As a result, all water discharged from Fleetwood Creek passes through either the Fleetwood Creek pumping station, or the two floodboxes. The water level difference between the Serpentine River in the outfall area and pumping station forebay determine whether water flows through the floodbox or is pumped over the dyke by the screw pump.

The City of Surrey owns and operates the pumping station, and sets the water level thresholds to satisfy local flooding criteria. The facility is not designed nor operated to "flood-proof" the immediate area (per. comm. Jeff Arason). Rather, Surrey operates the pumping station according to the following ARDSA standards:

1. Flooding should be restricted to a maximum of 5-days in duration for the 10-year, 5-day winter storm (November 1 to February 28);
2. Flooding should be restricted to a maximum of 2-days in duration for the 10-year, 2-day growing season storm (March 1 to October 31);
3. Between storm events, and in periods when drainage is required, the base flow level in ditches should be maintained at a minimum of 1.2 m below the adjacent ground level.

The City monitors and records pump cycling information and water levels immediately upstream and downstream of the station. The pump is set to turn on when water level in the pump forebay behind the dyke (Fleetwood Creek water elevation at the pumping station) reaches approximately –0.96 m and continues pumping until water level in the forebay is approximately –1.56 m. The pump discharges at a constant design rate of 1.09 m^3/s. The floodboxes are not monitored but are inspected on a regular basis.

Analysis of year 2008 data was conducted to determine operational characteristics of the pump and flapgates, and the influence of one on the other. It is possible to determine flap gate opening periods from calculating the elevation differential between upstream and downstream water elevations. The data also indicate the degree of gate opening given some head loss assumptions derived from the literature briefly described above.

Generally speaking, the greater the elevation difference, the greater hydraulic head that is available to open the gate.

The data analysis focussed on three periods that are considered critical for fish passage: adult coho spawner inmigration November – February; spring smolting period May-June peaking in mid May; and late summer rearing period when water flows are at a minimum in Fleetwood Creek and Serpentine River.

Coho Adult Inmigration November – February.

Pump station data was analysed for the months November-December 2008, and January-February 2008 to determine flapgate opening periods (Figure 2 and Figure 3, resp.). Initial analysis of the data indicates the following:

1. The Serpentine River water level in the vicinity of Fleetwood Creek is influenced by tidal action and the operation of the sea dam under the King George highway bridge. The sea dam, a series of large flapgates with vertical hinges, closes on a rising tide to prevent saline water from entering the Serpentine River. River water backs up behind the sea dam until the river water elevation is greater than the tide level. River water at this point will force the sea dam gates open and the river water level will subside. The regular oscillation of river water levels corresponds to rising and falling tides and precipitation runoff in the watershed.

2. The floodbox is often completely submerged during the winter months otherwise it is partially submerged. At no time is the floodbox completely out of the water. This has significance for understanding the floodbox head loss, and the hydraulic head required to open the flapgate.

3. When larger rain events occur in the Serpentine watershed, as is evident from the rapid rise in the Serpentine River water level, water levels in Fleetwood Creek also rise at approximately the same rate. However, once the water elevation in the pump station forebay reaches approximately –0.96 m, the pump turns on and pumps down the water level to –1.56 m and then shuts off. Once forebay water elevation rises to –0.96 m the pump turns on again and the cycle is repeated. Pump cycling will only stop (in most cases) when forebay water elevation is –1.0 m or lower. During the forebay draw down period, the flapgates close tightly as the water elevation in the Serpentine River rises and the forebay elevation drops creating a negative head differential.

4. During periods when no or little precipitation occurs, the Fleetwood Creek water level fluctuates according to the Serpentine water level. The head differential averages by an estimated 0.03 m and reached 0.08 m on occasion.

5. Occasionally during severe precipitation events in the watershed the Serpentine River water level rises faster and to a higher elevation than that in Fleetwood Creek. Secondly, on several occasions during the analysis period discharge in

Fleetwood Creek exceeded the pump capacity of 1.09 m^3/s and water elevation in the forebay rose above the –0.96 m set point with the pump on. During these events the flapgate remained shut.

6. As water levels drop in the floodbox, head loss increases and discharge decreases. This could be due to increased head loss due to the reduced buoyancy of the flapgate and/or increased culvert and inlet head loss. Although there is a greater differential head during these periods, this is likely due to increased head loss and not necessarily indicative of the gap between the gate and gate seat.

[redacted]

Figure [illegible]

The City of Surrey provided pump station operational and water level data for the station. Water level and pump operation were graphed for each month. The graphs were examined in detail to determine periods when coho adult inmigration might be possible, and the results were tabulated in Table 5. The opinion on whether coho inmigration was possible for each period is based on the head differential and flapgate observations under similar discharge conditions. It is important to note that there is no direct gate opening data to confirm this opinion.

Table 5. Fleetwood Cr. pumping station flapgate opening duration during coho spawner inmigration period.

Period	Positive head duration	Coho inmigration possible

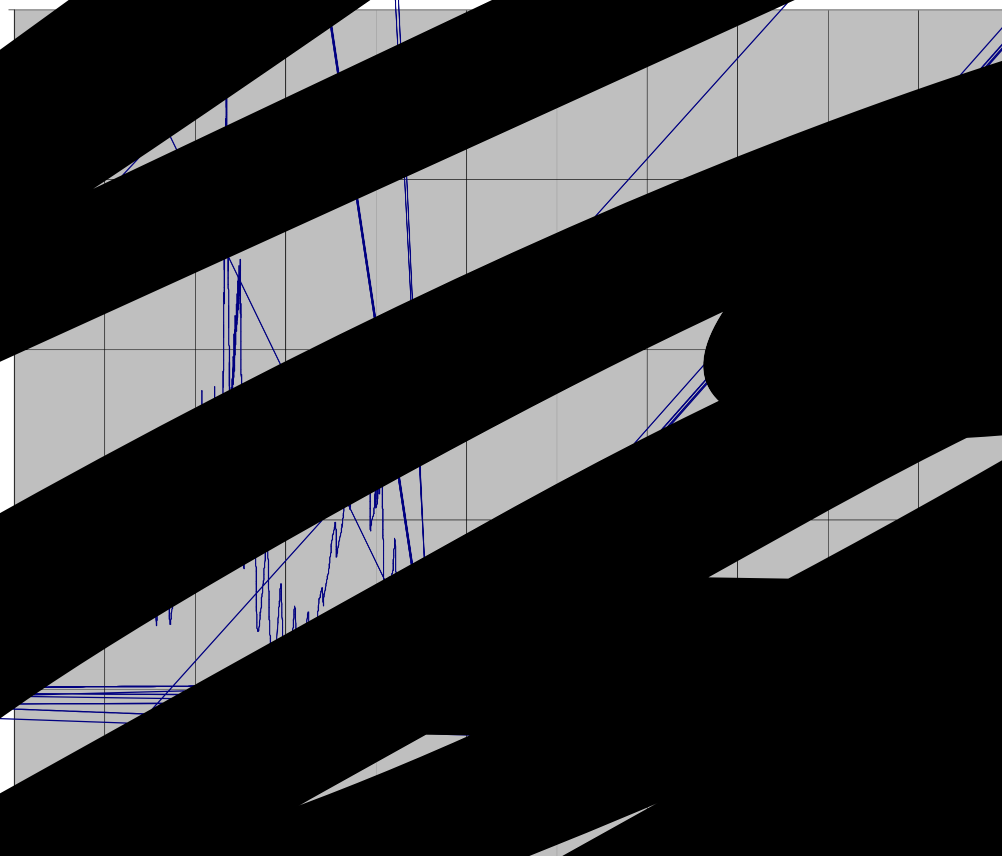
inmigration each month even though the positive head differential exists for several periods. In addition, the high water periods that cue coho to move into tributaries are when the flapgates are most likely to be closed. The lower water and low precipitation periods are when the greatest positive head differential exists since the pump activates when water levels rise due to precipitation in the watershed.

Smolt Outmigration Period April-June

During April – June period coho smolt from the lower mainland tributaries (no smolting period data specific to Fleetwood Creek is available). Fleetwood smolts can enter the Serpentine via the screw pump or through the floodbox. The screw pump was installed with this specific fish migration function in mind, and at least one study confirms that coho smolts (fork length 100 mm+) and cutthroat trout (fork length 200 mm+) are passed with minimal mortality (ECL Envirowest 1992). There is no evidence that the screw pump at Fleetwood Creek imparts mortality on smolts.

The opportunity for smolts to pass through the floodbox where there is the likelihood of a gate opening wide enough to allow passage appears to be limited to approximately 6 short periods (a matter of 2-6 hours each) throughout April, and one 4-day period in May (Figure 4). There is no data for June.

It is likely that smolts pass through the screw pump to access the Serpentine River, as there is limited opportunity for smolt passage through the floodboxes. Coho smolts would likely be migrating at times of higher flows during which time the Archimedes screw pump would be running frequently. Coho migration would not be delayed and downstream passage survival would likely be high through the screw pump. As ECL Envirowest (1992) found little mortality associated with the screw pump operation, we believe that downstream passage in Fleetwood Creek would be a low risk to smolts.



S erpent i

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Late Summer – Low Flow Period

Analysis of data for the traditional low flow period August to September indicates that there were no opportunities for fish passage (Figure 5). For most of the period, water levels in Fleetwood Creek were marginally below the Serpentine River. On one occasion Fleetwood Creek water levels marginally exceeded those of the Serpentine River, but not enough to open the gate sufficiently to facilitate passage of juvenile fish. Field observations of gate operation during summer and fall months in past years confirm this data analysis.

As long as water quality (temperature and dissolved oxygen in particular) and water depths are adequate to sustain residing salmonid populations, fish migration would be very limited during these low flow periods. However, if Fleetwood Creek flows are significantly cooler than Serpentine River fish may be attracted to enter the creek.

In most cases, fish migrate or move during freshets when water depths allow easier access and afford some protection against predators. However, if habitat condition degrades (i.e., low water depths, high water temperatures, low dissolved oxygen), fish will tend to migrate away from these conditions. If opportunities for downstream migration out of Fleetwood Creek are very limited during this period, it could reduce survival of salmonids in the creek during periods of poorer water quality. Similarly, if Fleetwood Creek could potentially provide a refuge of cooler water for Serpentine River fishes, then an opportunity to potentially increase fish survival and growth may be lost due to poor access.

[redacted]

Options for Improvement

Additional consultation with Surrey drainage engineers is required to better understand the complexities of the Fleetwood Creek area flood control facilities and procedures, and to further guide refinement of the following options. However, based on preliminary data analysis options to improve fish migration past the pumping station include:

1. Modification of the station's operational regime to allow for a greater percentage of flows to be discharged though the floodbox during certain time periods without increasing lowland flooding event probability. Examination of the water level data indicates that the pumping station operation determines the opening frequency, timing and duration of the flapgates. When the pump turns on, the flap gate closes under most circumstances.

As mentioned previously, the pump station is operated to ADRSA standards which dictate the length of localised flooding period permissible during summer and winter periods, and water level below floodplain elevation. Analysis of the advanced engineering design report of the pumping station (Associated Engineering 1993) indicates that there may be opportunities to raise the pump set points and allow for greater coho inmigration opportunities given:

- The installed pump discharge rate (1.09 m^3/s) is 36.3% greater than the rate recommended in the report (0.8 m^3/s) to satisfy ARDSA winter flooding standards. The installed pump can reduce floodwaters faster and reduce the risk of flooding due to it's greater discharge rate;
- The landowner is more concerned about flooding during growing season than winter flooding (Associated Engineering 1993). Growing season ARDSA standards are significantly less than winter standards. If the standard was changed to satisfy growing season standards the pump set points could be raised;
- The design pump discharge rate calculation assumes that the Fleetwood Park catchment area is fully developed which it is not. Total build out may occur in the future; however, until that time there may be an opportunity to raise the pump set points, which can always be lowered as the catchment develops further and floodwater volume that requires temporary storage and pumping increases.

Data and data analysis contained in the advanced engineering report was collected and completed over 15 years ago, and some of the assumptions and analysis should be revisited now that 15 years of post-construction water elevation, rainfall, and pump cycling data is available. It is recommended that the operation of the pumping station be analysed in detail to determine the optimal operation to satisfy both flood proofing criteria and fish passage.

2. Raising the set point on the pump, however, will only address periods when significant flow exists. Other periods, namely summer low flow periods, the

existing floodboxes and flapgates will continue to restrict fish migration in either direction.

3. Installation of an aluminium side mounted spring actuated gate similar to that at the 168th Street South Canal floodbox. Thomson (2005) found that the side mounted flapgate at that location was open 6 times wider 50% of the time and 10 times wider 33% of the time than the top mounted gate identical to those at the Fleetwood Creek pumping station. This recommendation was also made in the Associated Engineering (1993) advanced engineering design report.

4. Installation of an actuated combination gate (Thomson 1999a) that is both a flapgate and sluice gate. Operation of the gate would be tied to water level sensors and pump operation so as to allow for maximum flood protection during high water events, and maximum fish passage opportunities at all other times.

5. Mounting a lighter top mounted gate. The current 1.22 m diameter Armtec model 10C gate and seat weighs approximately 395 kg. A lighter gate would decrease the hydraulic head required to open the gate thus increase the length of time the gate is open and in some cases the gate would likely open wider. However, this option would still alienate fish habitat during low flow and fall spawning periods, as such it is not preferred.

6. Replace the current floodboxes with a self-regulated tide (SRT) gate. Set points for the tide gate closure and pump actuation would be similar. *This is the only option that will increase passage opportunities during all three periods – inmigration, smolting and summer low flow.*

Recommendation

The recommended option involves analysing the pump station operation and determining optimal operation for both flood protection and fish migration, coupled with an upgrade of the floodbox either a side mount, combination or self-regulating tide gate. At the very minimum, the floodbox gates should be converted to side mounted aluminium gates similar to that on the 168th Street ditch floodbox. It may be more efficient to replace both older floodboxes with a new single floodbox with a side mounted gate.

Although purchase and installation of an SRT gate is relatively expensive, it can satisfy all flood proofing and fish migration criteria. As such it is the recommended option.

5.2.2 McLean Creek

Facility Description

The North Debouville pumping station consists of four parallel floodboxes each mounted with a 2.2 m diameter top-mounted cast iron flapgate, and one axial flow pump rated at 1.26 m^3/s. The pump and motor were rebuilt and four new floodboxes were installed in 1992. The pump intake is only coarsely screened to prevent large floating debris from being entrained and thus the pump likely entrains juvenile fish or smolts. BC MoE and DFO are currently discussing options for screening the intake to prevent fish entrainment (per. comm. Mike Bristols).

Facility Operation

The facility lies in the Coquitlam Dyking District and is administered and maintained by the Ministry of Environment, Region 2 (per. comm. Mike Bristols, MoE) staff who visit the facility a few times a month to record pump hours in the on-site log book. There is no water level or pump actuation data, and the existing pump log data has not been compiled. The local agricultural community perform the majority of station maintenance and have access to the station (per. comm. Mike Bristols, MoE).

The pump operation is solely dictated by water levels in the forebay area. The MOE determines the pump activation set points in consultation with the local farming community. Pump set points do not vary seasonally as in many other areas that withdraw irrigation water during summer months.

Options for Improvement

There is little known about the operation of McLean Creek other than that indicated above. Without water level data and pump cycling data for McLean Creek[1] it is difficult to determine with any accuracy the pump and floodbox operational characteristics. However, it is highly likely that the pumping station and floodboxes function like many others reviewed throughout the lower mainland and detailed in Thomson (1999a). Based on this reasonable assumption the following options improving fish migration for McLean Creek are suggested. It is highly recommended that basic station operational data be collected and analysed before any of the options outlined below is pursued, as options other than those found below may be feasible:

1. Installation of a self regulating tide gate.
2. Installation of an actuated combination gate (Thomson 1999a) that is both a flapgate and sluice gate. Operation of the gate would be tied to water level sensors and pump operation.

[1] Water level data is not available for the Pitt River at the floodbox outfall, however there are local gauges immediately downstream and across the Pitt River that could be used if required.

3. Currently the pump is not adequately screened to prevent juvenile entrainment and mortality. Any option to modify the floodbox to allow adult spawners access to McLean Creek should also include provision for safe smolt outmigration each spring. Options to provide for safe smolt passage include:
    a. Installation of a fish friendly pump (Archimedes screw pump) or;
    b. Installation of a fish screen around pump intake that will prevent juvenile entrainment and mortality.

5.2.3 Chillukthan Slough

Biological Assumption

It is envisaged that Chillukthan Slough could function as a short term rearing habitat for outmigrating non-natal Chinook fry (particularly Harrison River stock) during their April-June descent to the ocean. Coho fry and juveniles may also inhabit a portion of the slough during their freshwater life stage. However, further sampling and analysis of water quality is required to determine its suitability over the summer period.

Pumping Station Description

Chillukthan Slough pumping station is located at the confluence of the slough and the Fraser River approximately 2.6 km southwest of Highway 99 at the western end of River Road. The pumping station consists of three floodboxes and three pumps of a combined capacity of 4.5 m^3/s. All three vertical axle pumps rotate at 580-695 rpm (per. comm. Gary Martin). None of the pumps is screened to prevent fish entrainment, and no fish deflection or entrainment prevention devices are employed at the station. The 3 floodboxes each contain 2 opposing flapgates for a total of 6 flapgates. All flapgates are approximately 2 m by 2 m in size, have a metal frame with a cedar wood interior, are side hinged and reportedly very heavy. The hinges are not sprung. Facility operators are able to manipulate slough water level by chaining shut flapgates, inserting stoplogs of varying crest elevations into the floodboxes, and opening a sluice or flapgate inset into two stoplogs to allow for limited water exchange.

General Operation

Delta operates the Chillukthan Slough pumping station to satisfy a number of objectives, two being to provide for flood protection, and another to provide irrigation water for agricultural operations located near the slough to the south. In order to satisfy these objectives, the pumping station is operated in three general modes – drainage, flushing and irrigation. See Figure 6 for water elevations during all three modes.

The operation of the flapgates was observed on June 5 2008[2] and were also examined by Thomson over several periods in 1999 and 2002. During some periods, the gates were open sufficiently wide (~0.5-1.0 m at the leading edge) with a very slight water current visible. From observations at this and other floodboxes throughout the lower mainland with similar gate arrangements, the side mounted gates open easily with little head differential irrespective of the gate weight. This observation is consistent with observations of other side mounted gates in the lower mainland.

Drainage Mode

Occurs between late October/early November to late April/early May. Water either is pumped out of the slough or drains by gravity through the floodbox. The pumps are set to activate when water level reaches approximately –0.45 m and remain on until water levels lower to –0.60 m. Pump set points can vary slightly from year to year.

Flushing Mode

Flushing mode occurs between the two principle modes – drainage and irrigation. It is meant to increase drainage and flush out saline water from the slough and usually takes 3 days (2006, 2007) although it lasted 47 days in 2008. In mid May, the pump set point is increased to approximately ±0.1 m and water in the slough is flushed out through the floodboxes when hydraulic conditions are met.

Irrigation Mode

During May to late October, Delta farmers rely on the slough for irrigation water. By mid to late May after the slough has been flushed for a few days, stop logs are inserted at the head of the floodbox culvert. Slough water elevation fluctuates between 0.2 and 0.5 m with a few periods of greater fluctuation. Most of the discharge out of the slough during this period is through the floodbox, although there is limited opportunity for fish to inmigrate as the stop logs create an upstream barrier most of the period the flapgates are open. On occasion, the pumps activate to discharge slough water due to a large precipitation event. Stop logs are removed in late October and the pump station returns to drainage mode.

Discussion

While Chillukthan Slough discharges into the Fraser River, water levels are largely dictated by tides due to its close proximity to Georgia Strait. Unlike most other floodbox and pumping station operations along the Fraser River, the spring freshet has little influence on the operation of the pumping station and the closure of the floodbox.

[2] During June the gates are typically closed as the stop logs are inserted. However, for a short 5 day period the stop logs were not inserted and the flapgates were operational.

In order to determine the gate opening schedule over a lengthy period, one year of data was looked at in detail, and three years of data were examined to ensure that 2006 data were representative of the station's operation. For the period of interest (April-June 2006) the floodbox opened approximately 11.5 % or 123 hours in the period (Figure 7). Over the period, the floodbox opened for 0.5 – 6 hours (average 2.6 hours) on 35 days, and remained closed for 10 days up to a maximum of 3 consecutive days. As a result, there is reasonable opportunity for Chinook juveniles to migrate into Chillukthan Slough from the Fraser River mainstem until mid May when the stop logs are inserted after which access is very limited or improbable. For Chinook juveniles in Chillukthan Slough attempting to outmigrate to the Fraser River and marine environments passage through the floodbox is possible during this same period, although when the flapgates are shut and the slough water level rises to the pump activation set point, the pump turns on. Juveniles entrained into the pump would likely suffer mortality as the pumps are unscreened, and rotate sufficiently quickly to impart mortality (see Thomson (1999a, 1999b) for detailed discussion).

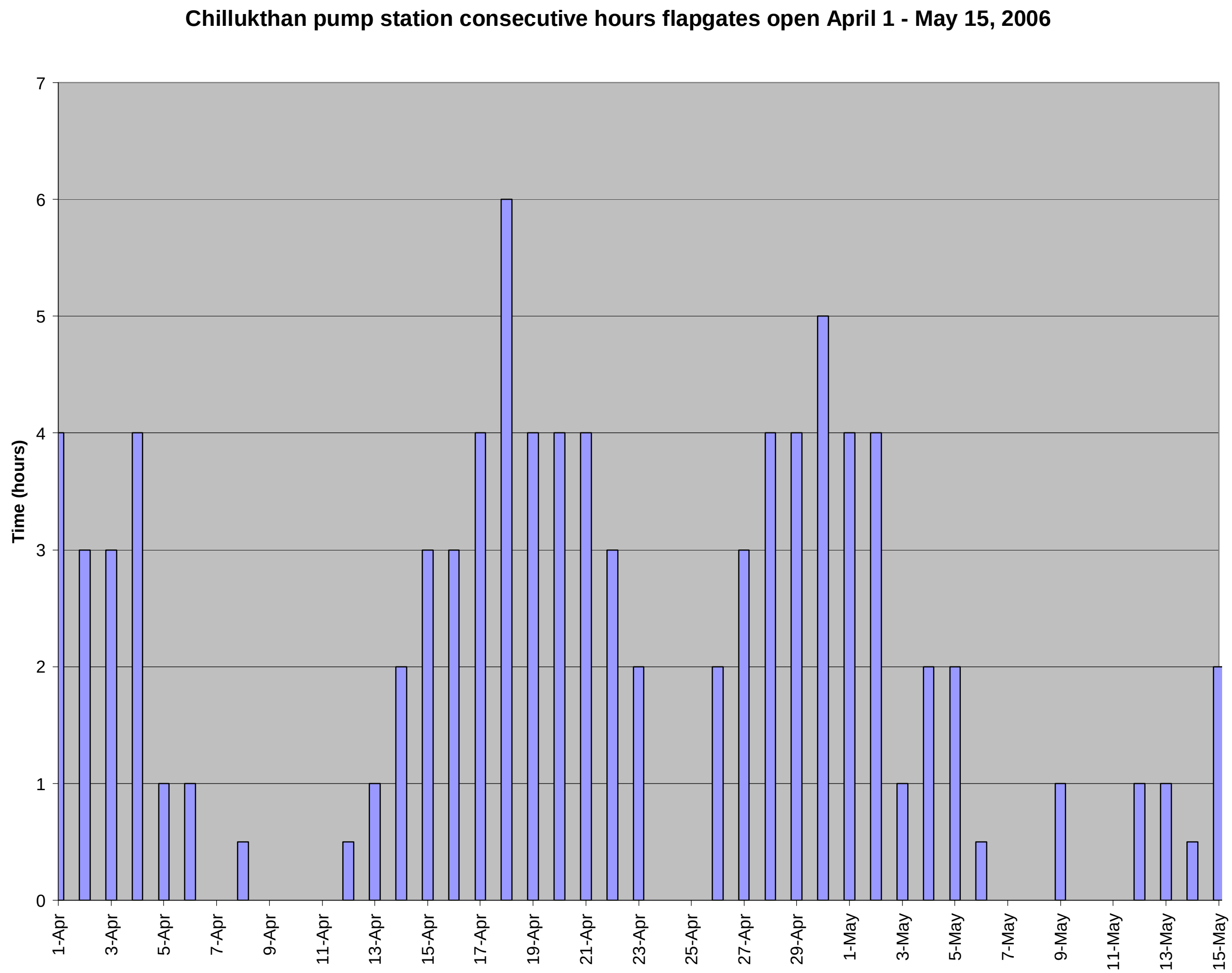

Figure 7. Consecutive hours that flapgates are open at Chillukthan Slough pump station, April 1 – May 15, 2006.

5.2.4 Crescent Slough – East; McDonald pumping station

Biological Assumption

It is envisaged that Crescent Slough could function as a short term rearing habitat for outmigrating non-natal Chinook fry (particularly Harrison River stock) during their April-June descent to the ocean. Coho fry and juveniles may also inhabit a portion of the slough during their freshwater life stage. However, further sampling and analysis of water quality is required to determine its suitability over the summer period.

Operation

The McDonald Pumping Station at 6200 River Road, Delta consists of one floodbox and three pumps of a combined capacity of 1.01 m^3/s. All three vertical axle pumps rotate at 880 rpm (per. comm. Gary Martin). None of the pumps is screened to prevent fish entrainment, and no fish deflection or entrainment prevention devices are employed at the station. The two opposing floodbox flapgates are approximately 2 m by 2 m in size, have a metal frame with a cedar wood interior, are side hinged and reportedly very heavy. The hinges are not sprung. Facility operators are able to manipulate slough water level by chaining shut flapgates, inserting stoplogs of varying crest elevations into the floodboxes, and opening a sluice or flapgate inset into two stoplogs to allow for limited water exchange.

The pumping station is run in a similar fashion to the Chillukthan Pumping Station. There are two main operational modes: drainage and irrigation. There is very little transition time from one mode to the other. See Figure 8 for water elevations during April – June 2006 which illustrates both modes.

Drainage Mode

Drainage mode occurs from late October to mid/late May and the pump maintains a maximum water elevation in the slough of approximately –0.24 m. When Fraser River water elevation drops below that of the slough, water discharges through the floodbox. During times when the Fraser River elevation is higher than the slough, water is discharged using the pumps.

Irrigation Mode

From mid/late May to late October the pumping station is put on irrigation mode where the slough water elevation is raised to approximately $\pm$0.15 m. Stop logs are inserted in the floodbox culvert and water levels in the slough fluctuate approximately 0.12 m. Drainage pumps are activated when the water level exceeds the pump set point, although water can overtop the stop logs and discharge out the floodbox.

Analysis of data for the April-June period indicates that the flapgate opening pattern is similar to Chillukthan Slough. Floodboxes at McDonald pump station are open for 235 hours or 21.5% of the total hours in the period April 1- May 16, 2006 (Figure 9). As with other pumping stations, once the stop logs are inserted mid May, juvenile Chinook access into the slough is for most periods blocked. Any juvenile Chinook already in the slough that attempt to outmigrate must do so via the pump if the gates are shut and suffer mortality, or outmigrate when the flapgates are open.

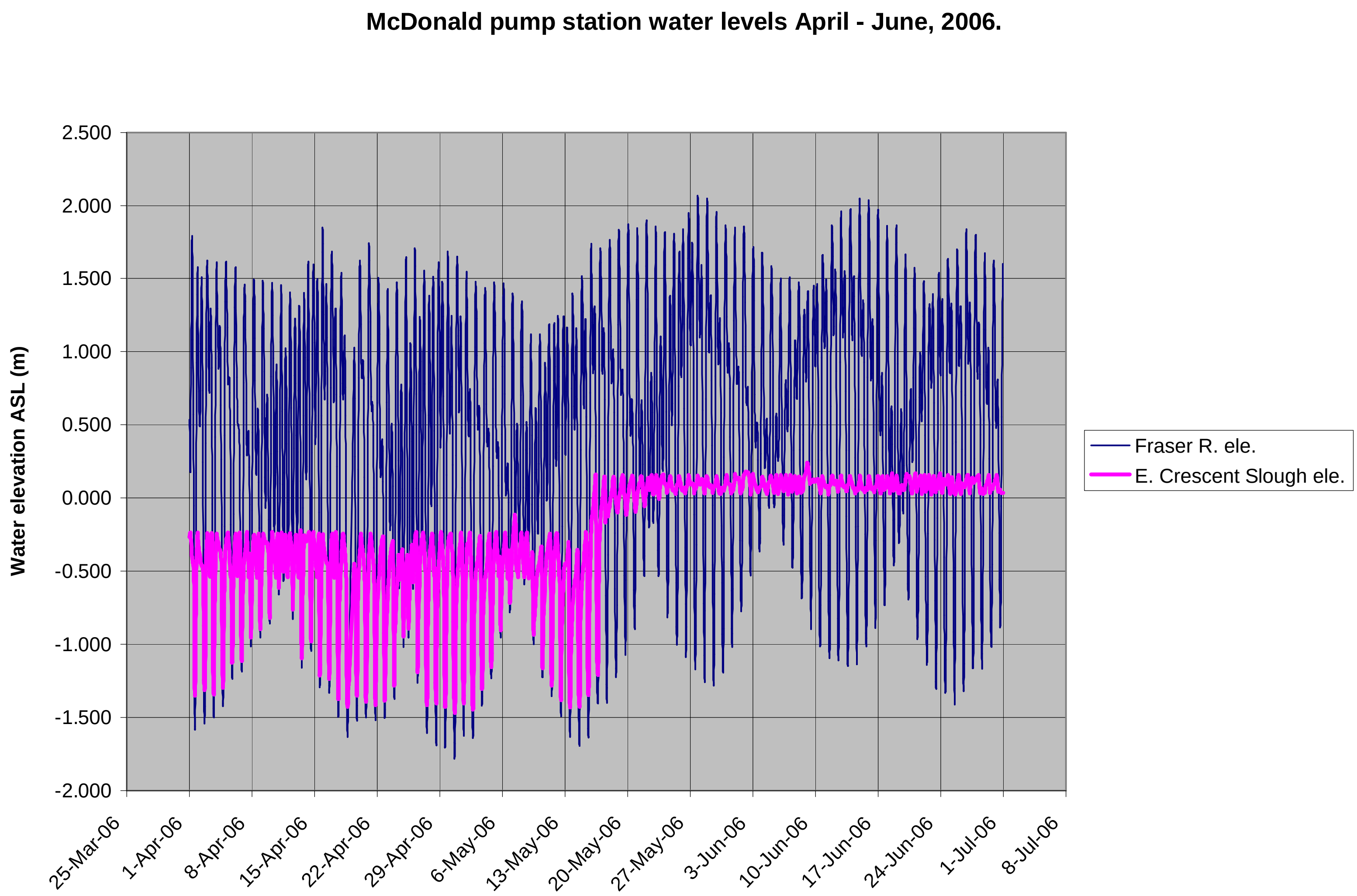

Figure 8. Water levels for Crescent Slough and Fraser River at McDonald pump station, April – June 2006.

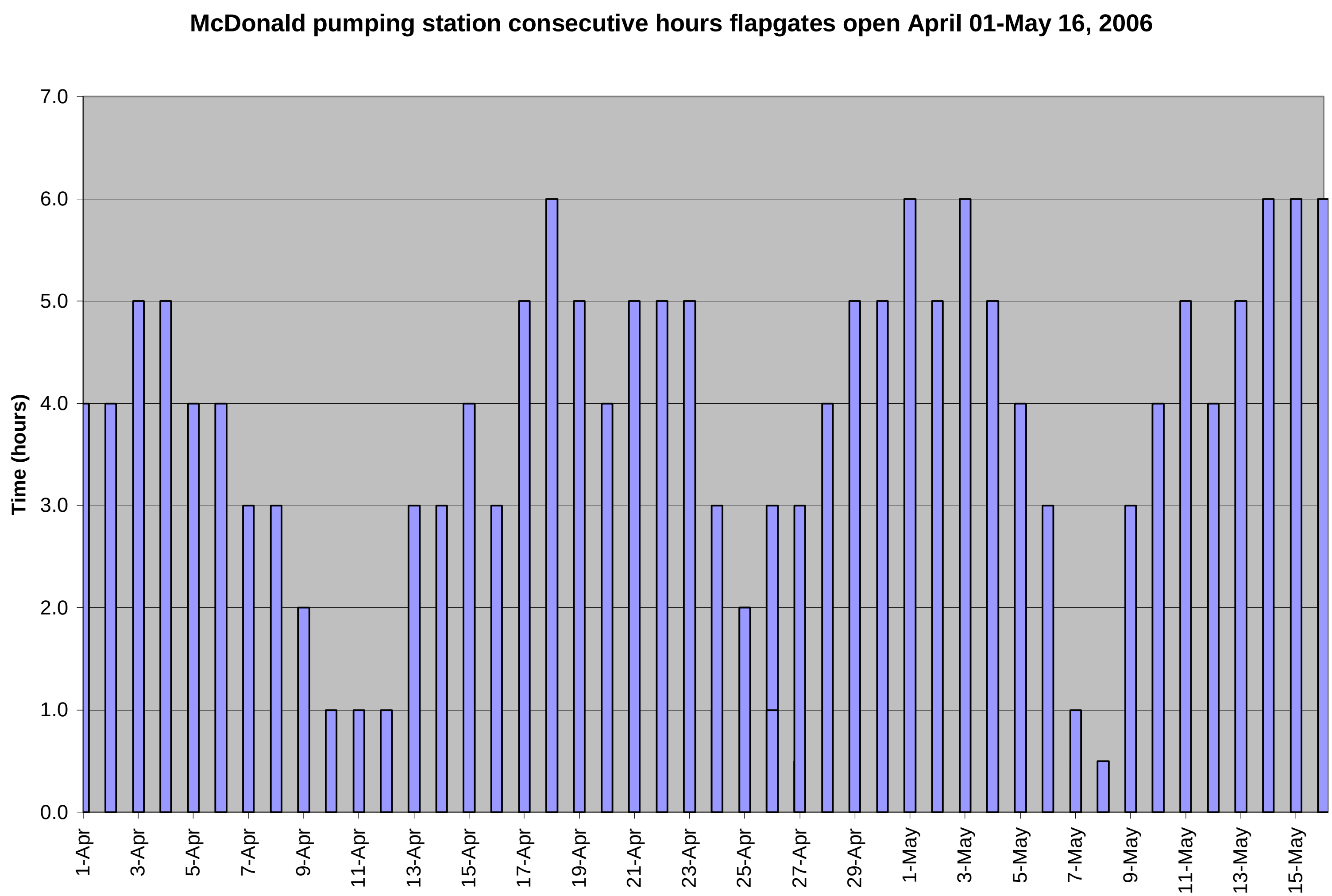

Figure 9. Consecutive hours that flapgates are open at McDonald pump station, April 1 – May 16, 2006.

5.2.5 Crescent Slough – West; Green Slough pumping station

The Green Slough Pump Station at 5596 River Road, Delta, is located at the confluence of Green Slough and Crescent Slough. Green Slough is outside of Delta's Fraser River dykes, whereas Crescent Slough drains the area to the south behind the dykes.

Biological Assumption

It is envisaged that Crescent Slough could function as a short term rearing habitat for outmigrating non-natal Chinook fry (particularly Harrison River stock) during their April-June descent to the ocean. Coho fry and juveniles may also inhabit a portion of the slough during their freshwater life stage. However, further sampling and analysis of water quality is required to determine its suitability over the summer period.

Operation

The Green Slough pumping station consists of two floodboxes and four pumps of a combined capacity of 6.25 m^3/s. All four vertical axle pumps rotate at 580-585 rpm (per. comm. Gary Martin). None of the pumps is screened to prevent fish entrainment, and no fish deflection or entrainment prevention devices are employed at the station. The four opposing floodbox flapgates are approximately 2 m by 2 m in size, have a metal frame with a cedar wood interior, are side hinged and reportedly very heavy. The hinges are not sprung. Facility operators are able to manipulate slough water level by chaining shut flapgates, inserting stoplogs of varying crest elevations into the floodboxes, and opening a sluice or flapgate inset into two stoplogs to allow for limited water exchange.

Three years of water elevation data (March 2006-March 2009) for the pumping station were examined and analysed to determine the various drainage modes and station operation. Fraser River water elevation data from the Chillukthan pump station was used to indicate tidal action as Fraser R. elevation data immediately downstream of the pump station is not collected by the municipality. It must be noted that Green Slough is shallow in places and drainage capacity is reduced. Poor drainage from the slough maintains higher water elevations for longer periods at the pumping station and thus affects the floodbox flapgate and pump operations.

The Green Slough Pump Station is run in a similar fashion to the Chillukthan and McDonald Pumping Stations. There are two main modes: drainage and irrigation. There is very little transition time from one mode to the other. Facility operators are able to manipulate slough water level by chaining shut flapgates, inserting stoplogs of varying crest elevations into the floodboxes, and opening a sluice or flapgate inset into two stoplogs to allow for limited water exchange. See Figure 10 for water elevation during the two modes for the April – June period.

Drainage Mode

Drainage mode occurs from late September/late November to mid May/early June. Over the three years of data examined, the set points for the pump cycling varied from –0.37 m to –0.58 m. The pumps draw down the slough 0.18-0.25 m once activated.

Unlike the operations of the Chillukthan and McDonald pumping stations, the data indicate that a significant percentage of the Green Slough while in drainage mode is pumped. Unfortunately, numerical analysis of the floodbox operation is limited as Fraser River water elevation data was not available and there is poor drainage in Green Slough that affects floodbox flapgate operation. The data indicate that there are periods when the slough elevation is higher than the Fraser River elevation when significant floodbox discharge would be expected yet no or little discharge occurs. The floodboxes appear to operate only when the slough water elevation exceeds approximately –0.62 m. Below this elevation water is discharged from the slough via the pumps. However, the data are not entirely consistent in this regard over the three years examined. Some possible explanations include restricted floodbox operation, variable pump set points and different drainage characteristics of Green Slough from year to year (e.g., from build-up of sediment).

Irrigation Mode

From mid May/early June to late September/late November the pumping station is put on irrigation mode where the slough water elevation is raised to approximately +0.11 m. Stop logs are inserted in the floodbox culvert and water levels in the slough fluctuate approximately 0.20-0.25 m. Drainage pumps are activated when the water level exceeds the set point, although water can overtop the stop logs and discharge out the floodbox.

Although numerical analysis of the floodbox operation is not possible due to reasons stated above, it is clear that the floodboxes open more frequently and for greater periods when Crescent Slough water elevations are higher than in drainage mode and when the stoplogs are inserted. Thus unlike McDonald and Chillukthan pump stations, fish access opportunities into Crescent Slough may be greater after the stop logs are inserted. However, under certain hydraulic and water level conditions, the stoplogs act like a weir and could easily inhibit or prevent juvenile inmigration when the floodbox is open. Juvenile access would only be assured when the stoplogs were overtopped and the Fraser River water elevation was slightly below Crescent Slough water elevation to force the flapgates open. Once the Fraser River water elevation drops below that of the stoplog crest elevation, the hydraulic jump created downstream of the stoplog could prevent juvenile access into Crescent Slough.

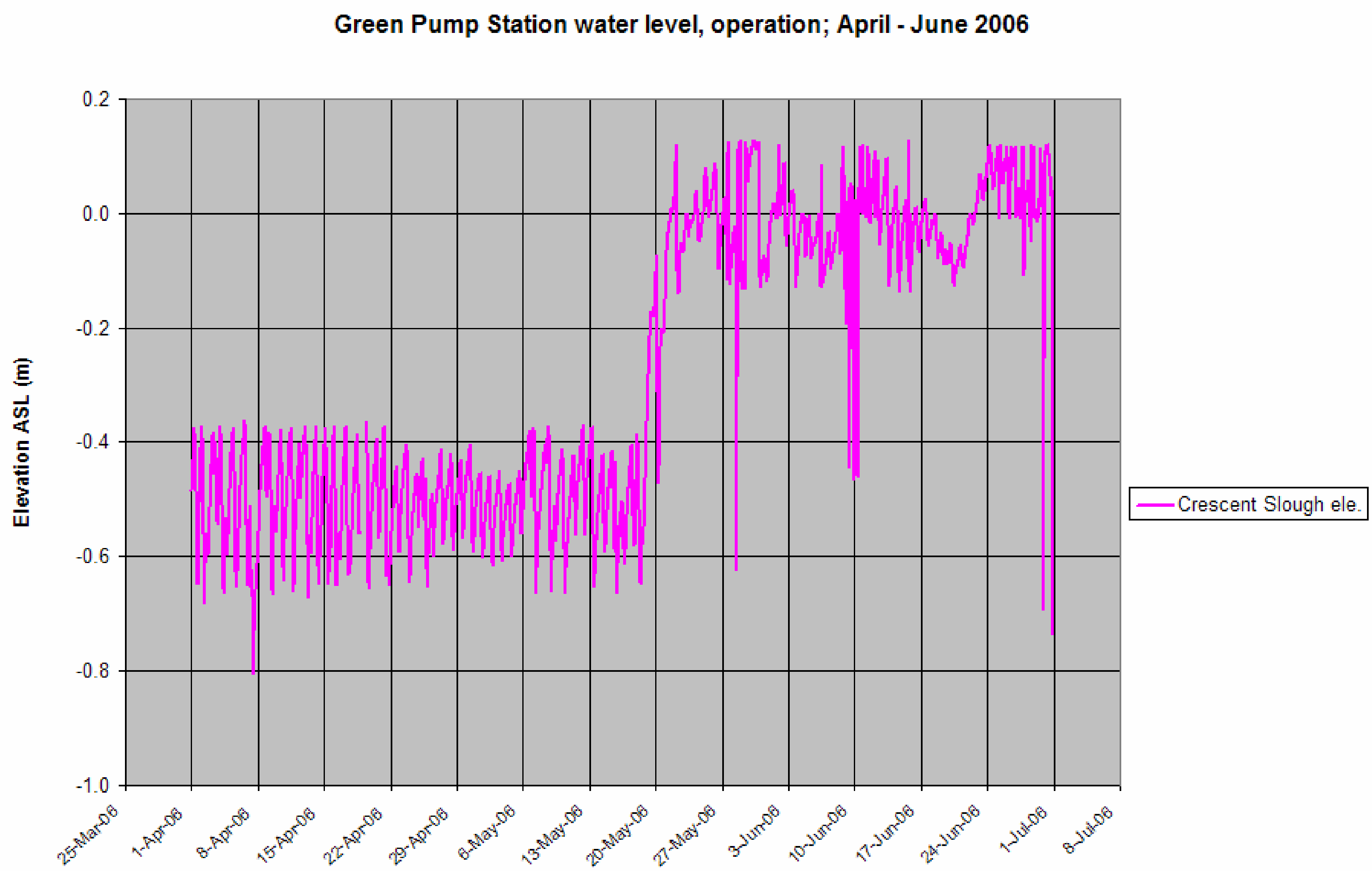

Figure 10. Water levels for Crescent Slough at Green Slough pump station, April – June 2006. Note no Fraser River elevation data.

Options for Improvement – Chillukthan and McDonald Pump Stations

Analysis of the water level data for the pump stations indicate that Chinook juveniles can access both sloughs almost daily until mid May when the stop logs are inserted in the floodboxes. After mid May access into the slough is likely very limited. Outmigrating juveniles after mid May would, at times, have to pass through the pumps during the summer irrigation period.

Based on discussions with Delta municipal staff, it appears as though the agricultural sector reliant upon irrigation water withdrawn from the slough determine the timing and operation of the irrigation mode. Stop logs are inserted in the floodboxes to both raise the water level in the slough to increase irrigation water capacity, as well as to prevent saline water from infiltrating the slough. No physical changes at the pump station will increase or improve fish access into the slough when satisfying these conditions is required. Thus changes to the station operation require an analysis of irrigation needs and schedules.

As such, the following issues require discussion with the agricultural community, Delta municipal staff and other stakeholders:

- Possible delay of the irrigation start date until June 30th;
- Possible use of other water sources available to irrigators between May 15th –June 30th;
- Changes to agricultural practices that can be made to enable delay of irrigation until June 30th.

Outmigration of Chinook juveniles would also benefit from the delay of the irrigation mode until July 1st as currently they pass, at times, through the pumps after stop logs are installed and likely suffer significant mortality.

Operational adjustments for improving access for outmigrating Chinook juveniles are likely possible and should be explored in consultation with Delta municipal staff. Some of these options include:

- Installation of a new fish friendly pump to replace one of the existing pumps; or
- Screening existing pumps and allowing increased gravity discharge through the floodbox to continue until June 30th; or
- Removal of stop logs on occasion when correct hydraulic conditions exist during May 15-June 30th period to allow for increased outmigration through the floodbox.

Options for Improvement – Green Slough PumpingSstation

Initial analysis of the data indicates that juvenile Chinook inmigration is likely compromised during the April – June period. The floodbox operation, although not fully understood, appears limited due to the likely high and persistent receiving water elevation in Green Slough, and the need to keep Crescent Slough water elevation lower to reduce the risk of flooding.

While it is clear that the drainage pattern differs from the other two Delta pump stations examined, i.e., Chillukthan and McDonald, it is not possible to make recommendations as to station operation and plant modifications without additional data collection, analysis and station operation observation.

5.3 Engineering Feasibility and Cost

A preliminary conceptual review to determine the feasibility and approximate cost of replacing an existing flapgate with a self-regulating tidal gate was made for five higher priority sites including:

- Chillukthan Slough (East floodbox) in Delta;
- Green Slough / Crescent Slough (West floodbox) in Delta;
- 96th Street Ditch in Delta;
- Fleetwood Creek in Surrey; and
- McLean Creek in Coquitlam.

The assessment included a site visit, identifying any constraints for construction of the gates, assessing feasibility of replacing the gates, developing preliminary (Level-D) cost estimates for each site and preparing short technical memorandums outlining the results (Appendix 1-Appendix 6). A summary of the required works and the estimated cost are included in Table 6. The table has been ordered in priority based on cost-effectiveness and ease of installation; however, this list does not take habitat and fisheries considerations into account.

Table 6. Summary of preliminary concept review of floodboxes for tide-regulated gate installation.

Project Site	Expected Works	Estimated Cost
Green Slough/Crescent Slough - West Floodbox	▪ Replace one flap gate with tide-regulated gate	$134,000
Chillukthan Slough - East Floodbox	▪ Replace one flap gate with tide-regulated gate ▪ Install trash rack	$156,000
McLean Creek Outfall to Pitt River	▪ Replace one flap gate with tide-regulated gate ▪ Install trash rack	$275,000
Fleetwood Creek Outfall to Serpentine River	▪ Partially excavate back into dyke and cut back existing pipes ▪ Cast in-place new concrete headwall around both outfall pipes ▪ Install one tide-regulated gate, replace existing flap gate on other pipe ▪ Install trash rack on new headwall	$285,000
River Rd. at 96 St. Floodbox to Fraser River	▪ Remove all existing flap gates ▪ Excavate and remove existing timber headwall ▪ Cast in-place new concrete headwall around both existing timber floodboxes ▪ Install one tide-regulated gate, re-install 3 other existing flap gates ▪ Construct cobble and gravel weir downstream of outfall ▪ Install trash rack	$347,000

Note that the cost estimates include construction plus engineering, permitting, environmental monitoring, construction management and a contingency (25% to 40%). The construction costs assume that existing gates are replaced with a restrained side hinged tide regulated gate. Other gate types may be suitable for these locations which would likely change overall construction costs. Final selection of the type of gates will be completed during the detailed design stage.

As part of the planning process for installing new gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

5.3.1 Issues and Constraints

Chillukthan Slough

Several issues and constraints were identified for installation of a tide-regulated gate at Chillukthan Slough including:

- Working room above the flap gates and headwall is limited due to the sidewalk and River Road and the nearby intersection with Elliott Street. A portion of River Road would likely need to be blocked to allow equipment to hoist and lower the old and new flap gates.

- Equipment access to the channel of the slough, if necessary, would require removal of fencing and vegetation, and careful movement to prevent injury to the two pump station outfalls on the northeast side of the floodbox outlet.

- Due to the proximity of the wingwall to the gates on the southeast side and the fact that all of the gates are positioned very close together, the only flap gate that is an easy candidate for replacement with a tide-regulated gate is the one at the northeast edge of the headwall. The wing wall on the northeast side is nearly in line with the floodbox headwall and there is space for maneuvering of equipment and to mount the tide sensor and gate-regulating mechanism.

- At low tide a small (50 mm) drop was observed at the outlet of the floodbox. In summer, due to lower tides, there may be more of a difference between the invert of the floodbox and the invert of the channel. The observed drop was minimal, so a constructed weir to maintain backwater through the structure is not recommended in this preliminary assessment, however this floodbox should be further reviewed for fish passage concerns prior to design for installation of a tide-regulated gate.

- There is currently no trash rack to protect the flap gates.

Crescent Slough

Several issues and constraints were identified for installation of a tide-regulated gate at Crescent Slough including:

- The exact size and configuration of the existing gates should be confirmed. This would require the cooperation of the staff at the Corporation of Delta to remove a section of grating and measure the gates at low tide.

- The perpendicular wing walls on either side of the face of the headwall were observed to be located very close to the gates. An access ladder may have to be moved and the horizontal grating re-configured in order to allow installation of the hinge tube at one side of the tide-regulated gate. The float well assembly and gate control enclosure would require mounting on the adjacent wing wall. Therefore only the two end gates may be considered for replacement by a tide-regulated gate.

96th Street Canal

Several issues and constraints were identified for installation of a tide-regulated gate at 96th Street Canal including:

- The outflow at this site is combined flow from Burns Bog and industrial sites near River Road.
- The downstream headwall around the flapgates is constructed of heavy timbers, specified in the As-Built drawings as 12-inch by 12-inch creosoted fir. While it appears to be in good condition and no sagging or malfunction of the existing gates was visible, a timber headwall may be expected to require replacement during the expected life of a new tide-regulated gate. The Golden Harvest gate would require fastening of the gate and the tide-regulating mechanism to the headwall as well. It could be secured to a timber headwall, but may be expected to require refurbishment and adjustment as the wood decays and requires replacing.
- The box and gate configuration includes four gates regulating the openings of only two separate boxes. Both boxes are constructed of wood.
- There is a drop of approximately 0.3 metres visible below the existing flap gates to the stream channel, which generated a small hydraulic jump approximately 0.5 metres downstream of the headwall at low tide. According to as-built drawings, there is approximately 2 feet (0.6 m) of headwall constructed below the openings of the floodbox.
- For construction access, the bank on the downstream side of the floodboxes is steep and falls away quickly at the edge of River Road. River Road is a busy two-lane road accessing industrial sites in the area and with a steady flow of large trucks and other traffic. The maneuverability for equipment working on the downstream face of the floodboxes would be space-limited and would require traffic handling for access from and working from the road itself.

- There is currently a wooden trash rack in poor condition protecting the flap gates from debris on the Fraser River. This trash rack should be replaced if a tide-regulated gate is installed.

Fleetwood Creek

Several issues and constraints were identified for installation of a tide-regulated gate at Fleetwood Creek including:

- Upstream of the floodbox, Fleetwood Creek drains as irrigation ditches through agricultural land and through at least two sets of CMP culverts at farm access roads. The culverts are on the order of 10 metres long, set low in the channels and generally appear to be backwatered from the outlet. It is not known if these culverts might be limiting for fish access to the upper reaches of the creek.

- The CMP pipes at the floodbox are set close together and extend out from the dyke with flap gates attached to collars on the pipes. There is no existing headwall to attach a new tide-regulated gate to.

- The side slopes on the dyke are steep (steeper than 2:1) and may impact maneuverability of equipment on the dyke crest.

- The existing pump station is constructed with a concrete section through the crest of the dyke. The dyke crest is therefore restricted at this point for passage of vehicles and equipment due to vertical faces on either side of the crest. The City of Surrey drawing shows the clear crest at this location as 3.2 m wide.

- There is currently no trash rack protecting either flap gate from debris.

McLean Creek

Several issues and constraints were identified for installation of a tide-regulated gate at McLean Creek including:

- Access to the site is through a gate controlled by others. This should not be a significant problem, but should be coordinated as needed for access to the dyke.

- The dyke crest is used extensively by the local residents for recreation and travel including walking, bicycling, motorbikes and vehicle use. Care must be taken to ensure that the public are kept safely away from working equipment.

- There is currently no trash rack to protect flap gates from debris on the River, although existing steel rails are mounted between each of the flap gates and on the wing walls on either side of the headwall. These likely could be used to support a trash rack.

6 RECOMMENDED NEXT STEPS

There are numerous actions that need to be completed prior to the rehabilitation of floodboxes at sites within the lower Fraser River. Described in Table 7 below are the recommendations from this study with associated action items that should be addressed to achieve the objective of rehabilitating known fish migration impediments in those sloughs and watercourses that could potentially provide significant benefits to the production of lower Fraser River salmon. Clearly, any recommended physical or operational changes to floodboxes or pump stations will require prior approval from key management agencies, including the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Table 7. Recommendations and action items to improve fish migration access at five high priority sites in lower Fraser River.

Watercourse	Recommendation	Action Item
Fleetwood Creek	Modify the station's operational regime to allow for a greater percentage of flows to be discharged though the floodbox during certain time periods without increasing lowland flooding event probability.	Consult with Surrey drainage engineers to better understand the complexities of the Fleetwood Creek area flood control facilities and procedures, and to guide refinement of rehabilitation options.
	Upgrade the floodbox gate to improve inmigration and outmigration of coho juveniles.	Consider converting the floodbox gates to side mounted aluminium gates similar to that on the 168th Street ditch floodbox. Or replace both older floodboxes with a new single floodbox with a side mounted gate, preferably as a self regulating tidal (SRT) gate.
McLean Creek	Improve access for fish inmigration and outmigration into McLean Creek through the floodbox and pump.	Consult with Ministry of Environment, Region 2 and local agricultural community to explore operational and structural options for floodbox and pump. Collect and analyze basic station operational data to refine rehabilitation options for floodbox and pump.
		If appropriate based on station analyses, install a SRT gate or an actuated combination gate.
		Install a fish screen to prevent juvenile entrainment and mortality, or install a fish friendly pump (Archimedes screw pump).
Chillukthan Slough	Modify the station's operational regime to allow for a greater percentage of flows to be discharged though the floodbox during certain time periods without increasing lowland flooding event probability or negatively affecting agricultural irrigation needs.	Consult with Delta drainage engineers to better understand the complexities of the Chillukthan Slough flood control facilities and procedures, agricultural irrigation requirements and water withdrawal timing, and to guide refinement of rehabilitation options.
		Options for consideration concerning irrigation withdrawals: 1. Delay irrigation start date until June 30th; 2. Use other water sources for irrigation between May 15th – June 30th; 3. Investigate changes that could be made to agricultural practices to enable a delay of irrigation until June 30th.
	Upgrade the floodbox gate to improve inmigration and outmigration of Chinook and coho juveniles.	Consider converting one of the floodbox gates to a side mounted SRT.

Crescent Slough	Modify the station's operational regime to allow for a greater percentage of flows to be discharged though the floodbox during certain time periods without increasing lowland flooding event probability or negatively affecting agricultural irrigation needs.	Consult with Delta drainage engineers to better understand the complexities of the Crescent Slough flood control facilities and procedures, agricultural irrigation requirements and water withdrawal timing, and to guide refinement of rehabilitation options.
		Options for consideration concerning irrigation withdrawals: 1. Delay irrigation start date until June 30th; 2. Use other water sources for irrigation between May 15th – June 30th; 3. Investigate changes that could be made to agricultural practices to enable a delay of irrigation until June 30th.
	Upgrade the pump or revise floodbox operation to improve outmigration of Chinook and coho juveniles.	Options for consideration concerning pump station: 1. Install a new fish friendly pump to replace one of the existing pumps; or 2. Screen existing pumps and allow increased gravity discharge through the floodbox to continue until June 30th; or 3. Remove stop logs on occasion when correct hydraulic conditions exist during May 15-June 30th period to allow for outmigration through the floodbox.
	Upgrade the floodbox gate to improve inmigration and outmigration of Chinook and coho juveniles.	Consider converting one of the floodbox gates to a side mounted SRT and adjust operational regime to allow gate openings during critical migration periods for juvenile salmon.
96th Street Canal	Improve access for fish inmigration and outmigration into 96th Street Canal through the floodbox.	Consult with Delta drainage engineers to better understand the complexities of the 96th Street Canal flood control facilities and procedures, and to guide refinement of rehabilitation options.
		Consider replacing one of the floodbox gates with a new SRT gate.
	Upgrade the pump station facility to improve outmigration of Chinook and coho juveniles.	Options for consideration concerning pump station: 1. Install a new fish friendly pump to replace the existing pump; or 2. Screen existing pump and allow increased gravity discharge through the floodbox.

7 ACKNOWLEDGMENTS

Several people participated in one way or another in the completion of this study. We thank Terry Point and Simon Campbell from the Musqueam Indian Band and who are members of the Musqueam Ecosystem Conservation Society, who assisted with the field assessments. We appreciate the assistance that environmental specialists and engineers within the various municipalities provided concerning historic and current information on fish distributions and floodbox / pump specifications and operational regimes. In particular, we would like to thank Jeff Arason, Carrie Baron of City of Surrey; Rob Racine, Hugh Fraser and Gary Martin of Corporation of Delta; and Mike Bristols and Neil Peters of BC Ministry of Environment. Kerry Stratton (LGL Limited) proofread and coordinated the production of this report. The support of all these individuals is greatly appreciated.

Disclaimer

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APPENDICES

Appendix 1. Cover letter and summary of preliminary concept review of floodboxes for tide-regulated gate installation for five high priority sites in the lower Fraser River.

March 31, 2009

Marc Gaboury, R.P.Bio.
Senior Fish Biologist
LGL Ltd.
2459 Holyrood Drive
Nanaimo BC V9S 4K7

Dear Mr. Gaboury:

RE: LGL Ltd.
DRAFT – Preliminary Conceptual Review of Proposed Tide Gate Replacements
8.1.1.1.1.1 Our File 2211.014

As requested, KWL has completed a preliminary conceptual review of the proposed tide gate replacement project at five sites including:

- Chillukthan Slough (East floodbox) in Delta;
- Green Slough / Crescent Slough (West floodbox) in Delta;
- 96th Street Ditch in Delta;
- Fleetwood Creek in Surrey; and
- McLean Creek in City of Coquitlam.

The assessment included a site visit, identifying any constraints for construction of the gates, assessing feasibility of replacing the gates, developing preliminary (Level-D) cost estimates for each site and preparing short technical memorandums outlining the results. The work was completed by Laurel Morgan, P.Eng., with input from David Matsubara, P.Eng and the undersigned.

A summary of the required works and the estimated cost are included in Table 1. The table has been ordered in priority based on cost-effectiveness and ease of installation; however, this list does not take habitat and fisheries considerations into account.

Table 1: Summary of Preliminary Concept Review of Floodboxes for Tide-Regulated Gate Installation

Project Site	Expected Works	Estimated Cost
Green Slough/Crescent Slough West Floodbox	▪ Replace one flap gate with tide-regulated gate	$134,000
Chillukthan Slough Floodbox	▪ Replace on flap gate with tide-regulated gate ▪ Install trash rack	$156,000
McLean Creek Outfall to Pitt River	▪ Replace one flap gate with tide-regulated gate ▪ Install trash rack	$275,000
Fleetwood Creek Outfall to Serpentine River	▪ Partially excavate back into dyke and cut back existing pipes ▪ Cast in-place new concrete headwall around both outfall pipes ▪ Install one tide-regulated gate, replace existing flap gate on other pipe ▪ Install trash rack on new headwall	$285,000
River Rd. at 96 St. Floodbox to Fraser River	▪ Remove all existing flap gates ▪ Excavate and remove existing timber headwall ▪ Cast in-place new concrete headwall around both existing timber floodboxes ▪ Install one tide-regulated gate, re-install 3 other existing flap gates ▪ Construct cobble and gravel weir downstream of outfall ▪ Install trash rack	$347,000

Note that the cost estimates include construction plus engineering, permitting, environmental monitoring, construction management and a contingency (25% to 40%). The construction costs assume that existing gates are replaced with a restrained side hinged tide regulated gate. Other gate types may be suitable for these locations which would likely change overall construction costs. Final selection of the type of gates will be completed during the detailed design stage.

Copies of the draft technical memorandums for each of the sites are enclosed. If you have any questions, please contact the undersigned at (250) 595-4223.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Craig Sutherland, P.Eng.
Water Resources Engineer

CS/
Encl.

Appendix 2. Flood box assessment for a tide regulated gate at Chillukthan Slough (East floodbox).

Technical Memorandum - DRAFT

DATE: March 31, 2009

TO: Marc Gaboury, R.P. Bio., LGL Ltd.

FROM: Craig Sutherland, P.Eng. and Laurel Morgan, P.Eng., P.E.

RE: **FLOODBOX ASSESSMENTS FOR TIDE REGULATED GATE**
Chillukthan Slough (East Floodbox), Delta, BC
2211.014

INTRODUCTION

Kerr Wood Leidal (KWL) was requested to review potential project sites for suitability and feasibility of construction to install tide-regulated side-mounted flapgates on existing floodboxes for the purpose of improving fish access through floodboxes. This work was performed at the direction of LGL, for the benefit of the Fraser Salmon Watersheds Program. Each potential site was reviewed independently based on several factors to assess value and appropriateness of a tide-regulated gate.

KWL has developed a preliminary assessment of each site, include the issues and constraints for installation of a tide-regulated gate, as well as estimate cost of the gate and installation.

BACKGROUND REVIEW

Background information for each potential site was review prior to field assessment. For the 3 sites in the Corporation of Delta, background information on the drainage and flood protection systems included:

- The Corporation of Delta Ladner Drainage Survey, 1980, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Ladner Drainage Survey, Phase 2, 1982, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Long Range Drainage Plan, July 2002, New East Consulting Services Ltd.
- Drainage Control Structures Inventory, August 2006, The Corporation of Delta, Engineering Department
- As-built drawing available on-line from the BC Ministry of Environment, Inspector of Dykes.

PROPOSED FLOOD GATE REPLACEMENT

There are indications that the existing side-mounted flood gates are hindering access for fish to side-channels and sloughs located on the land-side of flood protection works. Although some of the gates are side mounted, which are typically better than top-mounted gates, they still prevent fish access for the majority of the time. The two most significant barriers are high velocities through the gates and the culverts as well as gates closing too often and cutting off access. These gates use head differential between the upstream and downstream water levels to operate the gates. As such, they typically close when ever downstream water levels are higher than upstream water levels so gates are typically closed on rising tides.

There are several new flood gate designs now available which can improve fish access as well as tidal flushing in the cut-off back channels and sloughs. These gates remain open during low and medium tide levels or river levels and only close during high water levels to prevent flooding. They typically use absolute water levels on either the upstream or downstream side to trigger the gate to close. There are many different designs but they typically have three types of control mechanisms, mechanical, hydraulic or electrical.

The simplest of these is the mechanical types of gates which function using systems of floats and levers. Usually, they use two sets of floats, one set keeps the gate open while the other set is used to close the gate when water levels reach a the trigger water level. Although these gates use simple floats and levers to operate, they have been known to jam open with debris. A system to control debris at the gate is required for these types of gates. They also usually require large headwalls and significant space to allow the float and lever mechanisms to work properly.

The second type of gate uses a hydraulic piston to control the gate. These are sometimes controlled using hydraulic pumps. However, there are also some designs which use passive hydraulic systems which do not require any external power source. These passive systems use out-flowing tide to open the gate which is then locked open with a hydraulic piston. The piston is prevented from closing by a check valve installed in the hydraulic system. To close the gate, the check valve is released using a float switch mounted in a stilling well. Although these gates use more sophisticated technology, they tend to be lower maintenance than the purely mechanical systems. The trigger mechanisms are well protected and there is less likelihood of blockage caused by debris. In addition, in an emergency the gates can be closed manually by triggering the check valve. This valve can be located in an easily accessible kiosk. Although less likely to be jammed by debris, trash racks are recommended for these gates as well.

The final type of gate also uses hydraulic pistons to control the gate. However, they use electronic control systems to operate. Using these systems, the gates can be controlled to open and close based on a variety of variables such as date or time, upstream or downstream water levels, rainfall amounts or other variables. This requires electronic control and monitoring systems so will need external power. These are typically only used for specific purposes.

For the purposes of this initial review, we have assumed that the existing gates will be replaced with the hydraulic-type gates using the passive system. These gates are also known as tide-regulated side mounted gates. However, further detailed investigation may result in changing the type of gate to suit specific needs at the crossings.

FIELD SITE VISITS

Each site was reviewed in the field at low tide for several factors including:

- Verification of number, size, and type of existing gates
- Fish accessibility downstream of gates
- Presence of additional fish barriers upstream of floodboxes
- Construction access or constructability issues

The three sites in the Corporation of Delta were visited at low tide on the evening of 18 March, 2009. Photos were taken of the site, some of which are included for reference, below.

CHILLUKTHAN SLOUGH, DELTA, BC

Chillukthan Slough pump station and floodbox drain a portion of the Ladner area in Delta and are located at 4950 River Road. Chillukthan Slough drains northward through agricultural and residential areas in the south and west part of Ladner. Past the pump station and floodbox, Chillukthan Slough drains into Ladner Reach and then the Fraser River. The Chillukthan floodbox was installed prior to 1971 according to the Corporation of Delta "Drainage Control Structures Inventory". The name is also variously spelled as "Chillukthan" and "Cohilukthan", and the site is also called by the designation "Floodbox No. 112" and the catchment designation of FA-3. We have used the spelling "Chillukthan" for the purposes of this technical memorandum.

The headwall on the downstream side of the floodbox may have been replaced in 1988 in conjunction with an upgrade to the pump station. The floodbox consists of 3 large box culverts, shown as 10 feet wide "existing" boxes on January 1976 "As Constructed" drawings and 36 inches high in the data in the "Drainage Control Structures Inventory". This does not match with observations in the field. The floodbox gates are doubled side-swing flap gates that open from the center at each box. Each individual flap gate is taller than it is wide, approximately 3 feet tall by 2.5 feet wide, as shown in photos taken on-site at low tide. This would give box dimensions of approximately 3 feet tall by 5 feet wide for each of the three boxes. The downstream invert is shown as -1.1 m elevation in the "Drainage Control Structures Inventory".

SITE OBSERVATIONS RELATIVE TO CONSTRUCTION OF A TIDE-REGULATED FLAP GATE

There are some issues and constraints for an installation of a tide-regulated gate for the benefit of fish passage at this site.

- Working room above the flap gates and headwall is limited due to the sidewalk and River Road and the nearby intersection with Elliott Street. A portion of River Road would likely need to be blocked to allow equipment to hoist and lower the old and new flap gates.

- Equipment access to the channel of the slough, if necessary, would require removal of fencing and vegetation, and careful movement to prevent injury to the two pump station outfalls on the northeast side of the floodbox outlet.

- Due to the proximity of the wingwall to the gates on the southeast side and the fact that all of the gates are positioned very close together, the only flap gate that is an easy candidate for replacement with a tide-regulated gate is the one at the northeast edge of the headwall. The wing wall on the northeast side is nearly in line with the floodbox headwall and there is space for maneuvering of equipment and to mount the tide sensor and gate-regulating mechanism.

- At low tide a small (50 mm) drop was observed at the outlet of the floodbox. In summer, due to lower tides, there may be more of a difference between the invert of the floodbox and the invert of the channel. The observed drop was minimal, so a constructed weir to maintain backwater through the structure is not recommended in this preliminary assessment, however this floodbox should be further reviewed for fish passage concerns prior to design for installation of a tide-regulated gate.

- There is currently no trash rack to protect the flap gates.

CONSTRUCTION ITEMS FOR INSTALLATION OF A TIDE-REGULATED FLOOD GATE

In order to install a tide-regulated gate at this site, the floodbox would not require significant upgrades. Installation should be straightforward. The full work would be comprised of:

- Removal of one existing double side-hinged flap gate – likely the gate on the northeast side;
- Install one tide-regulated side-mounted flap gate; and
- Install trash rack grating across head wall to protect flap gates from debris.

COST ESTIMATE

A cost estimate for the noted works is shown in Table 1. The ‘Class D’ cost estimate is based on the limited site information available and is considered to estimate the magnitude of the construction costs for planning purposes.

REGULATIONS AND PERMITTING

As part of the planning process for installing gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Local Authority

The local authority has jurisdiction and responsibility for drainage within their region. As the flood gates are part of the drainage system, approval from the local authority will be required. The local authority will also take on future responsibility for operation and maintenance of the gates. Therefore, they will play a critical role in the selection of gate types and preferred designs. The municipality will require copies of the preliminary design drawings so that both their engineering and operations departments may review. They may also require an assessment of the impact to the drainage system as a result of changing the gate type. After construction, they will require record drawings as well as operation and maintenance manuals for the new gates.

Provincial Inspector of Dykes

The Provincial Inspector of Dykes (IOD) is responsible for safety of all flood protection measures in BC. To maintain the safety and integrity of dykes and to prevent detrimental effects on other parties and river processes, Section 2(4) of the Dyke Maintenance Act (DMA) provides that a person or a dyking authority must not make changes to a dyke, or to the area adjacent to a dyke without the prior written approval of the Inspector of Dykes (or a Deputy Inspector). The approval process requires submission of an application package including preliminary design drawings and specifications, a design brief which outlines design calculations and assumptions, and any previous correspondence with the IOD office. After construction, the IOD office requires a copy of the record drawings and construction report.

Ministry of Environment

The Ministry of Environment is responsible for protection of surface water as regulated in the Water Act. Section 9 of the Water Act requires that a person may only make "changes in and about a stream" under an Approval. It is likely that only a notification will be required for replacement of the tide gates. However, any additional works such as construction of headwalls or replacement of flood boxes will require full approval.

Both the notification and approval processes involve submission of a “Works in and about a stream” application package which includes the application form, a copy of the design drawings and an application fee. During review of the application it may be determined that an approval is required, in which case additional information such as habitat impact assessment and other information may be required. During the review process, the application package is also forwarded to the local Department of Fisheries and Oceans Regulatory Biologist for review.

Department of Fisheries and Oceans

Section 35(1) of the Federal Fisheries Act prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat. The only relief from this general prohibition is when a Subsection 35(2) Authorization is issued for HADD. It is unlikely that replacement of the tide gates will trigger the requirement for Authorization. However, it is prudent to receive a Letter of Advice from the local Regulatory Biologist which confirms that the proposed works are not considered to be a HADD and outline any required mitigative measures. This process usually involves meeting with the Regulatory Biologist on-site to review proposed works and address any concerns they may have.

The recommended approach for permitting would be to receive approval in principle from both the local authority and the IOD office prior to sending Section 9 Notification to MoE and discussing the project with DFO. The permitting process should be commenced at least four weeks prior to construction to allow sufficient time for review by all the agencies.

PHOTOS OF SITE


Photo 1: Chillukthan Slough – Floodbox outfall


Photo 2: Chillukthan Slough – Open flap gates, from above headwall

TABLE 1 - Class 'D' Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.1	Mobilization, Bonding and Insurance	each	1	6,750	6,750	
1.2	Site Preparation	each	1	2,500	2,500	
1.3	De-watering	days	2.5	1,000	2,500	shallow at low tide
1.4	Traffic Control	days	5	500	2,500	
2	**Drainage Works**					
2.1	Remove existing side mounted flap gate	each	1	2,500	2,500	remove northeast existing flap gate
2.2	Tide-regulated flap gate (supply to site)	each	1	54,000	54,000	one 38-in by 32-in flap gate, Golden Harvest or approved equal
2.3	Tide-regulated flap gate (installation)	each	1	8,000	8,000	
2.4	Trash Rack (supply and install)	each	1	18,000	18,000	approximately 18 m^2 of grating
2.5		each			0	
2.6		days			0	
3	**Restoration**					
3.1	re-vegetation of disturbed areas	lump sum	1	500	500	hand restore and revegetate disturbed ground
	SUBTOTAL				**97,250**	
	Engineering, Permitting, Environmental Monitoring & Construction Management	35%			34,038	
	Contingencies	25%			24,313	
	TOTAL AMOUNT (excl. GST)				**156,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects

Appendix 3. Flood box assessment for a tide regulated gate at Green / Crescent Slough (West floodbox).

Technical Memorandum - DRAFT

DATE: March 31, 2009

TO: Marc Gaboury, R.P.Bio., LGL Ltd.

FROM: Craig Sutherland, P.Eng. and Laurel Morgan, P.Eng., P.E.

RE: **FLOODBOX ASSESSMENTS FOR TIDE REGULATED GATE**
Green Slough/Crescent Slough (West) Floodbox
2211.014

INTRODUCTION

Kerr Wood Leidal (KWL) was requested to review potential project sites for suitability and feasibility of construction to install tide-regulated side-mounted flapgates on existing floodboxes for the purpose of improving fish access through floodboxes. This work was performed at the direction of LGL, for the benefit of the Fraser Salmon Watersheds Program. Each potential site was reviewed independently based on several factors to assess value and appropriateness of a tide-regulated gate.

KWL has developed a preliminary assessment of each site, include the issues and constraints for installation of a tide-regulated gate, as well as estimate cost of the gate and installation.

BACKGROUND REVIEW

Background information for each potential site was review prior to field assessment. For the 3 sites in the Corporation of Delta, background information on the drainage and flood protection systems included:

- The Corporation of Delta Ladner Drainage Survey, 1980, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Ladner Drainage Survey, Phase 2, 1982, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Long Range Drainage Plan, July 2002, New East Consulting Services Ltd.
- Drainage Control Structures Inventory, August 2006, The Corporation of Delta, Engineering Department
- As-built drawing available on-line from the BC Ministry of Environment, Inspector of Dykes.

PROPOSED FLOOD GATE REPLACEMENT

There are indications that the existing side-mounted flood gates are hindering access for fish to side-channels and sloughs located on the land-side of flood protection works. Although some of the gates are side mounted, which are typically better than top-mounted gates, they still prevent fish access for the majority of the time. The two most significant barriers are high velocities through the gates and the culverts as well as gates closing too often and cutting off access. These gates use head differential between the upstream and downstream water levels to operate the gates. As such, they typically close when ever downstream water levels are higher than upstream water levels so gates are typically closed on rising tides.

There are several new flood gate designs now available which can improve fish access as well as tidal flushing in the cut-off back channels and sloughs. These gates remain open during low and medium tide levels or river levels and only close during high water levels to prevent flooding. They typically use absolute water levels on either the upstream or downstream side to trigger the gate to close. There are many different designs but they typically have three types of control mechanisms, mechanical, hydraulic or electrical.

The simplest of these is the mechanical types of gates which function using systems of floats and levers. Usually, they use two sets of floats, one set keeps the gate open while the other set is used to close the gate when water levels reach a the trigger water level. Although these gates use simple floats and levers to operate, they have been known to jam open with debris. A system to control debris at the gate is required for these types of gates. They also usually require large headwalls and significant space to allow the float and lever mechanisms to work properly.

The second type of gate uses a hydraulic piston to control the gate. These are sometimes controlled using hydraulic pumps. However, there are also some designs which use passive hydraulic systems which do not require any external power source. These passive systems use out-flowing tide to open the gate which is then locked open with a hydraulic piston. The piston is prevented from closing by a check valve installed in the hydraulic system. To close the gate, the check valve is released using a float switch mounted in a stilling well. Although these gates use more sophisticated technology, they tend to be lower maintenance than the purely mechanical systems. The trigger mechanisms are well protected and there is less likelihood of blockage caused by debris. In addition, in an emergency the gates can be closed manually by triggering the check valve. This valve can be located in an easily accessible kiosk. Although less likely to be jammed by debris, trash racks are recommended for these gates as well.

The final type of gate also uses hydraulic pistons to control the gate. However, they use electronic control systems to operate. Using these systems, the gates can be controlled to open and close based on a variety of variables such as date or time, upstream or downstream water levels, rainfall amounts or other variables. This requires electronic control and monitoring systems so will need external power. These are typically only used for specific purposes.

For the purposes of this initial review, we have assumed that the existing gates will be replaced with the hydraulic-type gates using the passive system. These gates are also known as tide-regulated side mounted gates. However, further detailed investigation may result in changing the type of gate to suit specific needs at the crossings.

FIELD SITE VISITS

Each site was reviewed in the field at low tide for several factors including:

- Verification of number, size, and type of existing gates
- Fish accessibility downstream of gates
- Presence of additional fish barriers upstream of floodboxes
- Construction access or constructability issues

The three sites in the Corporation of Delta were visited at low tide on the evening of 18 March, 2009. Photos were taken of the site, some of which are included for reference, below.

GREEN SLOUGH/CRESCENT SLOUGH – WEST, DELTA, BC

Green Slough pump station and floodbox are located at 5778 River Road in Delta. Crescent Slough (West) drains toward the northwest through agricultural and residential areas in portion of Ladner in the western part of Delta and drains the south section of Crescent Slough through Green Slough to Deas Slough and the Fraser River. The Green Slough floodbox was installed prior to 1976 according to the Corporation of Delta "Drainage Control Structures Inventory". The site is also called by the designation "Floodbox No. 312" and the catchment designation of FA-4.

The as-built drawings in the "Drainage Control Structures Inventory" and available from the Inspector of Dykes office all show the floodbox as "existing", with no detailed information on the size or type. Field observation was severely hampered by the gratings covering top and face of the outlet gates, making it very difficult to see the gates at all. The existing configuration has four parallel box-section culverts with double side-mounted flap gates on the outlet. The gates open from the center of each flood box. The as-built drawing shows the boxes to be approximately 5 feet wide, which fits with the limited observations of the existing double side-mounted flap gates which were approximately 2.5 feet wide each. The height of the floodboxes is unknown and could not be measured at the time of the field visit. They are estimated to be 3 feet in height. A note on the as-built drawing that shows the "existing" floodbox indicates that the channel invert in the Slough downstream of the floodbox is elevation -3.8 m, but the invert of the floodbox is unknown. It is likely quite low though, as the floodbox gates appeared to be more than half submerged at near to low tide.

The banks of the slough are gently sloped and open access on either side of the floodbox outlet. The top of the headwall is far enough off of River Road that equipment should be able to work from above the headwall without impacting traffic other than as a distraction.

SITE OBSERVATIONS RELATIVE TO CONSTRUCTION OF A TIDE-REGULATED FLAP GATE

There are some issues and constraints for an installation of a tide-regulated gate for the benefit of fish passage at this site.

- The exact size and configuration of the existing gates should be confirmed. This would require the cooperation of the staff at the Corporation of Delta to remove a section of grating and measure the gates at low tide.

- The perpendicular wing walls on either side of the face of the headwall were observed to be located very close to the gates. An access ladder may have to be moved and the horizontal grating re-configured in order to allow installation of the hinge tube at one side of the tide-regulated gate. The float well assembly and gate control enclosure would require mounting on the adjacent wing wall. Therefore only the two end gates may be considered for replacement by a tide-regulated gate.

CONSTRUCTION ITEMS FOR INSTALLATION OF A TIDE-REGULATED FLOOD GATE

In order to install a tide-regulated gate at this site, the floodbox would not require significant upgrades, provided further inspection of the outlet in floodboxes in conjunction with the Corporation of Delta does not indicate any major discrepancies with the limited information available for this review. The only know issues are relocation of access ladders located on the perpendicular wing wall and re-configuration of the horizontal grating to accommodate the float well assembly and gate control enclosure. Otherwise, installation should be straightforward. The full work would be comprised of:

- Removal and relocation of access ladder;
- Removal of one double side-mounted flap gate at one flood box – likely the flood box on the northeast side;
- Install one tide-regulated side-mounted flap gate; and
- Replace horizontal grating over gates.

COST ESTIMATE

A cost estimate for the noted works is shown in Table 1. The ‘Class D’ cost estimate is based on the limited site information available and is considered to estimate the magnitude of the construction costs for planning purposes.

Regulations and Permitting

As part of the planning process for installing gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Local Authority

The local authority has jurisdiction and responsibility for drainage within their region. As the flood gates are part of the drainage system, approval from the local authority will be required. The local authority will also take on future responsibility for operation and maintenance of the gates. Therefore, they will play a critical role in the selection of gate types and preferred designs. The municipality will require copies of the preliminary design drawings so that both their engineering and operations departments may review. They may also require an assessment of the impact to the drainage system as a result of changing the gate type. After construction, they will require record drawings as well as operation and maintenance manuals for the new gates.

Provincial Inspector of Dykes

The Provincial Inspector of Dykes (IOD) is responsible for safety of all flood protection measures in BC. To maintain the safety and integrity of dykes and to prevent detrimental effects on other parties and river processes, Section 2(4) of the Dyke Maintenance Act (DMA) provides that a person or a dyking authority must not make changes to a dyke, or to the area adjacent to a dyke without the prior written approval of the Inspector of Dykes (or a Deputy Inspector). The approval process requires submission of an application package including preliminary design drawings and specifications, a design brief which outlines design calculations and assumptions, and any previous correspondence with the IOD office. After construction, the IOD office requires a copy of the record drawings and construction report.

Ministry of Environment

The Ministry of Environment is responsible for protection of surface water as regulated in the Water Act. Section 9 of the Water Act requires that a person may only make "changes in and about a stream" under an Approval. It is likely that only a notification will be required for replacement of the tide gates. However, any additional works such as construction of headwalls or replacement of flood boxes will require full approval.

Both the notification and approval processes involve submission of a "Works in and about a stream" application package which includes the application form, a copy of the design drawings and an application fee. During review of the application it may be determined that an approval is required, in which case additional information such as habitat impact assessment and other information may be required. During the review process, the application package is also forwarded to the local Department of Fisheries and Oceans Regulatory Biologist for review.

Department of Fisheries and Oceans

Section 35(1) of the Federal Fisheries Act prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat. The only relief from this general prohibition is when a Subsection 35(2) Authorization is issued for HADD. It is unlikely that replacement of the tide gates will trigger the requirement for Authorization. However, it is prudent to receive a Letter of Advice from the local Regulatory Biologist which confirms that the proposed works are not considered to be a HADD and outline any required mitigative measures. This process usually involves meeting with the Regulatory Biologist on-site to review proposed works and address any concerns they may have.

The recommended approach for permitting would be to receive approval in principle from both the local authority and the IOD office prior to sending Section 9 Notification to MoE and discussing the project with DFO. The permitting process should be commenced at least four weeks prior to construction to allow sufficient time for review by all the agencies.

PHOTOS OF SITE

Photo 1: Green Slough Floodbox – Floodbox outlet with 90° wingwalls

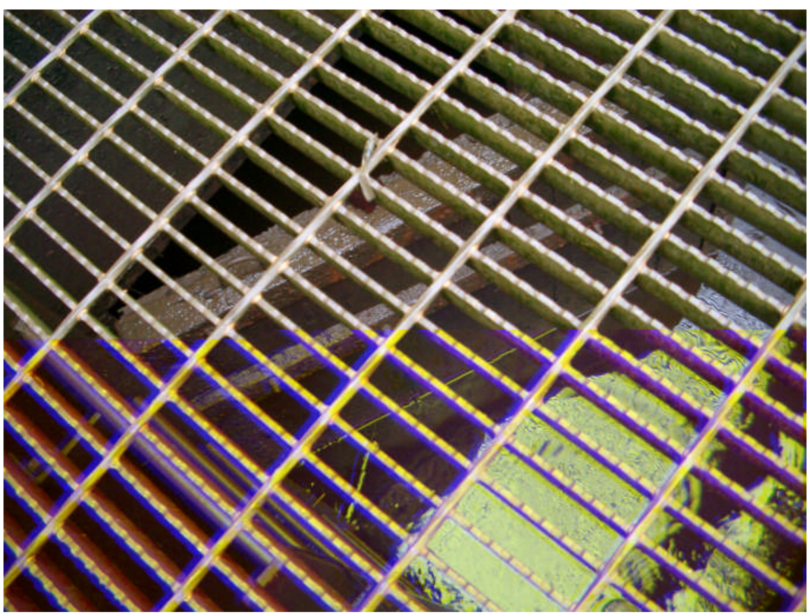

Photo 2: Green Slough Floodbox – Open flap gate viewed through grate from above

TABLE 1 - Class 'D' Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.1	Mobilization, Bonding and Insurance	each	1	7,650	7,650	Estimated at 9% Combined
1.2	Site Preparation	each	1	1,500	1,500	
1.3	De-watering	days	2.5	3,000	7,500	deep water at low tide
2	**Site Work**					
2.1	Remove, relocate access ladder and reconfigure grating	each	1	2,500	2,500	
3	**Drainage Works**					
3.1	Remove existing side mounted flap gate	each	1	2,000	2,000	remove northeast existing flap gate
3.2	Tide-regulated flap gate (supply to site)	each	1	54,000	54,000	one 38-in by 32-in flap gate, Golden Harvest or approved equal
3.3	Tide-regulated flap gate (install)	each	1	8,000	8,000	
4	**Restoration**					
4.1	Re-vegetation of disturbed areas	lump sum	1	500	500	hand restore and revegetate disturbed ground
	SUBTOTAL				**83,650**	
	Engineering, Permitting, Environmental Monitoring & Construction Management	35%			29,278	
	Contingencies	25%			20,913	
	TOTAL AMOUNT (excl. GST)				**134,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects

Appendix 4. Flood box assessment for a tide regulated gate at 96th Street Canal at River Road, Delta, BC.

Technical Memorandum - DRAFT

DATE: March 31, 2009

TO: Marc Gaboury, R.P.Bio., LGL Ltd.

FROM: Craig Sutherland, P.Eng. and Laurel Morgan, P.Eng., P.E.

RE: **FLOODBOX ASSESSMENTS FOR TIDE REGULATED GATE**
River Road at 96th Street, Delta, BC
2211.014

INTRODUCTION

Kerr Wood Leidal (KWL) was requested to review potential project sites for suitability and feasibility of construction to install tide-regulated side-mounted flapgates on existing floodboxes for the purpose of improving fish access through floodboxes. This work was performed at the direction of LGL, for the benefit of the Fraser Salmon Watersheds Program. Each potential site was reviewed independently based on several factors to assess value and appropriateness of a tide-regulated gate.

KWL has developed a preliminary assessment of each site, include the issues and constraints for installation of a tide-regulated gate, as well as estimate cost of the gate and installation.

BACKGROUND REVIEW

Background information for each potential site was review prior to field assessment. For the 3 sites in the Corporation of Delta, background information on the drainage and flood protection systems included:

- The Corporation of Delta Ladner Drainage Survey, 1980, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Ladner Drainage Survey, Phase 2, 1982, Dayton & Knight Ltd. Consulting Engineers
- The Corporation of Delta Long Range Drainage Plan, July 2002, New East Consulting Services Ltd.

- Drainage Control Structures Inventory, August 2006, The Corporation of Delta, Engineering Department
- As-built drawing available on-line from the BC Ministry of Environment, Inspector of Dykes.

PROPOSED FLOOD GATE REPLACEMENT

There are indications that the existing side-mounted flood gates are hindering access for fish to side-channels and sloughs located on the land-side of flood protection works. Although some of the gates are side mounted, which are typically better than top-mounted gates, they still prevent fish access for the majority of the time. The two most significant barriers are high velocities through the gates and the culverts as well as gates closing too often and cutting off access. These gates use head differential between the upstream and downstream water levels to operate the gates. As such, they typically close when ever downstream water levels are higher than upstream water levels so gates are typically closed on rising tides.

There are several new flood gate designs now available which can improve fish access as well as tidal flushing in the cut-off back channels and sloughs. These gates remain open during low and medium tide levels or river levels and only close during high water levels to prevent flooding. They typically use absolute water levels on either the upstream or downstream side to trigger the gate to close. There are many different designs but they typically have three types of control mechanisms, mechanical, hydraulic or electrical.

The simplest of these is the mechanical types of gates which function using systems of floats and levers. Usually, they use two sets of floats, one set keeps the gate open while the other set is used to close the gate when water levels reach a the trigger water level. Although these gates use simple floats and levers to operate, they have been known to jam open with debris. A system to control debris at the gate is required for these types of gates. They also usually require large headwalls and significant space to allow the float and lever mechanisms to work properly.

The second type of gate uses a hydraulic piston to control the gate. These are sometimes controlled using hydraulic pumps. However, there are also some designs which use passive hydraulic systems which do not require any external power source. These passive systems use out-flowing tide to open the gate which is then locked open with a hydraulic piston. The piston is prevented from closing by a check valve installed in t and close based on a variety of variables such as date or time, upstream or downstream water levels, rainfall amounts or other variables. This requires electronic control and monitoring systems so will need external power. These are typically only used for specific purposes.

For the purposes of this initial review, we have assumed that the existing gates will be replaced with the hydraulic-type gates using the passive system. These gates are also known as tide-regulated side mounted gates. However, further detailed investigation may result in changing the type of gate to suit specific needs at the crossings.

FIELD SITE VISITS

Each site was reviewed in the field at low tide for several factors including:

- Verification of number, size, and type of existing gates
- Fish accessibility downstream of gates
- Presence of additional fish barriers upstream of floodboxes
- Construction access or constructability issues

The three sites in the Corporation of Delta were visited at low tide on the evening of 18 March, 2009. Photos were taken of the site, some of the photos are included for reference, below.

RIVER ROAD AT 96TH STREET, DELTA, BC

The pump station and floodboxes on River Road at 96th Street drain flow from Burns Bog and nearby areas of industrial development along River Road to the Fraser River. The 1970/1976 as-built Drawings of the flood boxes in this location from the MOE Inspector of Dykes identify the site as Flood Box No. 102. More current Corporation of Delta documents identify the site as "Gravel Ridge Floodbox" and by the Catchment designation of FA-8-1. There is a single pipe outfall with round flapgate from the pump station. The floodbox consists of two parallel wooden boxes with four rectangular side-mounted flap gates. The Corporation of Delta lists the downstream invert of the floodbox at -0.13 m elevation (no datum). From the as-built drawings, the existing flap gates cover openings 3 feet wide by 4 feet high (0.91 m by 1.22 m). At the time of the field visit the gates were chained to a half-open position.

SITE OBSERVATIONS RELATIVE TO CONSTRUCTION OF A TIDE-REGULATED FLAP GATE

There are some issues and constraints to be considered for installation of a tide-regulated gate for the benefit of fish passage at this site.

- The outflow at this site is combined flow from Burns Bog and industrial sites near River Road.

- The downstream headwall around the flapgates is constructed of heavy timbers, specified in the As-Built drawings as 12-inch by 12-inch creosoted fir. While it appears to be in good condition and no sagging or malfunction of the existing gates was visible, a timber headwall may be expected to require replacement during the expected life of a new tide-regulated gate. The Golden Harvest gate would require fastening of the gate and the tide-regulating mechanism to the headwall as well. It could be secured to a timber headwall, but may be expected to require refurbishment and adjustment as the wood decays and requires replacing.

- The box and gate configuration includes four gates regulating the openings of only two separate boxes. Both boxes are constructed of wood.
- There is a drop of approximately 0.3 metres visible below the existing flap gates to the stream channel, which generated a small hydraulic jump approximately 0.5 metres downstream of the headwall at low tide. According to as-built drawings, there is approximately 2 feet (0.6 m) of headwall constructed below the openings of the floodbox.
- For construction access, the bank on the downstream side of the floodboxes is steep and falls 0 0 1 9 0 rg 0(r)-287.3equi420.0(k)018.0(l)-1.0(y)-420.0(a)4.0(t)-2

Cost Estimate

A cost estimate for the noted works is shown in Table 1. The 'Class D' cost estimate is based on the limited site information available and is considered to estimate the magnitude of the construction costs for planning purposes.

Regulations and Permitting

As part of the planning process for installing gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Local Authority

The local authority has jurisdiction and responsibility for drainage within their region. As the flood gates are part of the drainage system, approval from the local authority will be required. The local authority will also take on future responsibility for operation and maintenance of the gates. Therefore, they will play a critical role in the selection of gate types and preferred designs. The municipality will require copies of the preliminary design drawings so that both their engineering and operations departments may review. They may also require an assessment of the impact to the drainage system as a result of changing the gate type. After construction, they will require record drawings as well as operation and maintenance manuals for the new gates.

Provincial Inspector of Dykes

The Provincial Inspector of Dykes (IOD) is responsible for safety of all flood protection measures in BC. To maintain the safety and integrity of dykes and to prevent detrimental effects on other parties and river processes, Section 2(4) of the Dyke Maintenance Act (DMA) provides that a person or a dyking authority must not make changes to a dyke, or to the area adjacent to a dyke without the prior written approval of the Inspector of Dykes (or a Deputy Inspector). The approval process requires submission of an application package including preliminary design drawings and specifications, a design brief which outlines design calculations and assumptions, and any previous correspondence with the IOD office. After construction, the IOD office requires a copy of the record drawings and construction report.

Ministry of Environment

The Ministry of Environment is responsible for protection of surface water as regulated in the Water Act. Section 9 of the Water Act requires that a person may only make "changes in and about a stream" under an Approval. It is likely that only a notification will be required for replacement of the tide gates. However, any additional works such as construction of headwalls or replacement of flood boxes will require full approval.

Both the notification and approval processes involve submission of a "Works in and about a stream" application package which includes the application form, a copy of the design drawings and an application fee. During review of the application it may be determined that an approval is required, in which case additional information such as habitat impact assessment and other information may be required. During the review process, the application package is also forwarded to the local Department of Fisheries and Oceans Regulatory Biologist for review.

Department of Fisheries and Oceans

Section 35(1) of the Federal Fisheries Act prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat. The only relief from this general prohibition is when a Subsection 35(2) Authorization is issued for HADD. It is unlikely that replacement of the tide gates will trigger the requirement for Authorization. However, it is prudent to receive a Letter of Advice from the local Regulatory Biologist which confirms that the proposed works are not considered to be a HADD and outline any required mitigative measures. This process usually involves meeting with the Regulatory Biologist on-site to review proposed works and address any concerns they may have.

The recommended approach for permitting would be to receive approval in principle from both the local authority and the IOD office prior to sending Section 9 Notification to MoE and discussing the project with DFO. The permitting process should be commenced at least four weeks prior to construction to allow sufficient time for review by all the agencies.

PHOTOS OF SITE

Photo 1: River Road at 96 St. – Pump station and floodbox outfall

Photo 2: River Road at 96 St. – Looking down on open flap gates at low tide


Photo 3: River Road at 96 St. – Drop at outfall below floodbox invert

TABLE 1 - Class 'D' Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.1	Mobilization, Bonding and Insurance	each	1	16,200	16,200	
1.2	Site Preparation	each	1	5,000	5,000	
1.3	De-watering	days	10	2,500	25,000	shallow at low tide, but ongoing over several days for concrete work
1.4	Traffic Control	days	15	500	7,500	River Road, may require night work
2	**Site Work**					
2.1	Excavation (clear, grub, excavate, restore)	m^3	8	300	2,400	
2.2	Dismantle, remove, dispose of existing timber headwall	each	1	2,500	2,500	
3	**Drainage Works**					
3.1	Remove existing side mounted flap gates	each	4	2,500	10,000	
3.2	Concrete headwall, (forming, steel, concrete, finishing)	m^3	16	2,500	40,000	Replace existing headwall and wingwalls
3.3	Cobble and gravel riffle/ Newbury weir (excavation, rock and gravel placement)	m^3	2	1,500	3,000	approximately 0.3 m high weir, plus footing
3.4	Tide-regulated flap gate (supply and install)	each	1	77,500	77,500	52-inch high by 40-inch wide stainless steel gate, Golden Harvest or approved equal
3.5	Reinstall side-mounted flap gates for remaining openings	each	3	1,500	4,500	require new hardware to attach
3.6	Trash rack over headwall (supply and install)	each	1	27,000	27,000	approximately 27 m^2 of grating

Continued on next page

TABLE 1 (Continued)

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
4	**Restoration**					
4.1	re-grading of slopes to finish grade	lump sum	1	1,000	1,000	
4.2	re-vegetation of disturbed areas	lump sum	1	500	500	
	SUBTOTAL				**222,100**	
	Engineering, Permitting, Environmental Monitoring & Construction Management	30%			66,630	
	Contingencies	40%			88,840	
	TOTAL AMOUNT (excl. GST)				**378,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.

Appendix 5. Flood box assessment for a tide regulated gate at Fleetwood Creek, Surrey, BC.

Technical Memorandum - DRAFT

DATE: March 31, 2009

TO: Marc Gaboury, R.P.Bio, LGL Ltd.

FROM: Craig Sutherland, P.Eng. and Laurel Morgan, P.Eng., P.E.

RE: **FLOODBOX ASSESSMENTS FOR TIDE REGULATED GATE**
Fleetwood Creek, Surrey, BC
2211.014

INTRODUCTION

Kerr Wood Leidal (KWL) was requested to review potential project sites for suitability and feasibility of construction to install tide-regulated side-mounted flapgates on existing floodboxes for the purpose of improving fish access through floodboxes. This work was performed at the direction of LGL, for the benefit of the Fraser Salmon Watersheds Program. Each potential site was reviewed independently based on several factors to assess value and appropriateness of a tide-regulated gate.

KWL has developed a preliminary assessment of each site, include the issues and constraints for installation of a tide-regulated gate, as well as estimate cost of the gate and installation.

BACKGROUND REVIEW

Background information for each potential site was review prior to field assessment. Information for the Fleetwood Creek site was somewhat limited.

The City of Surrey maintains drainage facilities for Fleetwood Creek drainage to the Serpentine River. Fleetwood Creek is drained by two 1200 mm diameter floodboxes with top-mounted circular flap gates, and a single 1.2 m^3/s screw-type pump. The City of Surrey was able to provide a single As-Built drawing for the Fleetwood Creek site showing the location and size of the floodbox and gates. The drawing is by Stantec Consulting Ltd., titled “Central Serpentine Dyke Upgrade Project, Serpentine River, West Channel, Plan and Profile Sta: 0+900 to Sta: 1+200”, and dated 03/02/01, with revisions dated 2003. In addition, the City was able to provide records of river level that indicate the existing flap gates are generally partially or fully submerged.

PROPOSED FLOOD GATE REPLACEMENT

There are indications that the existing side-mounted flood gates are hindering access for fish to side-channels and sloughs located on the land-side of flood protection works. Although some of the gates are side mounted, which are typically better than top-mounted gates, they still prevent fish access for the majority of the time. The two most significant barriers are high velocities through the gates and the culverts as well as gates closing too often and cutting off access. These gates use head differential between the upstream and downstream water levels to operate the gates. As such, they typically close when ever downstream water levels are higher than upstream water levels so gates are typically closed on rising tides.

There are several new flood gate designs now available which can improve fish access as well as tidal flushing in the cut-off back channels and sloughs. These gates remain open during low and medium tide levels or river levels and only close during high water levels to prevent flooding. They typically use absolute water levels on either the upstream or downstream side to trigger the gate to close. There are many different designs but they typically have three types of control mechanisms, mechanical, hydraulic or electrical.

The simplest of these is the mechanical types of gates which function using systems of floats and levers. Usually, they use two sets of floats, one set keeps the gate open while the other set is used to close the gate when water levels reach a the trigger water level. Although these gates use simple floats and levers to operate, they have been known to jam open with debris. A system to control debris at the gate is required for these types of gates. They also usually require large headwalls and significant space to allow the float and lever mechanisms to work properly.

The second type of gate uses a hydraulic piston to control the gate. These are sometimes controlled using hydraulic pumps. However, there are also some designs which use passive hydraulic systems which do not require any external power source. These passive systems use out-flowing tide to open the gate which is then locked open with a hydraulic piston. The piston is prevented from closing by a check valve installed in the hydraulic system. To close the gate, the check valve is released using a float switch mounted in a stilling well. Although these gates use more sophisticated technology, they tend to be lower maintenance than the purely mechanical systems. The trigger mechanisms are well protected and there is less likelihood of blockage caused by debris. In addition, in an emergency the gates can be closed manually by triggering the check valve. This valve can be located in an easily accessible kiosk. Although less likely to be jammed by debris, trash racks are recommended for these gates as well.

The final type of gate also uses hydraulic pistons to control the gate. However, they use electronic control systems to operate. Using these systems, the gates can be controlled to open and close based on a variety of variables such as date or time, upstream or downstream water levels, rainfall amounts or other variables. This requires electronic control and monitoring systems so will need external power. These are typically only used for specific purposes.

For the purposes of this initial review, we have assumed that the existing gates will be replaced with the hydraulic-type gates using the passive system. These gates are also known as tide-regulated side mounted gates. However, further detailed investigation may result in changing the type of gate to suit specific needs at the crossings.

FIELD SITE VISITS

Each site was reviewed in the field at low tide for several factors including:

- Verification of number, size, and type of existing gates
- Fish accessibility downstream of gates
- Presence of additional fish barriers upstream of floodboxes
- Construction access or constructability issues

Fleetwood Creek in the City of Surrey was visited at low tide on 30 March, 2009 in the company of Matt Brown of the City of Surrey Engineering Department. Photos were taken of the site, some of which are included for reference, below.

FLEETWOOD CREEK, SURREY, BC

A pump station and double floodbox drains Fleetwood Creek in Surrey to the Serpentine River. The Serpentine River itself is controlled at its mouth, and during high tides will store the flow of the Serpentine within the dyked river section. The river then drains the backwater during low tides. Thus the backwater in the Serpentine is tidally influenced but the backwater is not actually tide flow. Fleetwood Creek drains through agricultural lands to the City of Surrey's pump station and floodbox. The pump station is a single screw-type pump with 1.2 m^3/s capacity. The floodbox consists of two 1,200 mm diameter CMP pipes through the dyke, with the top-mounted flap gates hung on the end of the pipes. Inverts of the existing floodbox outlets are shown as -1.86 and -1.87m elevation (datum not shown, but may be on another drawing of the set). The Serpentine River dyke was upgraded in 2003 and the floodbox pipes were both replaced at that time according to the drawing provided by the City of Surrey.

Access to the site is from 160 Street on the north side of the Serpentine River. The City of Surrey maintains an access road and right-of-way that extends from the bottom of 160 Street to the dyke but the access is gated and locked. The access road is located on private property, posted "No Trespassing" and access may only be obtained via the City and accompanied by City staff. Additional access to floodbox may be available from up- or downstream of the Fleetwood Creek outfall via traverse along the crest of the dyke, but should also be coordinated through the City of Surrey.

SITE OBSERVATIONS RELATIVE TO CONSTRUCTION OF A TIDE-REGULATED FLAP GATE

There are some issues and constraints for an installation of a tide-regulated gate for the benefit of fish passage at this site.

- Upstream of the floodbox, Fleetwood Creek drains as irrigation ditches through agricultural land and through at least two sets of CMP culverts at farm access roads. The culverts are on the order of 10 metres long, set low in the channels and generally appear to be backwatered from the outlet. It is not known if these culverts might be limiting for fish access to the upper reaches of the creek.

- The CMP pipes at the floodbox are set close together and extend out from the dyke with flap gates attached to collars on the pipes. There is no existing headwall to attach a new tide-regulated gate to.

- The side slopes on the dyke are steep (steeper than 2:1) and may impact maneuverability of equipment on the dyke crest.

- The existing pump station is constructed with a concrete section through the crest of the dyke. The dyke crest is therefore restricted at this point for passage of vehicles and equipment due to vertical faces on either side of the crest. The City of Surrey drawing shows the clear crest at this location as 3.2 m wide.

- There is currently no trash rack protecting either flap gate from debris.

CONSTRUCTION ITEMS FOR INSTALLATION OF A TIDE-REGULATED FLOOD GATE

In order to install a tide-regulated gate at this site, the floodbox would require several upgrades. The primary upgrade would be to partially excavate the dyke back around the floodbox outfall and to cast in-place a new concrete headwall around the two pipes. The two pipes appear to have approximately 1 metre of separation between them, and the headwall would extend approximately 0.5 m on either side before the perpendicular wing wall begins. The concrete headwall would then allow a trash rack to be affixed to the front and top of the headwall and wing walls to protect the outfall flap gates from debris. In an email conversation with Jeff Arason at the City of Surrey, Mr. Arason noted that the floodboxes would require replacement before their normal expected 40-year life if significant settlement of the dyke fill and deformation of the CMP pipes occurred. If this were to occur, the pipes could be replaced with concrete pipes with pre-cast headwalls, which would be sufficient for installation of a tide-regulated gate. The full work would be comprised of:

- Dyke excavation around both pipes at outfall and cut back existing pipes;
- Cast in-place new head wall around existing pipes with perpendicular wing walls;
- Re-construct dyke section to match existing;
- Install one tide-regulated side-mounted flap gate; and

- Install trash rack across new concrete headwall to protect flap gate from debris.

COST ESTIMATE

A cost estimate for the noted works is shown in Table 1. The 'Class D' cost estimate is based on the limited site information available and is considered to estimate the magnitude of the construction costs for planning purposes.

REGULATIONS AND PERMITTING

As part of the planning process for installing gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Local Authority

The local authority has jurisdiction and responsibility for drainage within their region. As the flood gates are part of the drainage system, approval from the local authority will be required. The local authority will also take on future responsibility for operation and maintenance of the gates. Therefore, they will play a critical role in the selection of gate types and preferred designs. The municipality will require copies of the preliminary design drawings so that both their engineering and operations departments may review. They may also require an assessment of the impact to the drainage system as a result of changing the gate type. After construction, they will require record drawings as well as operation and maintenance manuals for the new gates.

Provincial Inspector of Dykes

The Provincial Inspector of Dykes (IOD) is responsible for safety of all flood protection measures in BC. To maintain the safety and integrity of dykes and to prevent detrimental effects on other parties and river processes, Section 2(4) of the Dyke Maintenance Act (DMA) provides that a person or a dyking authority must not make changes to a dyke, or to the area adjacent to a dyke without the prior written approval of the Inspector of Dykes (or a Deputy Inspector). The approval process requires submission of an application package including preliminary design drawings and specifications, a design brief which outlines design calculations and assumptions, and any previous correspondence with the IOD office. After construction, the IOD office requires a copy of the record drawings and construction report.

Ministry of Environment

The Ministry of Environment is responsible for protection of surface water as regulated in the Water Act. Section 9 of the Water Act requires that a person may only make “changes in and about a stream” under an Approval. It is likely that only a notification will be required for replacement of the tide gates. However, any additional works such as construction of headwalls or replacement of flood boxes will require full approval.

Both the notification and approval processes involve submission of a “Works in and about a stream” application package which includes the application form, a copy of the design drawings and an application fee. During review of the application it may be determined that an approval is required, in which case additional information such as habitat impact assessment and other information may be required. During the review process, the application package is also forwarded to the local Department of Fisheries and Oceans Regulatory Biologist for review.

Department of Fisheries and Oceans

Section 35(1) of the Federal Fisheries Act prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat. The only relief from this general prohibition is when a Subsection 35(2) Authorization is issued for HADD. It is unlikely that replacement of the tide gates will trigger the requirement for Authorization. However, it is prudent to receive a Letter of Advice from the local Regulatory Biologist which confirms that the proposed works are not considered to be a HADD and outline any required mitigative measures. This process usually involves meeting with the Regulatory Biologist on-site to review proposed works and address any concerns they may have.

The recommended approach for permitting would be to receive approval in principle from both the local authority and the IOD office prior to sending Section 9 Notification to MoE and discussing the project with DFO. The permitting process should be commenced at least four weeks prior to construction to allow sufficient time for review by all the agencies.

PHOTOS OF SITE

Photo 1: Fleetwood Creek Floodbox – Outfall with flap gates

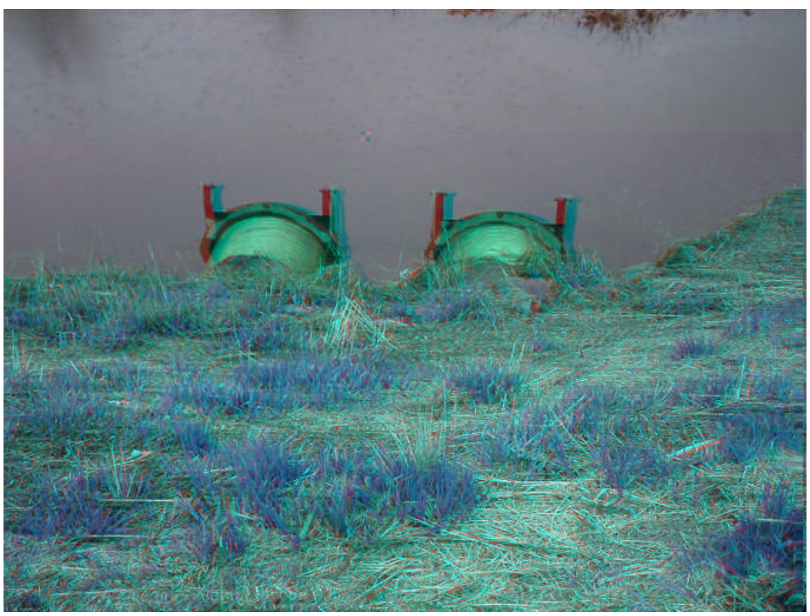

Photo 2: Fleetwood Creek Floodbox – Outfall from directly above on the dyke crest

Photo 3: Fleetwood Creek Pump Station – Pump station constructed through dyke crest

TABLE 1 - Class 'D' Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	Total Price $	Comment
1	**General**					
1.1	Mobilization, Bonding and Insurance	each	1	12,600	12,600	
1.2	Site Preparation	each	1	4,500	4,500	
1.3	De-watering	days	12	2,500	30,000	deep water at high tide, slow current, requires coffer dam
2	**Site Work**					
2.1	Excavation and Backfill (clear, grub, excavate, backfill and compaction)	m^3	30	75	2,250	
2.2	Remove, dispose of ends of existing CMP pipe and one flap gate	each	1	1,500	1,500	
3	**Drainage Works**					
3.1	Cast in-place concrete headwall (forming, steel, concrete, finishing)	m^3	10	2,500	25,000	cut into dyke and form headwall around existing pipes
3.2	Tide-regulated flap gate (supply and install)	each	1	77,000	77,000	52-inch stainless steel square gate, Golden Harvest or approved equal
3.3	Re-install one existing flap gate on other outfall pipe	each	1	1,000	1,000	re-use on existing flap gate
3.4	Trash Rack over headwall (supply and install)	each	1	10,000	10,000	approximately 10 m^2 of grating
4	**Restoration**					
4.1	re-grading of slopes to finish grade	lump sum	1	2,500	2,500	
4.2	re-vegetation of disturbed areas	lump sum	1	1,500	1,500	
	SUBTOTAL				**167,850**	
	Engineering, Permitting, Environmental Monitoring & Construction Management	30%			50,355	
	Contingencies	40%			67,140	
	TOTAL AMOUNT (excl. GST)				**285,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects

Appendix 6. Flood box assessment for a tide regulated gate at McLean Creek floodbox.

Technical Memorandum - DRAFT

DATE: March 31, 2009

TO: Marc Gaboury, R.P.Bio., LGL Ltd.

FROM: Craig Sutherland, P.Eng. and Laurel Morgan, P.Eng., P.E.

RE: **FLOODBOX ASSESSMENTS FOR TIDE REGULATED GATE**
McLean Creek Floodbox
2211.014

INTRODUCTION

Kerr Wood Leidal (KWL) was requested to review potential project sites for suitability and feasibility of construction to install tide-regulated side-mounted flapgates on existing floodboxes for the purpose of improving fish access through floodboxes. This work was performed at the direction of LGL, for the benefit of the Fraser Salmon Watersheds Program. Each potential site was reviewed independently based on several factors to assess value and appropriateness of a tide-regulated gate.

KWL has developed a preliminary assessment of each site, include the issues and constraints for installation of a tide-regulated gate, as well as estimate cost of the gate and installation.

BACKGROUND REVIEW

Background information for each potential site was review prior to field assessment. Information for the McLean Creek site was somewhat limited.

The floodbox at the outlet of McLean Creek in Coquitlam was originally constructed and maintained by the Coquitlam Dyking District. The Coquitlam Dyking District has since been disbanded and taken over by the Ministry of Environment, Inspector of Dykes office which currently maintains this system. No documentation or As-built drawings were provided by the Inspector of Dykes office, but confirmation of the size and type of floodbox and outlets, and invert elevation of the outlet, was provided over the phone by Mr. Mike Bristol at the Inspector of Dykes office. A survey drawing provided by Mr. Dana Soong at the City of Coquitlam shows the location and top-of-concrete elevations for the floodbox headwalls at the inlet and outlet.

PROPOSED FLOOD GATE REPLACEMENT

There are indications that the existing side-mounted flood gates are hindering access for fish to side-channels and sloughs located on the land-side of flood protection works. Although some of the gates are side mounted, which are typically better than top-mounted gates, they still prevent fish access for the majority of the time. The two most significant barriers are high velocities through the gates and the culverts as well as gates closing too often and cutting off access. These gates use head differential between the upstream and downstream water levels to operate the gates. As such, they typically close when ever downstream water levels are higher than upstream water levels so gates are typically closed on rising tides.

There are several new flood gate designs now available which can improve fish access as well as tidal flushing in the cut-off back channels and sloughs. These gates remain open during low and medium tide levels or river levels and only close during high water levels to prevent flooding. They typically use absolute water levels on either the upstream or downstream side to trigger the gate to close. There are many different designs but they typically have three types of control mechanisms, mechanical, hydraulic or electrical.

The simplest of these is the mechanical types of gates which function using systems of floats and levers. Usually, they use two sets of floats, one set keeps the gate open while the other set is used to close the gate when water levels reach a the trigger water level. Although these gates use simple floats and levers to operate, they have been known to jam open with debris. A system to control debris at the gate is required for these types of gates. They also usually require large headwalls and significant space to allow the float and lever mechanisms to work properly.

The second type of gate uses a hydraulic piston to control the gate. These are sometimes controlled using hydraulic pumps. However, there are also some designs which use passive hydraulic systems which do not require any external power source. These passive systems use out-flowing tide to open the gate which is then locked open with a hydraulic piston. The piston is prevented from closing by a check valve installed in the hydraulic system. To close the gate, the check valve is released using a float switch mounted in a stilling well. Although these gates use more sophisticated technology, they tend to be lower maintenance than the purely mechanical systems. The trigger mechanisms are well protected and there is less likelihood of blockage caused by debris. In addition, in an emergency the gates can be closed manually by triggering the check valve. This valve can be located in an easily accessible kiosk. Although less likely to be jammed by debris, trash racks are recommended for these gates as well.

The final type of gate also uses hydraulic pistons to control the gate. However, they use electronic control systems to operate. Using these systems, the gates can be controlled to open and close based on a variety of variables such as date or time, upstream or downstream water levels, rainfall amounts or other variables. This requires electronic control and monitoring systems so will need external power. These are typically only used for specific purposes.

For the purposes of this initial review, we have assumed that the existing gates will be replaced with the hydraulic-type gates using the passive system. These gates are also known as tide-regulated side mounted gates. However, further detailed investigation may result in changing the type of gate to suit specific needs at the crossings.

FIELD SITE VISITS

Each site was reviewed in the field at low tide for several factors including:

- Verification of number, size, and type of existing gates
- Fish accessibility downstream of gates
- Presence of additional fish barriers upstream of floodboxes
- Construction access or constructability issues

McLean Creek in Coquitlam was visited approximately 2 hours after low tide in the afternoon of 25 March, 2009. Photos were taken of the site, some of which are included for reference, below.

MCLEAN CREEK, COQUITLAM, BC

McLean Creek drains toward the south through a constructed reservoir in Minnekhada Regional Park in Coquitlam and then through agricultural land to the Pitt River. The floodbox and pump station at the Pitt River were part of the Coquitlam Dyking District unit that district was taken over by the Ministry of Environment's Inspector of Dykes office, which now controls and maintains the dyke and the floodbox. The information available for this site is minimal. The City of Coquitlam has a survey from 2005 showing the top of concrete elevations for the floodbox headwalls. The Inspector of Dykes office has no drawings but some information on the floodbox including:

- The floodbox consists of four 1,830 mm (72-inch) diameter circular pipe sections with top-mounted round flap gates at the outlet, installed in 1984;
- The invert at the downstream end is -0.8 m GSC;
- Field measurement of the flap gates was recorded as 2.2 m diameter;
- The Inspector of Dykes would be required to approve any plan to alter or change the floodbox in any way; and
- The owners of the agricultural land behind the dyke consider the creek to be part of their irrigation system and would likely see no value in any improvements for the purpose of fish passage.

The site visit confirmed the configuration and approximate size of the floodbox outlets. At a couple of hours after low tide the flaps were observed to be nearly half submerged, with a strong tidal current flowing upstream through the floodbox.

Access to the site is along the top of the dyke from Oliver Road. There is farm gate that could close off access but it was wide open at the time of the site visit and a discussion with a local farm worker indicated that many people regularly access the dyke crest via that route.

SITE OBSERVATIONS RELATIVE TO CONSTRUCTION OF A TIDE-REGULATED FLAP GATE

There are few issues and constraints for an installation of a tide-regulated gate for the benefit of fish passage at this site.

- Access to the site is through a gate controlled by others. This should not be a significant problem, but should be coordinated as needed for access to the dyke.
- The dyke crest is used extensively by the local residents for recreation and travel including walking, bicycling, motorbikes and vehicle use. Care must be taken to ensure that the public are kept safely away from working equipment.
- There is currently no trash rack to protect flap gates from debris on the River, although existing steel rails are mounted between each of the flap gates and on the wing walls on either side of the headwall. These likely could be used to support a trash rack.

CONSTRUCTION ITEMS FOR INSTALLATION OF A TIDE-REGULATED FLOOD GATE

In order to install a tide-regulated gate at this site, the floodbox would not require upgrades. Installation should be straightforward. The full work would be comprised of:

- Removal of one panel of chain-link fence from the top of the headwall;
- Removal of one existing flap gate – likely the gate on the northeast side;
- Install one tide-regulated side-mounted flap gate;
- Install trash rack across headwall between wing walls; and
- Re-install panel of fence above headwall.

COST ESTIMATE

A cost estimate for the noted works is shown in Table 1. The ‘Class D’ cost estimate is based on the limited site information available and is considered to estimate the magnitude of the construction costs for planning purposes.

REGULATIONS AND PERMITTING

As part of the planning process for installing gates, approval from several agencies will be required prior to installation. This includes the local authority (Municipality or Regional

District), the Provincial Inspector of Dykes office, the Provincial Ministry of Environment and the Federal Department of Fisheries and Oceans.

Local Authority

The local authority has jurisdiction and responsibility for drainage within their region. As the flood gates are part of the drainage system, approval from the local authority will be required. The local authority will also take on future responsibility for operation and maintenance of the gates. Therefore, they will play a critical role in the selection of gate types and preferred designs. The municipality will require copies of the preliminary design drawings so that both their engineering and operations departments may review. They may also require an assessment of the impact to the drainage system as a result of changing the gate type. After construction, they will require record drawings as well as operation and maintenance manuals for the new gates.

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The Ministry of Environment is responsible for protection of surface water as regulated in the Water Act. Section 9 of the Water Act requires that a person may only make "changes in and about a stream" under an Approval. It is likely that only a notification will be required for replacement of the tide gates. However, any additional works such as construction of headwalls or replacement of flood boxes will require full approval.

Both the notification and approval processes involve submission of a "Works in and about a stream" application package which includes the application form, a copy of the design drawings and an application fee. During review of the application it may be determined that an approval is required, in which case additional information such as habitat impact assessment and other information may be required. During the review process, the application package is also forwarded to the local Department of Fisheries and Oceans Regulatory Biologist for review.

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Section 35(1) of the Federal Fisheries Act prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat. The only relief from this general prohibition is when a Subsection 35(2) Authorization is issued for HADD. It is unlikely that replacement of the tide gates will trigger the requirement for Authorization. However, it is prudent to receive a Letter of Advice from the local Regulatory Biologist which confirms that the proposed works are not considered to be a HADD and outline any required mitigative measures. This process usually involves meeting with the Regulatory Biologist on-site to review proposed works and address any concerns they may have.

The recommended approach for permitting would be to receive approval in principle from both the local authority and the IOD office prior to sending Section 9 Notification to MoE and discussing the project with DFO. The permitting process should be commenced at least four weeks prior to construction to allow sufficient time for review by all the agencies.

PHOTOS OF SITE

Photo 1: Mclean Creek Floodbox – Outlet headwall with four flap gates

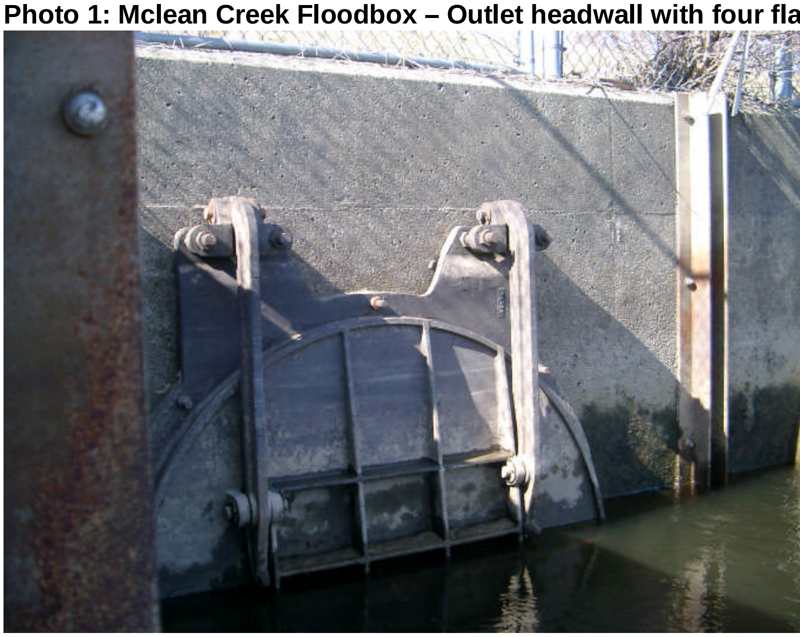

Photo 2: McLean Creek Floodbox – close-up view of flap gate

TABLE 1 - Class 'D' Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comment
1	**General**					
1.1	Mobilization, Bonding and Insurance	each	1	14,400	14,400	
1.2	Site Preparation	each	1	2,500	2,500	
1.3	De-watering	days	2.5	3,000	7,500	deep water at low tide
2	**Site Work**					
2.1	Remove and replace panel chain-link fence above headwall	each	1	1,500	1,500	
3	**Drainage Works**					
3.1	Remove existing top mounted flap gate	each	1	1,500	1,500	remove one existing flap gate
3.2	Tide-regulated flap gate (supply and install)	each	1	120,000	120,000	74-inch stainless steel square gate, Golden Harvest or approved equal
3.3	Trash Rack (supply and install)	each	1	39,000	39,000	approximately 39 m^2 of grating
4	**Restoration**					
4.1	re-vegetation of disturbed areas	lump sum	1	3,000	3,000	hand restore and revegetate disturbed ground
	SUBTOTAL				**189,400**	
	Engineering, Permitting, Environmental Monitoring & Construction Management	20%			37,880	
	Contingencies	25%			47,350	
	TOTAL AMOUNT (excl. GST)				**275,000**	

Note: Estimates have been prepared with little or no site information and as such indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects