EA 1623

MISSION CREEK HABITAT RESTORATION: DETAILED FEASIBLITY STUDIES

***Prepared for*:**

Ministry of Water, Land and Air Protection
Unit 201 - 3547 Skaha Lake Rd.
Penticton, BC
V2A 7K2

March 2004

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1 INTRODUCTION

Restoration of Mission Creek is one of the major components in a multi-faceted plan to restore depressed kokanee and rainbow trout stocks and recover a viable sports fishery in Okanagan Lake. The rationale for undertaking restoration work in Mission Creek is based on its relative contribution to Okanagan Lake fish production. The urgency of implementing restorative measures on the spawning and rearing habitats of kokanee and rainbow trout is due to the continuing declines in Okanagan Lake wild fish stocks over the past 30 years.

The overarching goal for restoration of Mission Creek is to restore those channel and corridor characteristics that will maximize fish habitat and aquatic ecosystem benefits. Achievement of both the restoration goal and the vision of the creek under a restored condition are comprised of a strategic and orderly sequence of changes to the physical characteristics of the existing stream corridor.

This project follows from discussions held on 14 May 2003 with Central Okanagan Regional District (CORD), The City of Kelowna, and Friends of Mission Creek representatives on the restoration options presented in the report 'Mission Creek Habitat Restoration Feasibility' by Gaboury and Slaney (2003). The outcome of the discussions was a recommendation to undertake detailed feasibility studies on three priority areas: a) setting back dykes immediately upstream of the Casorso bridge crossing, b) sediment trap installation near Hollywood Road, and c) setback dyke and meandering channel construction within the Benvoulin Woods area. The objectives for this project were to:

1. Conduct topographic surveys and prepare detailed restoration designs, as preliminary construction drawings, for two priority sites identified in Gaboury and Slaney (2003). The restoration designs pertain to sediment traps near Hollywood Road, and setting back dykes in the vicinity of the Casorso Road bridge crossing.
2. Conduct detailed topographic surveys and prepare plan and cross section view drawings of the Benvoulin Woods area. The drawings will be used as a basis for the presentation of restoration designs for setting back dykes, and reconstructing meanders and floodplains in the Benvoulin Woods area.
3. Conduct site assessments and contact appropriate individuals from the City of Kelowna, CORD, landowners and stakeholders to discuss the three restoration projects. Document and incorporate the input and recommendations from these individuals into a detailed implementation plan.
4. Estimate the costs to purchase the required land and construct the restoration works.

This project was funded by the Ministry of Water, Land and Air Protection's (MWLAP) Habitat Conservation Trust Fund and managed by the British Columbia Conservation Foundation (BCCF).

2 SITE EVALUATIONS

2.1 Setback Dykes

An important step for setting back dykes along Mission Creek was to achieve consensus among government representatives and stakeholders for the conceptual plan and scheduling of the projects. As such, discussions were held with representatives from CORD, City of Kelowna, Friends of Mission Creek Society, MWLAP and other relevant stakeholders relating to setting back the dykes along Mission Creek (Map 1).

It was suggested that construction of the setback dykes should generally proceed from the downstream to upstream sections in Mission Creek, but be strategically scheduled and coordinated with proposed construction of other infrastructure on the creek. Also, setback dyke sections where significant improvements in fish habitat may potentially occur and with lower land purchase costs would be prioritized higher. A prioritized order for construction of the setback dyke sections downstream of KLO Road was developed as follows:

1. Construction of a 730 m section of setback dyke on the northwest bank of Mission Creek and upstream of Casorso Road (on or affecting properties identified as: Westbank First Nation, PID 008-504-130 and PID 024-008-164),
2. Construction of a 680 m section of setback dyke on the northwest bank, downstream of Casorso Road (on or affecting properties identified as: Westbank First Nation and dedicated road allowances),
3. Construction of a 1020 m section of setback dyke on the southeast bank, downstream of Casorso Road (on or affecting properties identified as: Westbank First Nation, PID 011-099-895 and PID 014-767-538),
4. Construction of 190 and 530 m sections of setback dyke on the northwest and southeast banks, respectively, upstream of Casorso Road (on or affecting properties identified as: PID 024-008-184, PID 009-417-770 and dedicated road allowances), and
5. Construction of a 420 m section of setback dyke on the northwest bank, downstream of KLO Road (on or affecting properties identified as: dedicated road allowances).

The 730 m section of setback dyke immediately upstream of Casorso Road was determined to have the highest priority for construction because:

- There was significant logistical and financial benefits associated with coordinating setback dyke construction with the planning and construction of a new Casorso Road bridge by the City of Kelowna,
- This section of channel is highly utilized by kokanee for spawning and, in comparison to the other proposed setback dyke sections, offers a wider setback distance that would result in greater benefits to native fish species habitats, and

- There was a strong willingness by the City of Kelowna, affected landowners and community organizations to cooperate with the setback dyke project in this section of channel.

The conceptual design of the setback dyke alignment upstream of Casorso Road was examined through an onsite meeting with Mark Watt (City of Kelowna), Sandra Mah and Bill Voss (CORD), Stu Mould (Friends of Mission Creek), and Andrew Wilson (MWLAP) on 23 September 2003. During the onsite meeting, response from the representatives on the proposed setback project was favourable. There was general agreement and a mutual understanding from the onsite meeting that:

- The setback dyke project had merit, with anticipated hydrological, fisheries, wildlife and aesthetic benefits,
- There was an opportunity for scheduling construction of setback dykes near Casorso Road with the City of Kelowna's bridge construction, and
- There was an opportunity for cost-sharing of setback dyke construction with the City of Kelowna, as compensation for the Casorso bridge replacement footprint impact on fish habitat.

Several important concerns were raised, however, that needed to be incorporated into the preliminary design or coordinated to coincide with ongoing or planned activities by the City of Kelowna, CORD, and Friends of Mission Creek. The concerns included:

- Coordinating the survey and design process of the setback dykes so that preliminary design drawings of the setback dyke project could be reviewed and incorporated, in a timely manner, into the planning for Casorso Road bridge replacement by the City of Kelowna,
- Willingness of private landowners to sell, lease or donate the land necessary for the setback dykes,
- Identifying the funding source(s) for purchasing the private lands,
- Incorporating the Mission Creek Greenway trail into the setback dyke design, ensuring there is an appropriate top width for the dyke to accommodate the trail, and ensuring the cost estimates include preparation and surfacing of the dyke for trail use, and
- Considering access to and possible re-location or re-design of the viewing platform under a setback dyke project.

All of the concerns identified above were considered during the evaluation and design stages. Preliminary designs for the 730 m section of setback dyke upstream of Casorso Road were sent on 22 March 2004 to M. Watt (City of Kelowna) for review. Following the City's review of the preliminary plans, discussions on co-funding for the setback dyke construction and scheduling of bridge and dyke construction are anticipated between City and MWLAP representatives.

The impact of setting back dykes on the Mission Creek Greenway viewing platform was also assessed and options were discussed with the City of Kelowna and Friends of Mission Creek to ensure that any potential access or visual impacts caused by dyke

setback were mitigated. The discussion that follows concentrates on the land status, design and construction issues associated with the highest priority setback dyke section identified above.

2.1.1 Land Status

For all proposed setback dyke areas in the Mission Creek restoration plan, there are 11 lots in private ownership and five lots owned by the Crown, as shown in Map 1 and Table 1. Generally, all private land parcels affected by the proposed project are zoned AG (agriculture).

For the highest priority setback dyke section immediately upstream of Casorso Road, there are two affected lots in private ownership, another owned by Westbank First Nations, and a road right-of-way owned by the City of Kelowna. Portions of each lot would be required for the setback dyke restoration project, for a total private land area of 2.63 ha. The setback dyke upstream of Casorso Road would be constructed on a City of Kelowna dedicated road allowance and on private land. Channel reconstruction inside of the setback dyke would affect Westbank First Nation property as well as private land. Harald Hall (Friends of Mission Creek) made initial contact with one of the landowners affected by the setback dyke project. Generally, the landowner was receptive to selling the portion of property required for the project. A decision on the potential purchaser(s) of the land parcel is tied to the decision on cost-sharing of setback dyke construction between the City of Kelowna and MWLAP. The decision will relate to City of Kelowna compensation for the Casorso bridge replacement footprint impact on fish habitat and a desire to secure this property, in perpetuity, for the Greenway trail. Currently, the private property is under lease to the City for the Greenway trail. Further discussions with the private landowners and Westbank First Nation are anticipated after a decision on co-funding is reached between the City and MWLAP.

Table 1. Area of each private and Crown land parcel required for setback dyke construction in Mission Creek. Dedicated road allowances are not included.

Bank of River	Ownership	Cross Sections	Plan Number (PID#)	Total Lot Area (ha)	Area of Lot Required for Setback Dyke Construction (ha)	% Within Setback Area
Southeast	Private	13 to 16	011-099-895	6.77	1.36	20%
Northwest	Private[1]	22 to 26	008-504-130	18.07	2.50	14%
Northwest	Private[1]	26	024-008-168	4.54	0.13	3%
Southeast	Private	30 to 31	009-417-770	7.23	0.37	5%
Northwest	Private[2]	39A to 42	001-714-791	13.37	4.08	31%
Northwest	Private[2]	41 to 42	001-714-783	10.21	0.61	6%
Southeast & Northwest	Private[2]	41A	011-074-132	2.42	0.63	26%
Northwest	Private	42	011-074-281	1.95	0.26	13%
Southeast & Northwest	Private	43	007-938-675	2.43	0.81	33%
Southeast & Northwest	Private	43 to 46	011-074-311	12.19	3.12	26%
Southeast & Northwest	Private	47 to 50	003-979-440	7.04	1.75	25%
Southeast	Crown / Other	9 to 13	014-767-538	12.50	0.99	8%
Northwest	Crown / Other[1]	22	Westbank FN	2.03	0.13	6%
Southeast & Northwest	Crown / Other	16 to 20	Westbank FN	2.03	0.62	31%
Northwest	Crown / Other	41	024-208-124	0.89	0.89	100%
Southeast & Northwest	Crown / Other	46 to 47	017-816-874	22.61	2.06	9%
Northwest	Crown / Other	27 to 28	024-008-184	1.33	0.55	41%
Private Lands[1] - Highest Priority Setback Dyke Site, Immediately Upstream of Casorso Road						
Private Lands[2] - Benvoulin Woods Area						

2.2 Sediment Traps

The conceptual design of the sediment traps proposed in Gaboury and Slaney (2003) was examined through an onsite meeting with Sandra Mah and Bill Voss (CORD), Stu Mould (Friends of Mission Creek), and Andrew Wilson (MWLAP) on 23 September 2003. The proposed site for the sediment traps is located in a deeply incised section of the creek near Hollywood Road, with private property on the right bank and CORD property on the left bank (Map 1). During the onsite meeting, response from the representatives on the proposed sediment trap project was favourable. There was general agreement and a mutual understanding from the onsite meeting that:

- The sediment trap project had merit, with anticipated hydrological, fisheries, wildlife and aesthetic benefits, particularly for improvements to downstream areas where the sediments currently accumulate,
- Construction of the sediment traps within an incised reach of the creek near Hollywood Road was an ideal site as it will result in no additional flood risk to the adjacent private properties on the right bank or CORD property on the left bank, and
- There was potential for long term maintenance of the sediment traps by recouping the cost of gravel disposal through the potential value of the gravel for road or other construction purposes.

No significant concerns have been identified with this proposed project. Sandra Mah (CORD) and Mark Watt (City of Kelowna) have been contacted to determine their agencies' interest in extracting the sand, gravel and cobbles that will accumulate in the sediment traps. Limited interest on this issue has been shown from the agencies to date. As occurs presently, removal of the accumulated sediments in the creek is undertaken by the Province of British Columbia. This responsibility could continue for the sediment traps. Maintenance of the sediment traps will be important to determine prior to their construction. The potential partnerships for funding this project have not been identified to date.

2.2.1 Land Status

There appears to be no private lands affected by this project and, therefore, no acquisition required. However, during the topographic surveys it was noted that the northerly boundary of Lot 13, Plan 187, appeared to run close to the upper sediment trap. Legal plan 1249 for this area is a very old plan (1904), and because the creek has moved around since 1904, no iron pins marking the corners were found. It is recommended that the survey corners be re-established by a land surveyor before any construction work is undertaken. After the sediment traps are constructed, access to the traps during excavation and disposal of the accumulated gravels would be from existing roads and temporary trails within the river corridor.

2.3 Benvoulin Woods Meander Channel

Restoration work in the Benvoulin Woods area would follow an orderly sequence that includes: 1) setting back the dykes, 2) lowering the elevation of the existing dyke and streambank to create a floodplain that is regularly inundated (i.e., equal to or greater than a 3 year flood), 3) constructing a meandering channel with pools and riffles, and 4) establishing vegetation on the re-constructed banks and floodplain. Meandering will diversify the channel in plan and profile and provide heterogeneous and desirable habitat characteristics, such as areas of shallow riffles and deep pools, discrete micro- and macro-habitats where silt, sand, gravel, cobbles and boulders have been sorted, increased instream cover, local velocity and depth diversity, and reduced instream sedimentation and embeddedness. A meandering channel with pools, riffles and an extensive riparian area will maximize the benefits to all native fish species within Mission Creek, with particular improvement of spawning and/or rearing habitats for kokanee and rainbow trout.

The conceptual design for a setback dyke and meandering channel in the Benvoulin Woods area, as proposed in Gaboury and Slaney (2003), was examined through an onsite meeting with Sandra Mah and Bill Voss (CORD), Stu Mould (Friends of Mission Creek), and Andrew Wilson (MWLAP) on 23 September 2003. During the onsite meeting, response from the representatives on the proposed project was favourable. There was general agreement and a mutual understanding from the onsite meeting that the Benvoulin Woods project had merit, with anticipated hydrological, fisheries, wildlife and aesthetic benefits.

Several important concerns were raised, however, that need to be considered in the future during the preparation of a detailed design. The concerns included:

- Ensuring the proposed works do not negatively impact the health or abundance of the existing wildlife and black cottonwood stands,
- Willingness of private landowners to sell, lease or donate the land necessary for the new meandering channel and setback dyke,
- Identifying the funding source(s) for purchasing the private lands, and
- Incorporating the Mission Creek Greenway trail into the setback dyke design, ensuring there is an appropriate top width for the dyke to accommodate the trail, and ensuring the cost estimates include preparation and surfacing of the dyke for trail use.

To address the concerns, ground surveys were conducted by fisheries and wildlife biologists in the Benvoulin Woods area to assess existing habitat conditions, to assess the impact of setback dykes and meandering channel construction, and to recommend alternative protection, restoration or mitigation options that would ensure equitable benefits to all resources. Also, the City of Kelowna, CORD, Friends of Mission Creek Society, Central Okanagan Parks and Wildlife Trust (COPWT), affected landowners, MWLAP and other stakeholders were consulted.

Sandra Mah (CORD) made initial contact with a representative of the Central Okanagan Parks and Wildlife Trust, the title holder for a significant portion of the Benvoulin Woods area (PID 024-208-124). Similar to comments received from Friends of Mission Creek Society, the COPWT had concerns regarding the location of the meander channel, the proposed dyke setback, and effects the new channel and dyke alignments would have on the property and nesting herons.

After discussions with the Friends of Mission Creek and COPWT and completion of our biological site assessments, a modified channel and setback dyke conceptual design was proposed that would minimize the impacts on wildlife and black cottonwood stands in the Benvoulin Woods area (Map 1). The revised meander channel design addresses the concerns expressed by Friends of Mission Creek and COPWT and includes a re-alignment of the meandering channel and removal of the lower meander from the original restoration design. Based on the revised design, discussions with affected landowners were pursued. Harald Hall (Friends of Mission Creek) made initial contact with one of the landowners affected by the project. Generally, the landowner was receptive to selling the portion of property required for the project. The landowner hopes to re-zone the properties in the future from ALR to high density, multi-family and commercial zoning. As part of re-zoning approval, the landowner would allocate the necessary land required for the Benvoulin Woods restoration project to the City of Kelowna (or other legal entity) as part of the required public space or park dedication for the re-zoned developable land. However, the decision on re-zoning of the land parcels (PIDs 001-714-791, 001-714-783) lies with the Agricultural Land Commission and the City of Kelowna.

Other landowners whose properties are affected by the project have not been contacted. Litigation concerning ownership issues (i.e., PID 011-074-132) is currently being resolved in the courts and our discussions have been delayed until after resolution. Also, further discussions with the private landowners are anticipated after funding sources for land purchase have been secured.

2.3.1 Land Status

For the Benvoulin Woods area project, there are three affected lots in private ownership and one owned by Central Okanagan Parks and Wildlife Trust (Table 1). The private land parcels affected by the proposed project are zoned AG (agriculture). Portions of each lot would be required for the setback dyke and Benvoulin Woods meander restoration projects, for a total private land area of 5.32 ha.

2.3.2 Wildlife Assessment

An assessment of the Benvoulin Woods area adjacent to Mission Creek in Kelowna, British Columbia was conducted in support of a project with the objective to re-introduce a meandering channel with functional pools, riffles and floodplain into Mission Creek. Benvoulin Woods is of particular interest due to the presence of a large stand of black cottonwood (*Populus balsamifera ssp. trichocarpa*), which represents a rare ecosystem in the Okanagan. The area also has high wildlife values for birds, small mammals, large mammals, and possibly for reptiles and amphibians.

The objectives of this site visit were to:

1. Identify current wildlife use by mammals, birds, amphibians and reptiles,
2. Discuss the potential impacts of channel restoration on wildlife in Benvoulin Woods, and
3. Provide mitigation measures for the proposed channel restoration project to ensure that wildlife and habitat values remain high post-restoration.

The following is a summary of the results and recommendations from the wildlife assessment conducted on 24 September 2003. The complete report is reproduced in Appendix A.

Because there are significant differences regarding wildlife use of the woods, it was practical to delineate two distinct portions of the woods: the north and the south. The south woods are delineated by KLO Road to the south and the 4.5 km marker of the Greenway to the north. The north woods extend north from the 4.5 km marker to approximately 5.2 km on the Greenway trail.

Bird species identified in the south woods included: sandhill cranes *(Grus canadensis)*, great blue herons (*Ardea herodias),* northern flickers (*Colaptes auratus*), pileated woodpeckers *(Dryocopus pileatus)*, and numerous species of songbirds. Great blue herons roost in some of the larger black cottonwood and they may collect nesting materials from Benvoulin Woods. It is likely that the bird diversity is high; however, the timing of the survey did not permit the development of a comprehensive species list.

Large black cottonwood trees, some over 100 years of age, were numerous in the south woods. The trees would be used by many species of birds and several of them had large cavities excavated at their bases, indicating use by large mammals.

Other wildlife species inhabitants included: beaver (*Castor canadensis*), mink (*Mustela vison*), white-tailed deer (*Odocoileus hemionus*), and raccoon (*Procyon ater*). The south woods may also provide important breeding habitat for pond-breeding amphibians, such as the Tiger Salamander (*Ambystoma tigrinum*), as there exists marsh and pond habitats with submergent and emergent vegetation, both of which are important for pond-breeding amphibians. The Tiger Salamander is currently Red-listed in British Columbia and listed as Endangered by COSEWIC. It is not known if Tiger Salamanders breed or occur in Benvoulin Woods.

The north woods were more open than the south woods, providing suitable flyways for owl species (e.g., long-eared owl *(Asio otus)*, great horned owl *(Bubo virginianus)*) and possibly bats. The presence of large cottonwood trees with cavities approximately ¾ of the way up the tree provides suitable roosting / nesting opportunities for owls. Wildlife species identified in the north woods included: black bears (*Ursus americanus*), white-tailed deer, and coyote (*Canis latrans*).

The proposed re-meandering of Mission Creek through Benvoulin Woods will undoubtedly impact the terrestrial wildlife habitat of Benvoulin Woods. However, the temporal effects will likely be short-lived, as the addition of a waterway through the woods would likely enhance the habitat for terrestrial wildlife and birds through the development of riparian habitat. The following items list the potential impacts and some possible mitigation measures that could be used to minimize or remove those impacts.

1. Impact: Disturbance of the South Woods, particularly nesting sandhill cranes

Mitigation: Avoid routing the meander of Mission Creek through the south woods area and avoid construction during the sandhill crane nesting season. Nesting usually begins in early to mid-May. Cranes normally lay two eggs, which hatch in approximately 30 days, or early-mid-June. Fledging occurs 2 to 2½ months after hatching, usually sometime in August. It is recommended that an environmental monitor be on hand to observe sandhill crane activity prior to construction and during the construction phase.

2. Impact: Loss of nesting habitat for primary and secondary cavity nesters.

Mitigation: Avoid the unnecessary removal of live trees or snags that contain cavities. When snags or live trees are removed for channel construction, leave the downed trees on the banks of the new channel to provide feeding habitat for woodpeckers and coarse woody debris (CWD) for small mammals, reptiles, amphibians, and terrestrial molluscs.

3. Impact: Loss of terrestrial habitat due to channel construction.

Mitigation: There will be a reduction in total useable land area for terrestrial wildlife. However, the addition of a watered creek channel through the woods will likely increase the volume and diversity of riparian-associated vegetation along the banks of the creek. This habitat will have the potential of becoming more valuable to terrestrial wildlife than the habitat that currently exists in Benvoulin Woods. Enhancement will be related to deciduous browse for deer, and an increase in riparian-associated vegetation which can

provide important nesting habitats for songbirds, as well as escape and security habitat for small mammals.

Mitigation: The historical channel of Mission Creek is still visible in Benvoulin Woods. It would be advantageous to use the footprint of the existing creek bed in the woods as the guideline for the development of a new channel. This would focus the construction activities of the new channel in a specific area and will likely reduce the impact of construction on the surrounding terrestrial habitats.

4. Impact: Disruption of pond-breeding amphibian habitat

Mitigation: The timing of the site visit (September) did not enable an accurate assessment of amphibian species using Benvoulin Woods. To ensure that pond-breeding amphibians are not affected by this project, any habitat-altering activities that would specifically affect the ponds and wetland habitats should be avoided during spring. This is also addressed in point 1 above.

Mitigation: Additional breeding habitat will likely be associated with the meander through Benvoulin woods, especially in quiescent backwaters. Areas of pooling and slow moving water can be created through the addition of CWD.

In general, it is anticipated that the impacts to wildlife and wildlife habitat in Benvoulin Woods will be minimal to none. In fact, in landscapes that are water-limited, the addition of water often enhances the quality of habitat for terrestrial and semi-aquatic organisms. The addition of water to Benvoulin Woods by way of a meander of Mission Creek will likely increase wildlife values through increases in the density and species composition of riparian-associated vegetation, and increases in vegetated cover. To minimize the spatial scale over which impacts are realized, it will be important to consider using construction methods that constrain construction activities to as small a footprint as is practical. Furthermore, where tree removal is required, retention of the woody material should be considered as suitable for use as instream large organic debris (LOD) or stream-side CWD.

Where possible it would be desirable to avoid the removal of larger black-cottonwood trees, as these trees represent the oldest of the trees in Benvoulin Woods and are important habitat features, functioning as wildlife trees. To avoid disturbance to sandhill cranes and/or great blue herons, construction activities should avoid the south woods entirely and construction activities should not occur during the nesting / fledging period. Finally, it is recommended that an environmental monitor be on hand during construction activities to note any effects of the construction process on wildlife. While it is understood that this type of project cannot proceed without a significant impact to the terrestrial habitat and wildlife, it will be important to note any major adverse impacts on wildlife during the construction period. Additionally, it is anticipated that the temporal impacts will be relatively short-lived and the spatial impacts will be minimized by an overall increase in habitat value for wildlife, which will be realized post-construction.

3 RESTORATION DESIGNS

3.1 Setback Dykes

Preliminary restoration designs for setback dykes were prepared for a 730 m section on the right bank of Mission Creek upstream of Casorso Road (Appendix B). A new floodplain will be contoured on the right bank by removing the existing dyke. The floodplain will be constructed at an elevation 1.2 m above the channel bottom. The new floodplain elevation would allow for overtopping of the central channel banks when flows are greater than a three year flood. Low elevation flow retard bars will be constructed on the new floodplain to deflect flood flows towards the existing mainstem and reduce soil erosion while vegetation is becoming established. The re-established floodplain and riparian zone will be revegetated with a diversity of native grasses, shrubs and trees.

The setback dyke would adhere to the Provincial standard dyke design and have top widths of 4 m, a 2:1 side slope for the dyke on the side closest to the creek, and similar top elevations as the existing dykes. The dykes would be constructed using spoil from construction of the floodplain and removal of the existing dykes.

In the preliminary design, the viewing platform will remain as is in its present location and would function as an island in >3 yr floods. Access to the platform during <3 yr floods would not be impeded as floodwaters would remain within the existing channel banks. If desired, access during floods up to a 200 yr recurrence interval could be possible through the construction of a raised (1 m high) boardwalk about 21 m long.

The potential effects of setback dykes on water levels and stream velocities were modeled using the HEC-RAS computer program (Appendix D). According to the modeling results, setback dyke construction does not result in a significant change in the hydrology of the river, and the current Casorso bridge crossing remains as the main cause of backwatering effects during floods in this section of river.

3.2 Sediment Traps

Preliminary restoration designs were prepared for sedimentation basins near Hollywood Road (Appendix B). The potential effects of the constructed sedimentation basins on water levels were calculated manually. Based on these calculations, it was determined that construction of the instream structures will not result in an impact to the surrounding private or CORD properties. This reach of Mission Creek is deeply incised with the streambed between 3 and 4 m below the streambanks. As shown on the cross sections of the preliminary restoration drawings (see drawing MWLAP 123), the 200 yr flood would be contained within the channel.

The material collected by the sediment traps will vary considerably in size and volume depending on the magnitude of the stream flows and bed load. The design is based on trapping the material that presently gets deposited between the ECCO Centre and Casorso Road. The dykes along this section of channel give a good indication of the size of material that would be trapped as the dykes are built from gravel deposited in the

creek. From observations of this material, the size varies from 100 mm to fine sands. The sediment traps will collect about 5000 m^3 of material before they need to be cleaned out.

3.3 Benvoulin Woods Meander Channel

Detailed topographic surveys were conducted in the Benvoulin Woods area, and plan and cross section view drawings were prepared (Appendix C). Based on the output of discussions and the assessment of the area by wildlife and fish biologists, a revised conceptual design plan that best meets all parties' requirements and expectations was identified (Map 1). Preliminary design drawings were not prepared under this project, but should be completed under the proposed implementation plan schedule described below.

4 IMPLEMENTATION PLAN

4.1 Setback Dykes

The implementation steps leading up to setback dyke construction immediately upstream of Casorso Road are summarized in Table 2. Implementation activities that include negotiation, notification, approvals and preparation of the final construction drawings will be led primarily by MWLAP, with support from engineering and biological consultants. A potential implementation schedule with estimated cost for each action has been included. Excluding land purchases, the costs for these implementation actions are estimated at $18,500.

Values for the land within the proposed setback dyke project area vary considerably based upon the productive capacity of the land. The land within the proposed setback dyke zone is currently non-productive farmland. The market value of these acreages is considered to be similar to recent (2003) land purchases along the river, ranging from about $35,000 to $50,000 Canadian per acre. A value of $100,000 per ha ($40,000 per acre) was used as the unit land purchase cost in the calculations.

The costs to purchase the necessary private land parcels is estimated at $263,000 (Table 3) provided the riparian zones can be subdivided from existing properties. Cost to construct the setback dykes from Casorso Road bridge to just upstream of cross section 26 is estimated at $350,000 (Table 4). Engineering and supervision were estimated at about 15% of the construction costs and construction management and administration at about 10%.

4.2 Sediment Traps

The implementation steps leading up to sediment trap construction near Hollywood Road are summarized in Table 5. Implementation activities that include notification, approvals and preparation of the construction drawings will be undertaken primarily by MWLAP, in conjunction with engineering and biological consultants. A potential

implementation schedule with estimated cost for each action has been included. The costs for these implementation actions are estimated at $13,000.

Cost to construct the sediment traps near Hollywod Road is estimated at $160,000 (Table 6). Engineering and supervision were estimated at about 15% of the construction costs and construction management and administration at about 10%.

4.3 Benvoulin Woods Meander Channel

The implementation steps leading up to setback dyke and meandering channel construction in the Benvoulin Woods area are summarized in Table 7. Implementation activities that include assessments, negotiation, notification, hydraulic analyses, and preparation of a preliminary restoration design and construction drawings will be led by MWLAP, with support from engineering and biological consultants. An additional spring field assessment to identify bird and amphibian species and their distribution in Benvoulin Woods is recommended. The rationale for this recommendation is amphibian species, for example, may use the Benvoulin ponds and wetlands for breeding and would not have been found in the brief fall (2003) survey. A potential implementation schedule with estimated cost for each action has been included. Excluding land purchases, the costs for these implementation activities are estimated at $40,000.

Values for the land within the proposed setback dyke and meandering channel project area vary considerably based upon the productive capacity of the land. The parcels of land within the proposed restoration zones range from unproductive to highly productive farmland. Developed rural residences are not within the area enclosed by the proposed setback dykes. The market value of these acreages is considered to be similar to recent (2003) land purchases along the river, ranging from about $35,000 to $50,000 Canadian per acre. A value of $100,000 per ha ($40,000 per acre) was used as the unit land purchase cost in the calculations.

The costs to purchase the necessary private land parcels is estimated at $532,000 (Table 3) provided the riparian zones can be subdivided from existing properties. Cost to construct the setback dykes and meandering channel within the Benvoulin Woods area is estimated at $640,000 (Table 8). Engineering and supervision were estimated at about 15% of the construction costs and construction management and administration at about 10%. In addition to sediment issues during construction, the environmental monitor would be responsible for monitoring of sensitive wildlife species to ensure impacts are prevented or minimized.

Table 2. Implementation steps leading to construction of setback dykes immediately upstream of Casorso bridge crossing.

Action	Responsibility	Schedule	Estimated Cost
1. obtaining final approval of the preliminary design (as presented in this report) from the affected landowners, management agencies, governments and stakeholders,	Consultant and MWLAP	April-July 2004	$3000
2. initiating land negotiation and securing the necessary land parcels from various land owners through purchase, lease, or donation,	Consultant and MWLAP	June 2004-?	Negotiation-$3000 Purchase-?
3. obtaining approval to subdivide lands presently in the Agricultural Land Reserve (ALR),	Consultant and MWLAP	June-Dec 2004	$500
4. obtaining approval to re-zone or adjust ALR classification to allow for setback dyke construction,	Consultant and MWLAP	June-Dec 2004	$2000
5. obtaining regulatory approvals from the management agencies, and stakeholders for setback dyke construction,	Consultant and MWLAP	April-June 2005	$5000
6. preparing final, approved construction drawings.	Engineering and biological consultants	July-August 2005	$5000
		Total Estimated Cost	**$18,500+**

Table 3. Area and estimated purchase cost of each private land parcel required for setback dyke and meander channel construction in Mission Creek. Cost estimated at $100,000 per ha ($40,000 per acre).

Bank of River	Ownership	Cross Sections	Plan Number (PID#)	Total Lot Area (ha)	Area of Lot Required for Setback Dyke Construction (ha)	% Within Setback Area	Estimated Purchase Cost
Southeast	Private	13 to 16	011-099-895	6.77	1.36	20%	$136,000
Northwest	Private[1]	22 to 26	008-504-130	18.07	2.50	14%	$250,000
Northwest	Private[1]	26	024-008-168	4.54	0.13	3%	$13,000
Southeast	Private	30 to 31	009-417-770	7.23	0.37	5%	$37,000
Northwest	Private[2]	39A to 42	001-714-791	13.37	4.08	31%	$408,000
Northwest	Private[2]	41 to 42	001-714-783	10.21	0.61	6%	$61,000
Southeast & Northwest	Private[2]	41A	011-074-132	2.42	0.63	26%	$63,000
Northwest	Private	42	011-074-281	1.95	0.26	13%	$26,000
Southeast & Northwest	Private	43	007-938-675	2.43	0.81	33%	$81,000
Southeast & Northwest	Private	43 to 46	011-074-311	12.19	3.12	26%	$312,000
Southeast & Northwest	Private	47 to 50	003-979-440	7.04	1.75	25%	$175,000
Southeast	Crown / Other	9 to 13	014-767-538	12.50	0.99	8%	$0
Northwest	Crown / Other[1]	22	Westbank FN	2.03	0.13	6%	$0
Southeast & Northwest	Crown / Other	16 to 20	Westbank FN	2.03	0.62	31%	$0
Northwest	Crown / Other	41	024-208-124	0.89	0.89	100%	$0
Southeast & Northwest	Crown / Other	46 to 47	017-816-874	22.61	2.06	9%	$0
Northwest	Crown / Other	27 to 28	024-008-184	1.33	0.55	41%	$0
Total for Private Lands[1] - Highest Priority Setback Dyke Site, Immediately Upstream of Casorso Road							$263,000
Total for Private Lands[2] - Benvoulin Woods Area							$532,000
					Total Estimated Land Purchase Cost		**$1,562,000**

Table 4. Estimated cost to construct 730 m of setback dyke immediately upstream of Casorso bridge crossing (February 2004 estimate).

Description	Unit Cost	Units	Total Cost
Tree & Brush Removal			$ 25,000
Stripping & Stockpiling Topsoil	$ 10.00 \m^3	2,000	$ 20,000
Pitrun Gravel for Dyke	$ 9.00 \m^3	15,000	$ 135,000
Crushed Gravel for Dyke Surface	$ 20.00 \m^3	280	$ 5,600
Rock Revetment	$ 60.00 \m^3	460	$ 27,600
Geotextile Cloth	$ 2.00 \m^2	2,500	$ 5,000
Hydro Seeding	$ 0.50 \m^2	7,300	$ 3,650
Replacement of Stripped Topsoil	$ 10.00 \m^3	2,000	$ 20,000
Tree Planting	$ 40.00 \tree	550	$ 22,000
Fence Replacement	$ 10.00 \m	580	$ 5,800
Environmental Monitor during Construction	$ 400.00 \day	19	$ 7,600
Sub Total			$ 277,250
Engineering & Contingencies @ ~15%			$ 41,500
Construction Management & Administration @ ~10%			$ 31,250
Total for Construction			$ 350,000

Table 5. Implementation steps leading to construction of sediment traps near Hollywood Road.

Action	Responsibility	Schedule	Estimated Cost
1. obtaining final approval of the preliminary design (as presented in this report) from agencies, City of Kelowna, CORD and stakeholders,	Consultant and MWLAP	April-July 2004	$3000
2. obtaining regulatory approvals from provincial and federal management agencies for sediment trap construction,	Consultant and MWLAP	April-June 2005	$5000
3. preparing final, approved construction drawings.	Engineering and biological consultants	July-August 2005	$5000
		Total Estimated Cost	**$13,000**

Table 6. Estimated cost to construct sediment traps near Hollywood Road (February 2004 estimate).

Description	Unit Cost		Units	Total Cost
Tree & Brush Removal	$ 150.00	\tree	20	$ 3,000
Fence Replacement	$ 10.00	\m	100	$ 1,000
Rock Riprap (600-900 mm size)	$ 50.00	$\m^3$	2,200	$ 110,000
Rock Riprap (1200 mm size)	$ 100.00	$\m^3$	60	$ 6,000
Environmental Monitor during Construction	$ 400.00	\day	10	$ 4,000
Sub Total				$ 124,000
Engineering & Contingencies @ ~15%				$ 20,000
Construction Management & Administration @ ~10%				$ 16,000
Total for Construction				$ 160,000

Table 7. Implementation steps for the design and construction of setback dykes and meander channel in the Benvoulin Woods area.

Action	Responsibility	Schedule	Estimated Cost
1. spring assessment of wildlife habitat	Consultant and MWLAP	April-July 2004	$2500
2. obtaining approval in principle of the conceptual design (presented in this report) from the affected landowners, management agencies, governments and stakeholders,	Consultant and MWLAP	April-July 2004	$3000
3. initiating land negotiation and securing the necessary land parcels from various land owners through purchase, lease, or donation,	Consultant and MWLAP	June 2004-?	Negotiation-$3000 Purchase-?
4. obtaining approval to subdivide lands presently in the Agricultural Land Reserve (ALR),	Consultant and MWLAP	June-Dec 2004	$500
5. obtaining approval to re-zone or adjust ALR classification to allow for setback dyke and channel construction,	Consultant and MWLAP	June-Dec 2004	$2000
6. preparing preliminary engineering drawings of the setback dyke and channel layout showing plan, profile and cross section views of the proposed works,	Engineering and biological consultants	Sept 2004 - Jan 2005	$10,000
7. incorporating a hiking / biking path on the setback dyke design,	Engineering consultant	Sept 2004 - Jan 2005	$0 –included in #6
8. conducting an analysis of the hydraulic effects (i.e., flooding, erosion and sedimentation) of the proposed works using current computer modeling programs,	Engineering consultant	Jan –March 2005	$10,000
9. analyzing potential liabilities for public and private lands,	Engineering consultant	Jan –March 2005	$0 –included in #8
10. obtaining regulatory approvals from the management agencies, and stakeholders for setback dyke construction,	Consultant and MWLAP	April-June 2005	$5000
11. preparing final, approved construction drawings.	Engineering and biological consultants	July-August 2005	$5000
		Total Estimated Cost	**$40,000+**

Table 8. Estimated cost to construct 900 m of setback dyke and 400 m of meander channel in the Benvoulin Woods area (February 2004 estimate).

Description	Unit Cost	Units	Total Cost
Tree & Brush Removal			$ 30,822
Stripping & Stockpiling Topsoil	$ 10.00 \m^3	2,466	$ 24,658
Pitrun Gravel for Dyke	$ 9.00 \m^3	18,493	$ 166,438
Crushed Gravel for Dyke Surface	$ 20.00 \m^3	345	$ 6,904
Rock Revetment	$ 60.00 \m^3	567	$ 34,027
Geotextile Cloth	$ 2.00 \m^2	3,082	$ 6,164
Hydro Seeding	$ 0.50 \m^2	9,000	$ 4,500
Replacement of Stripped Topsoil	$ 10.00 \m^3	2,466	$ 24,658
Tree Planting	$ 40.00 \tree	678	$ 27,123
Fence Replacement	$ 10.00 \m	715	$ 7,151
Channel Construction	$ 4.00 \m^3	24,000	$ 96,000
Riffle Rock (600-900 mm size)	$ 50.00 \m^3	1,350	$ 67,500
Environmental Monitor during Construction	$ 400.00 \day	30	$ 12,000
Sub Total			$ 507,945
Engineering & Contingencies @ ~15%			$ 74,000
Construction Management & Administration @ ~10%			$ 58,055
Total for Construction			$ 640,000

4.4 Land Negotiation

For the three proposed restoration projects, setback dykes would need to be constructed on portions of five privately owned properties (Table 1). All lots are zoned for agricultural use (i.e., ALR) and non-conforming uses require authorization. Thus, rezoning to Conservation Area (CA) is recommended. In preliminary discussions with the Agricultural Land Commission (ALC), rezoning to CA appears to be acceptable if the lands are riparian wetlands and marginally productive hay meadows rather than highly productive vineyards and orchards (S. Matthews MWLAP pers. comm.). As an alternative to re-zoning, the use of ALR land for biodiversity conservation and wildlife purposes is permitted by Regulation #171/2002 (as per Section 3(f)) (K.B. Miller, Agricultural Land Commission, letter to S. Matthews dated 31 July 2003). For all properties which would need to be subdivided and purchased before setback dyke construction proceeds, an 'Application by Land Owner for Exclusion, Inclusion, Subdivision, Non-farm Use in the ALR' (http://www.alc.gov.bc.ca/Forms/ALRApp_Landowner.pdf) would need to be submitted for review by the ALC. The ALC will then base its decision on whether or not to allow rezoning or an alternative use of ALR land by conducting an on-site review of the properties to consider the impacts of the subdivision and reconstruction of the setback dyke on the agricultural resource.

During these negotiations, all relevant parties should be kept informed and notified in writing as the project proceeds. The notification contact list should include, at a minimum, City of Kelowna, Regional District of Central Okanagan, Okanagan Nation Alliance, Friends of Mission Creek, Central Okanagan Parks and Wildlife Trust, Agricultural Land Commission, Ministry of Water, Land and Air Protection, Ministry of Agriculture and Fisheries, Fisheries and Oceans Canada, and individual land owners.

Following a decision on re-zoning the next logical steps would include:

1 Retain the services of a local certified land appraiser/negotiator or realtor,
2 Confirm subdivision or alteration of property boundaries,
3 Determine owner's willingness to sell,
4 Appraise land value,
5 Identify funding sources,
6 Commit funding, and
7 Negotiate sale.

4.5 Agency Approvals

In summary, approvals will be required from the agencies listed in the following table:

Agency	Legislation	Description
Agricultural Land Commission		Approval to rezone subdivided parcels from ALR to CA or adjust ALR zoning for biodiversity conservation and wildlife purposes
DFO	Fisheries Act	Approval for activities that affect fish habitat
MWLAP (Regional Operations)	Fisheries Act Fish Protection Act	Approval for activities that affect fish habitat
MWLAP (Water Mgt)	Water Act	Water license. Approval for alteration and work in and about a stream (Section 9)
Transport Canada	Navigable Waters Protection Act	Permit for activities around navigable waters.
BC Health	Health Act	Approval of construction camp, sewage disposal and potable water supply
BC Municipal Affairs, Recreation & Housing: Archaeology Branch	Heritage Conservation Act	Approval to excavate and alter sites of archaeological significance
BC Assets and Lands		Permission to use Crown Land
City of Kelowna		Permission to construct setback dykes (e.g., right-of-ways)
Regional District of Central Okanagan	Municipal Act Regional Bylaws	Approval of zoning. Permits for construction
Okanagan Nation Alliance	Case Law	Mandatory Consultation

5 CONCLUDING REMARKS

Mission Creek is the largest tributary of Okanagan Lake and supports the highest number of spawning kokanee. As stated in the Okanagan Lake Action Plan, restoration of the watershed is considered fundamental to recovery of the spawning and rearing habitats of kokanee and rainbow trout. Setback dyke construction in a 1 km section of river corridor upstream of the Casorso Road bridge crossing and construction of sediment traps near Hollywood Road would be significant steps towards restoration of the Mission Creek watershed.

Restoration of Mission Creek will involve the cooperation and commitment from all levels of government as well as local community groups within the Kelowna area. A coalition made up of the City of Kelowna, Regional District of Central Okanagan, Westbank First Nation, Friends of Mission Creek, Central Okanagan Parks and Wildlife Trust, Canada Department of Fisheries and Oceans, and Ministry of Water, Land and

Air Protection in conjunction with other community groups is envisioned to oversee and champion the long term restoration of Mission Creek. Implementation will require considerable effort to ensure widespread support and funding. The united support of the coalition to restore Mission Creek will provide the impetus to implement priority restoration projects as described in this report. Time is of the essence since restoration options are quickly disappearing as new initiatives for land development arise.

6 REFERENCES

Gaboury, M. and P. Slaney. 2003. Mission Creek habitat restoration feasibility. Prepared for Ministry of Water, Land and Air Protection, Penticton, BC. LGL Limited, Sidney, BC and P. Slaney Aquatic Science Inc., Coquitlam, BC.

Map

Appendix A

Wildlife assessment of Benvoulin Woods area (completed by Virgil Hawkes of LGL Limited, September 2003).

Introduction

An assessment of the Benvoulin Woods area adjacent to Mission Creek in Kelowna, British Columbia was conducted in support of a project with the objective to re-introduce meanders into Mission Creek. The portion of Mission Creek that flows past Benvoulin Woods has a north-south orientation and Benvoulin Woods lies to the west, occupying an area of approximately 2.84 ha, of which 1.30 ha is crown land. The proposed project will re-introduce a channel of Mission Creek through Benvoulin Woods by way of a meander with pools and riffles.

Benvoulin Woods is of particular interest due to the presence of a large stand of black cottonwood (*Populus balsamifera ssp. trichocarpa*), which represents a rare ecosystem in the Okanagan. The area also has high wildlife values for birds, small mammals, large mammals, and possibly for reptiles and amphibians.

The objectives of this site visit were to:

- Identify current wildlife use by mammals, birds, and amphibians and reptiles,
- Discuss the potential impacts of channel restoration on wildlife in Benvoulin Woods, and
- Provide mitigation measures for the proposed channel restoration project to ensure that wildlife and habitat values remain high post-restoration.

Although this wildlife assessment does not provide the detail necessary to produce a comprehensive report on the wildlife values in the area, it is sufficient to comment on the potential impacts of channel restoration on wildlife for the portions of Benvoulin Woods that would be directly and indirectly impacted.

Methods

A visual encounter survey was conducted on 24 September 2003. In general, non-systematic surveys were conducted of the Benvoulin Woods area and observations of wildlife sign, habitat, or sightings were made. Two routes were traversed. The first route meandered along the east side of Benvoulin Woods and the second route meandered along the west side and throughout the interior of the woods. Environmental conditions on 24 September 2003 were clear skies, sun, and air temperature of 21 °C changing to high clouds with approximately 80% cover in the afternoon with minimal change in the temperature. The first traverse of Benvoulin Woods began at 1030 h from the south and moved north, ending at 1300 h. The second traverse started at 1330 h and ended at 1530 h. Total survey time in Benvoulin Woods was 4.5 hours. Signs of wildlife and/or visual or auditory observation were recorded into a ‘rite in the rain’ field notebook. Photographs were taken of representative habitats or of habitats that could be of high wildlife value.

Results and Discussion

Because there are significant differences regarding wildlife use of the woods, it is practical to delineate two distinct portions of the woods: the north and the south. The south woods are delineated by KLO Road to the south and the 4.5 km marker of the Greenway to the north. The north woods extend north from the 4.5 km marker to approximately 5.2 km on the Greenway trail. A narrowing of the woods and a join with the adjacent agricultural fields also delineates the north end. The rationale for delineating two distinct areas is related to the knowledge that

Sandhill Cranes and Great Blue Herons either nest or roost in the south woods. The presence of these two species of woods is part of the reason why Benvoulin Woods has such high wildlife value.

Mission Creek: Historical Route

The historical route of Mission Creek, along with historical floodplains can be easily seen in the northern portion of Benvoulin Woods. The channel is approximately 18-20 m wide and moves away from the existing channel to the west and continues to approximately 50 m east of the agricultural land adjacent to the woods. At that point, the historical channel bends back to the east en route to reconnecting with the current channel. There are two areas of floodplain (or historical gravel islands) that can be seen in the north woods and appear as large openings in the forested canopy when viewing aerial photos.

South Woods

The south woods are a known nesting site for Sandhill Cranes and provide roosting habitat for Great Blue Herons (*Ardea herodias*). Great Blue Herons roost in some of the larger black cottonwood and they may collect nesting materials from Benvoulin Woods. Northern flickers, pileated woodpeckers, and numerous species of songbirds also use the south woods. It is likely that the bird diversity is high; however, the timing of the survey did not permit the development of a comprehensive species list. It is more appropriate to conduct a bird survey during the breeding season (May – July).

Adding to the wildlife values in the south woods is the presence of large black cottonwood trees that are likely to be approaching well over 100 years of age. These trees are used by many species of birds and several of them have large cavities excavated at their bases, which indicates use by large mammals.

The presence of beaver (*Castor canadensis*) was noted in several areas in the south woods, as was mink (*Mustela vison*) and white-tailed deer (*Odocoileus hemionus*). Raccoon tracks were also observed (*Procyon ater*). Presence was determined primarily through track identification in the mud adjacent to a small distributary (i.e., irrigation canal) of Mission Creek that is pumped along the west side of Mission Creek. The presence of an old beaver lodge was detected in the south woods.

An important habitat value is coarse woody debris (CWD). CWD is important habitat for reptiles, amphibians, small mammals, and terrestrial molluscs. The volume of coarse woody debris (CWD) is greatest in the south woods and in the interior of the woods when compared to the north woods. This habitat feature is well represented in Benvoulin Woods. One small mammal was seen during the assessment but was not identified to species.

The south woods may also provide important breeding habitat for pond-breeding amphibians as there exists marsh and pond habitats with submergent and emergent vegetation, both of which are important for pond-breeding amphibians.

North Woods

The north woods are more open than the south woods, providing suitable flyways for owl species (e.g., long-eared owl, great horned owl) and possibly bats. The presence of large cottonwood trees with cavities approximately ¾ of the way up the tree could indicate that owl species are roosting and/or nesting in Benvoulin Woods.

The presence of black bears (*Ursus americanus*) was also noted, with the majority of sign (scat) occurring in the north and western portions of the woods. The presence of black bears is not surprising given the proximity of Benvoulin Woods to Missions Creek, which is a known

Kokanee spawning area. White-tailed deer fecal pellet groups, tracks, and bones were detected in the north woods. A coyote (*Canis latrans*) skeleton was also detected. There also appeared to be significant human-related use of the north woods area, determined primarily by the presence of tree forts and building materials in the forest. These structures were located in the interior of the woods and were most easily accessed by a trail that traversed the woods from the east to west.

Potential Impacts

The proposed re-meandering of Mission Creek through Benvoulin Woods will undoubtedly impact the terrestrial wildlife habitat of Benvoulin Woods. However, the temporal effects will likely be short lived, as the addition of a waterway through the woods will enhance the habitat for terrestrial wildlife and birds through the development of riparian habitat. The following items list the potential impacts and some possible mitigation measures that could be used to minimize or remove those impacts.

1. Impact: Disturbance of the South Woods, particularly nesting Sandhill Cranes

Mitigation: Avoid routing the meander of Mission Creek through the south woods area and avoid construction during the Sandhill crane nesting season. Nesting usually begins in early to mid-May. Cranes normally lay two eggs, which hatch in approximately 30 days, or early-mid-June. Fledging occurs 2 to 21/2 months after hatching, usually sometime in August. It is recommended that an environmental monitor be on hand to observe Sandhill Crane activity prior to construction and during the construction phase.

2. Impact: Loss of nesting habitat for primary and secondary cavity nesters.

Mitigation: Avoid the unnecessary removal of live trees or snags that contain cavities. When snags or live trees that are removed, leave the trees on the banks of the new channel to provide feeding habitat for woodpeckers and CWD for small mammals, reptiles and amphibians, and terrestrial molluscs.

3. Impact: Loss of terrestrial habitat due to channel construction.

Mitigation: There will be a reduction in total useable land area for terrestrial wildlife. However, the addition of a watered creek channel through the woods will likely increase the volume and diversity of riparian-associated vegetation along the banks of the creek. This habitat will have the potential of becoming more valuable to terrestrial wildlife than the habitat that currently exists in Benvoulin Woods. Enhancement will be related to deciduous browse for deer, and increase in riparian-associated vegetation which can provide important nesting habitats for songbirds, and an increase in escape and security habitat for small mammals.

Mitigation: The historical channel of Mission Creek is still visible in Benvoulin Woods. It would be advantageous to use the footprint of the existing creek bed in the woods as the guideline for the development of a new channel. This would focus the construction activities of the new channel in a specific area and will likely reduce the impact of construction on the surrounding terrestrial habitats.

Potential Impacts to Species Groups

Cranes and Herons

Provided that the meander does not impede on the south woods, and that construction does not affect the nesting success of Sandhill Cranes, the development of a meander through Benvoulin Woods will not impact cranes or herons.

Songbirds

Songbirds will benefit from the meander by an increase in riparian-associated habitat that will provide increased nesting habitat, escape habitat, and security habitat. Furthermore, the meander will attract aquatic-associated insects, which provide food for some species of songbirds.

Owls

Owls likely roost and feed in Benvoulin Woods, and a small number of owls may nest there. The removal of large cottonwoods will be detrimental to nesting and/or roosting owls in the woods. Therefore, these habitat features should be left intact where ever possible.

Semi-aquatic Furbearers

Semi-aquatic furbearers (beaver and mink) will benefit from the availability of more aquatic habitat.

Large Terrestrial Mammals

Large terrestrial mammals (white-tailed deer, black bear) will be temporally and spatially displaced during the construction phase. These species will return post-construction and there will not likely be any significant impact on these species as a result of the meander through the woods.

Amphibians and Reptiles

Amphibians and reptiles are likely to be present throughout the woods, although the potential for them is greatest in the south woods. Amphibians and reptiles are likely to benefit from the addition of the meander, although the benefits would be greatest if there were quiescent pools or backwaters associated with the meander in which pond-breeding amphibians could breed.

Molluscs

Terrestrial molluscs (slugs and snails) were observed in both the north and south woods, although their distribution was limited to several metres from the small tributary that runs the length of the woods. Terrestrial molluscs are a relatively understudied group, and very little is known regarding species occurrence and distribution throughout British Columbia. Terrestrial molluscs usually require moist habitats under CWD or rocky materials in forested habitats. Urban greenbelts, such as the Benvoulin Woods may provide important refugia for the persistence of mollusc species in developed areas. The creation of a meander through Benvoulin Woods will undoubtedly provide additional habitat for terrestrial molluscs. Additionally, several species of aquatic molluscs (snails) were noted from the marsh at the south end of the survey area. As with terrestrial molluscs, the distribution and occurrence of this group in British Columbia has not received a lot of attention, and the aquatic snails will likely benefit from the addition of the meander through Benvoulin Woods.

Conclusions

In general, it is anticipated that the impacts to wildlife and wildlife habitat in Benvoulin Woods will be minimal to none. In fact, in landscapes that are water-limited, the addition of water often enhances the quality of habitat for terrestrial and semi-aquatic organisms. The addition of water to Benvoulin Woods by way of a meander of Mission Creek will likely increase wildlife values through increases in the density, and species composition of riparian-associated vegetation, and increases in vegetated cover. To minimize the spatial scale over which impacts are realized, it will be important to consider using construction methods that contain construction activities to as small a footprint as is practical. Furthermore, where tree removal is required, retention of the woody material should be considered as suitable to use for instream large organic debris (LOD) or stream-side CWD.

Where possible it would be desirable to avoid the removal of larger black cottonwood trees, as these trees represent the oldest of the trees in the Woods and are important habitat features, functioning as wildlife trees. To avoid disturbance to Sandhill Cranes and/or Great Blue Herons, construction activates should avoid the South Woods entirely and construction activities should not occur during the nesting / fledging period. Finally, it is recommended that an environmental monitor be on hand during construction activities to note any effects of the construction process on wildlife. While it is understood that this type of project can not proceed without a significant impact to the terrestrial habitat and wildlife, it will be important to note any major adverse impacts on wildlife during the construction period. Additionally, it is anticipated that the temporal impacts will be relatively short-lived and the spatial impacts will be minimized by an overall increase in habitat value for wildlife, which will be realized post-construction.

Appendix B

Preliminary design drawings for setback dykes and sediment traps.

1. Setback dykes – upstream of Casorso bridge crossing (drawings MWLAP 124A, 125A, 126 to 128)
2. Sediment traps – near Hollywood Road (drawings MWLAP 121 to 123).

Appendix C

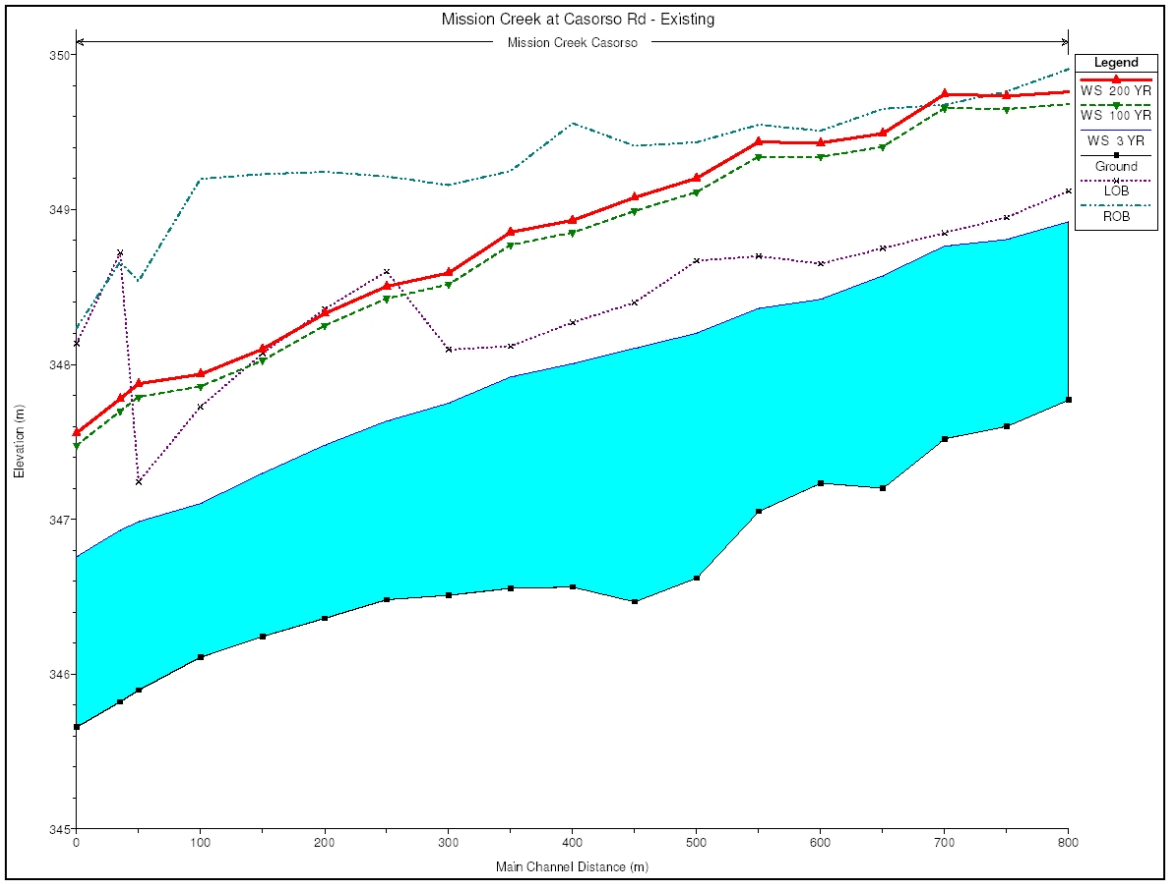
Survey drawings for Benvoulin Woods area.

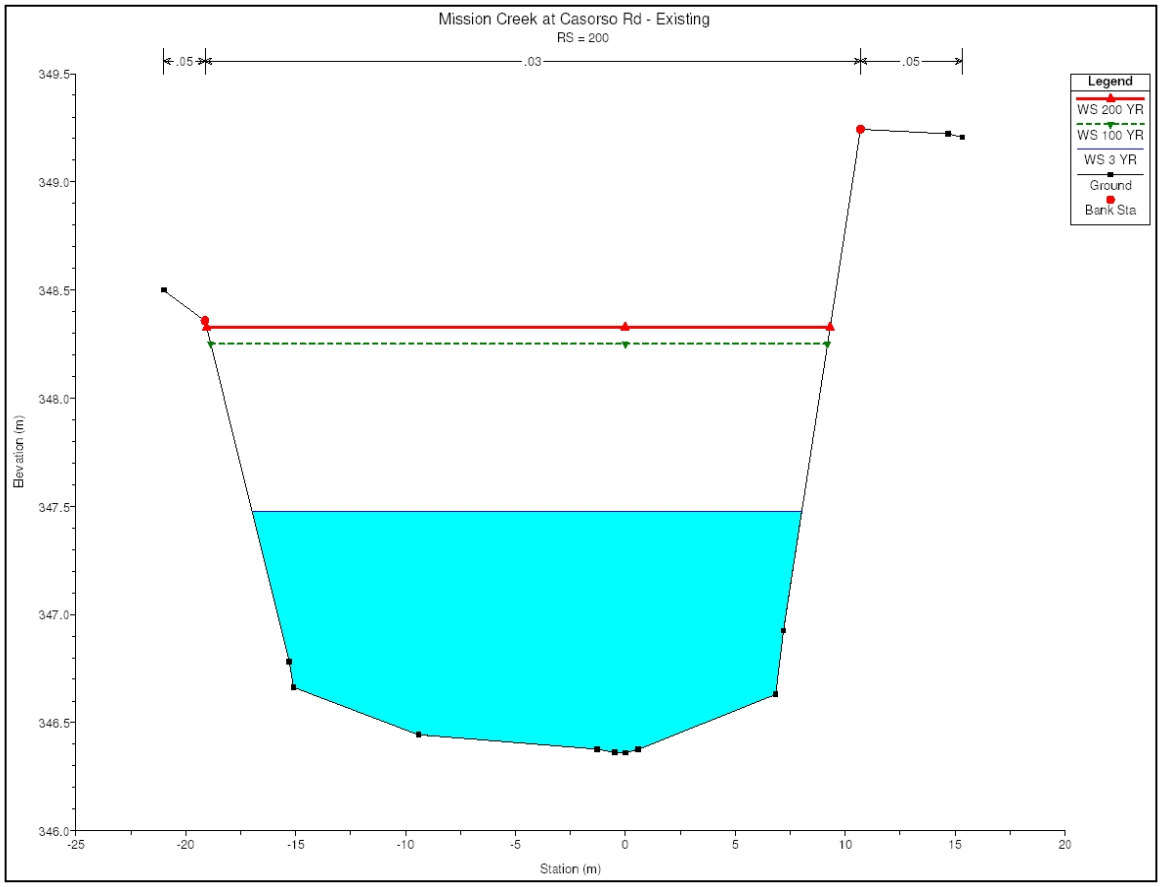
Appendix D

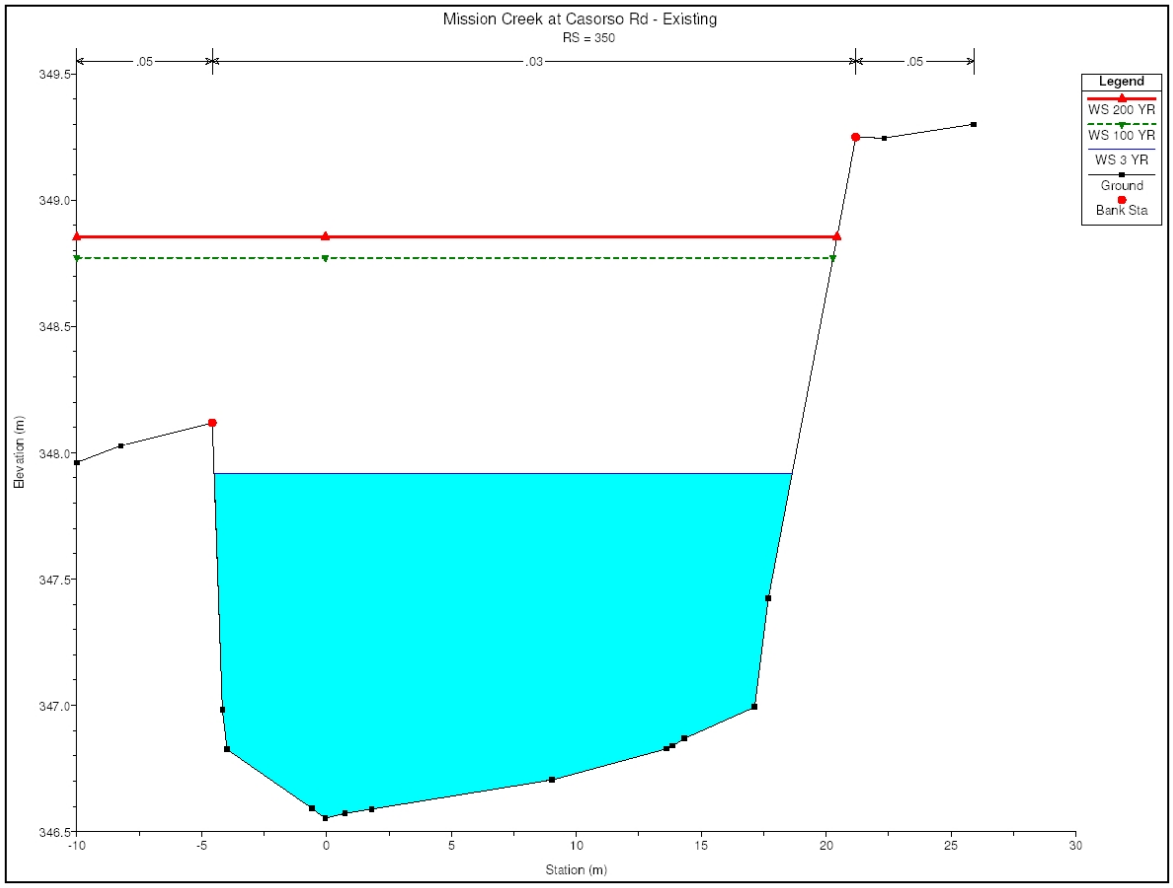
HEC-RAS analysis of hydrological effects of setback dykes upstream of Casorso Road, including summary table, profile and cross sections (completed by Mould Engineering 2004).

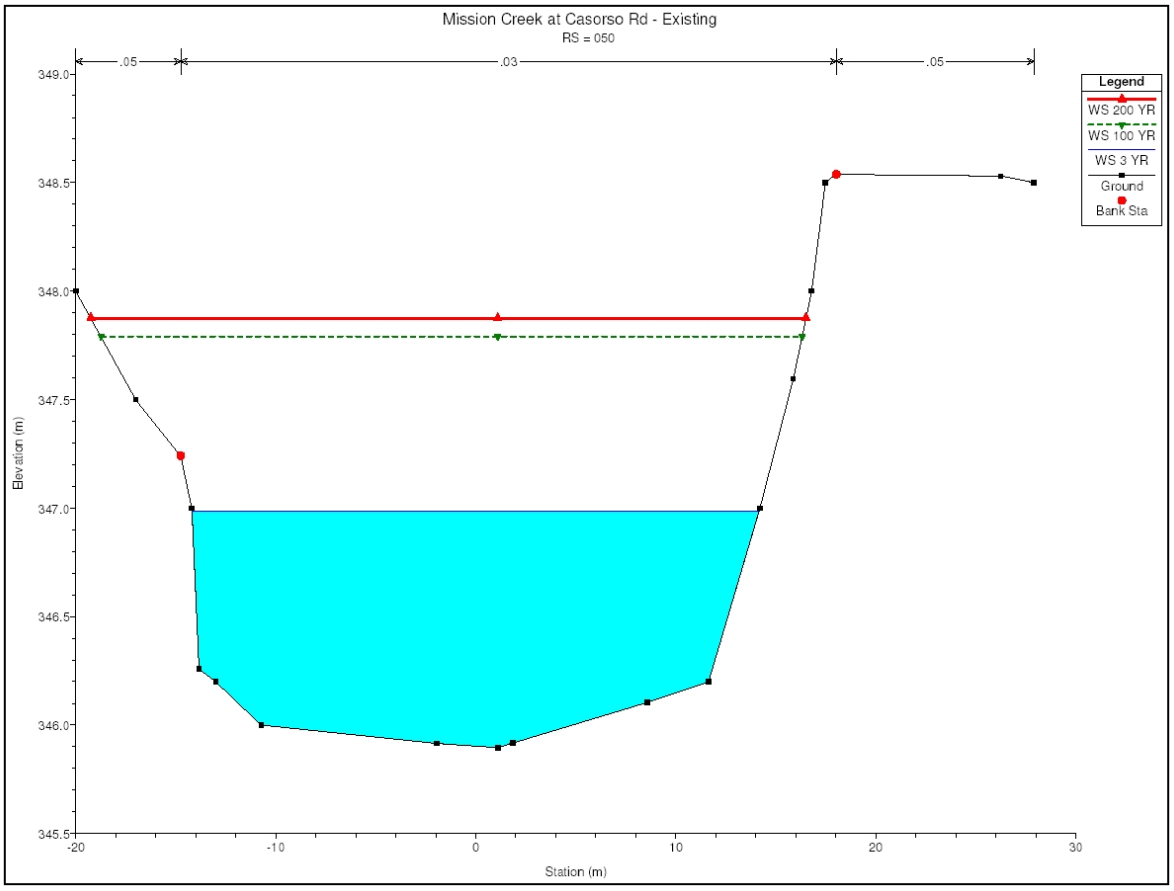
HEC-RAS Plan: Plan River: Mission Creek Reach: Casorso

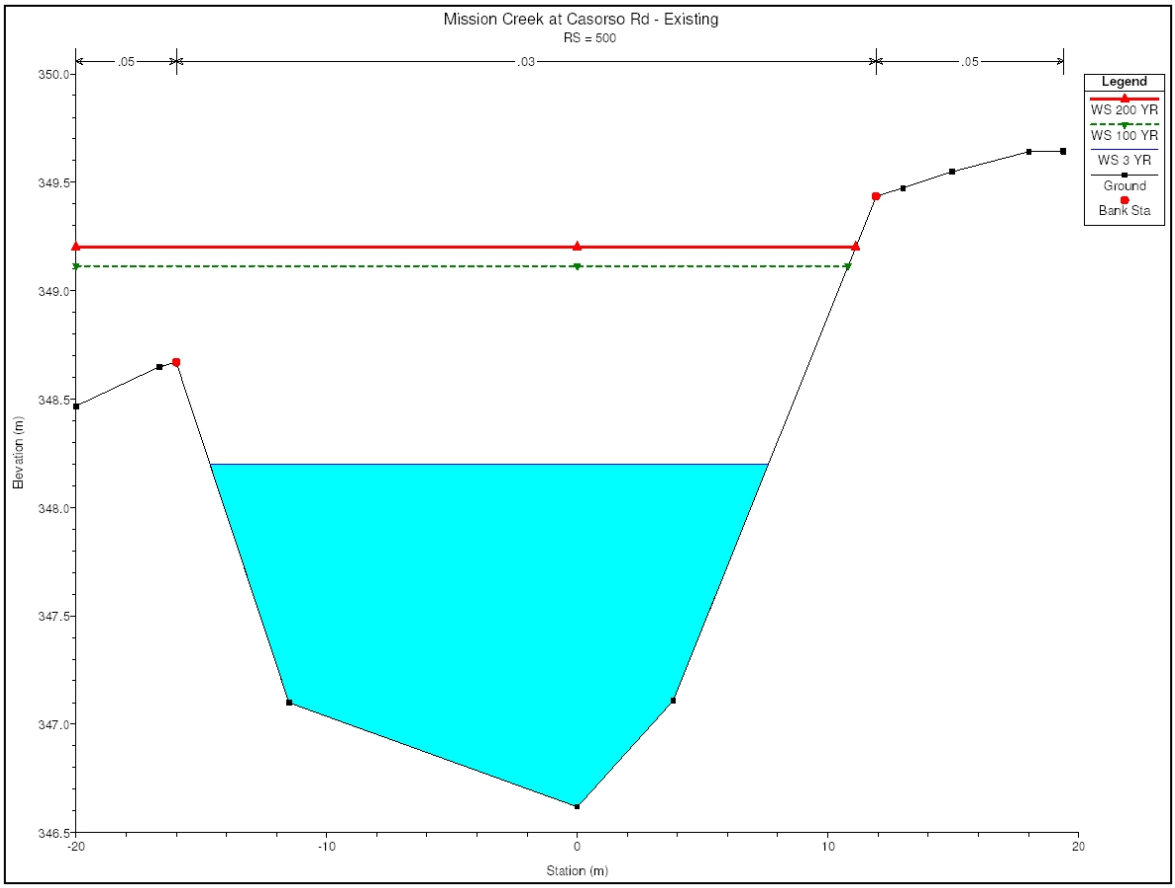
Reach	River Sta	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Casorso	800	3 YR	40	347.77	348.92	349.18	0.005944	2.27	17.59	20.83	0.79
Casorso	800	100 YR	107	347.77	349.68	350.15	0.005344	3.03	35.77	26.04	0.81
Casorso	800	200 YR	115	347.77	349.76	350.24	0.005245	3.09	37.83	26.41	0.81
Casorso	750	3 YR	40	347.6	348.81	348.95	0.002857	1.67	23.92	25.87	0.56
Casorso	750	100 YR	107	347.6	349.65	349.91	0.002477	2.27	47.61	29.67	0.57
Casorso	750	200 YR	115	347.6	349.73	350.01	0.00245	2.32	50.13	30.56	0.57
Casorso	700	3 YR	40	347.52	348.76	348.83	0.001291	1.18	33.96	34.36	0.38
Casorso	700	100 YR	107	347.52	349.66	349.79	0.001167	1.62	66.18	37.72	0.39
Casorso	700	200 YR	115	347.52	349.75	349.88	0.001148	1.65	69.93	44.01	0.39
Casorso	650	3 YR	40	347.2	348.57	348.73	0.003153	1.77	22.64	24.33	0.58
Casorso	650	100 YR	107	347.2	349.41	349.69	0.002702	2.38	46.54	30.53	0.59
Casorso	650	200 YR	115	347.2	349.49	349.79	0.002653	2.43	49.14	30.72	0.59
Casorso	600	3 YR	40	347.23	348.42	348.56	0.003376	1.67	23.99	29.21	0.59
Casorso	600	100 YR	107	347.23	349.34	349.55	0.002056	2.03	53.3	33.83	0.51
Casorso	600	200 YR	115	347.23	349.43	349.65	0.002003	2.06	56.37	34.16	0.51
Casorso	550	3 YR	40	347.05	348.36	348.43	0.001472	1.19	33.52	36.74	0.4
Casorso	550	100 YR	107	347.05	349.34	349.45	0.000949	1.47	73.57	43.28	0.36
Casorso	550	200 YR	115	347.05	349.44	349.55	0.000928	1.5	77.64	43.54	0.35
Casorso	500	3 YR	40	346.62	348.2	348.34	0.002217	1.65	24.31	22.27	0.5
Casorso	500	100 YR	107	346.62	349.11	349.37	0.002216	2.25	49.18	30.8	0.54
Casorso	500	200 YR	115	346.62	349.2	349.47	0.002196	2.3	51.92	31.11	0.54
Casorso	450	3 YR	40	346.47	348.1	348.23	0.001918	1.59	25.12	21.46	0.47
Casorso	450	100 YR	107	346.47	348.99	349.26	0.002128	2.31	48.65	28.76	0.53
Casorso	450	200 YR	115	346.47	349.08	349.36	0.002133	2.37	51.11	28.91	0.54
Casorso	400	3 YR	40	346.56	348	348.14	0.001975	1.6	25.02	21.39	0.47
Casorso	400	100 YR	107	346.56	348.85	349.14	0.002375	2.41	45.79	26.14	0.56
Casorso	400	200 YR	115	346.56	348.93	349.24	0.002403	2.48	47.89	26.26	0.56
Casorso	350	3 YR	40	346.55	347.92	348.04	0.001867	1.52	26.26	23.13	0.46
Casorso	350	100 YR	107	346.55	348.77	349.02	0.002069	2.23	50.7	30.27	0.52
Casorso	350	200 YR	115	346.55	348.85	349.12	0.002079	2.29	53.21	30.43	0.52
Casorso	300	3 YR	40	346.51	347.75	347.91	0.003016	1.8	22.17	22.06	0.57
Casorso	300	100 YR	107	346.51	348.52	348.88	0.003492	2.66	40.48	25.42	0.67
Casorso	300	200 YR	115	346.51	348.59	348.97	0.003515	2.73	42.37	25.63	0.67
Casorso	250	3 YR	40	346.48	347.63	347.77	0.002531	1.62	24.7	25.61	0.53
Casorso	250	100 YR	107	346.48	348.43	348.7	0.002624	2.32	46.4	29.46	0.58
Casorso	250	200 YR	115	346.48	348.5	348.79	0.002627	2.37	48.7	29.91	0.58
Casorso	200	3 YR	40	346.36	347.48	347.63	0.003002	1.72	23.26	25	0.57
Casorso	200	100 YR	107	346.36	348.25	348.56	0.00308	2.44	43.82	28.06	0.62
Casorso	200	200 YR	115	346.36	348.33	348.65	0.003078	2.5	45.99	28.37	0.63
Casorso	150	3 YR	40	346.24	347.3	347.46	0.003482	1.82	22.03	24.29	0.61
Casorso	150	100 YR	107	346.24	348.03	348.38	0.003751	2.64	40.52	26.55	0.68
Casorso	150	200 YR	115	346.24	348.1	348.47	0.00375	2.71	42.46	27.08	0.69
Casorso	100	3 YR	40	346.11	347.1	347.28	0.003991	1.86	21.47	25.4	0.65
Casorso	100	100 YR	107	346.11	347.86	348.19	0.003584	2.55	42	29.08	0.67
Casorso	100	200 YR	115	346.11	347.94	348.28	0.003508	2.6	44.29	29.65	0.67
Casorso	50	3 YR	40	345.9	346.98	347.11	0.002473	1.54	25.95	28.34	0.51
Casorso	50	100 YR	107	345.9	347.79	348.02	0.002226	2.13	51.28	35.05	0.53
Casorso	50	200 YR	115	345.9	347.87	348.11	0.002181	2.17	54.26	35.75	0.53
Casorso	35	3 YR	40	345.82	346.93	347.06	0.00283	1.64	24.38	26.78	0.55
Casorso	35	100 YR	107	345.82	347.7	347.98	0.002782	2.35	45.6	28.32	0.59
Casorso	35	200 YR	115	345.82	347.78	348.07	0.002763	2.4	47.86	28.48	0.59
Casorso	0	3 YR	40	345.66	346.76	346.94	0.004087	1.9	21.03	24.49	0.66
Casorso	0	100 YR	107	345.66	347.48	347.85	0.004111	2.71	39.5	26.84	0.71
Casorso	0	200 YR	115	345.66	347.56	347.95	0.004035	2.76	41.67	27.1	0.71

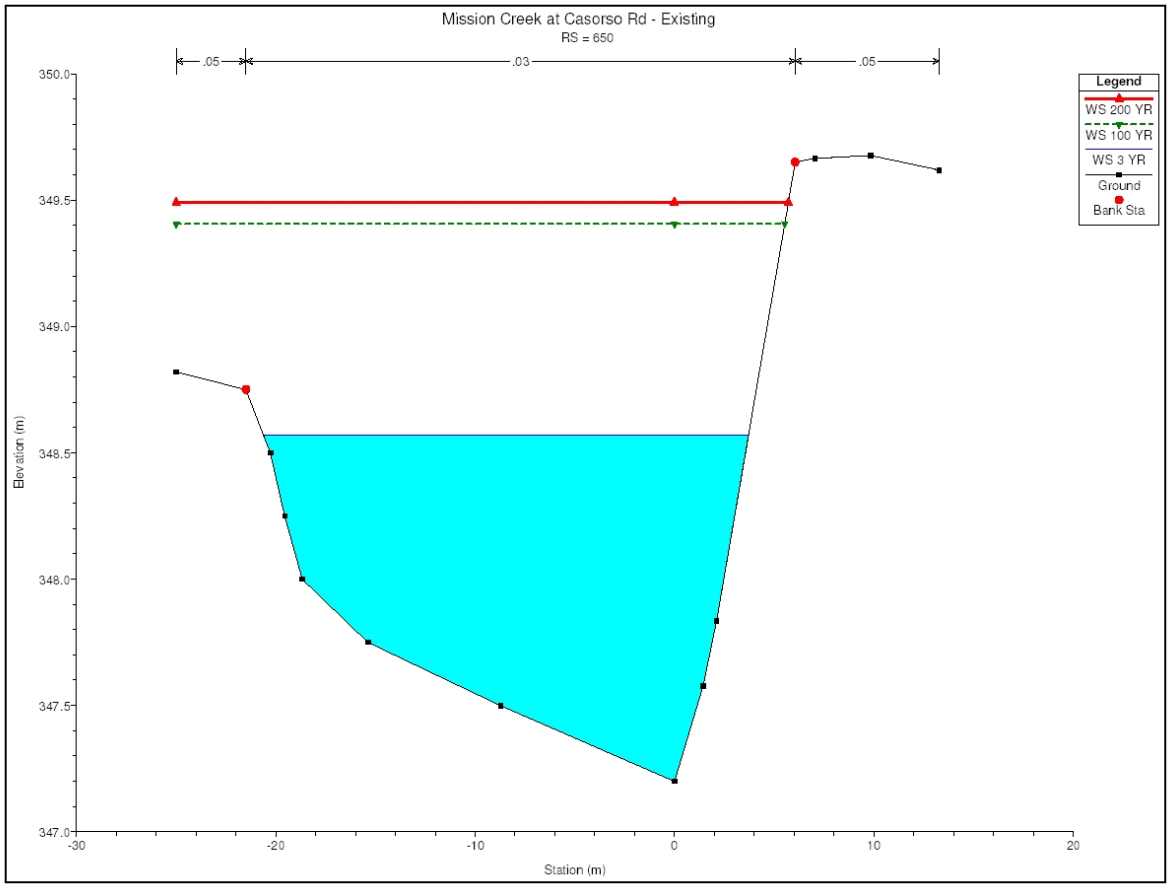

Mission Creek at Casorso Rd - Existing
Mission Creek Casorso
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
LOB
ROB
Elevation (m)
Main Channel Distance (m)
350
349
348
347
346
345
0
100
200
300
400
500
600
700
800

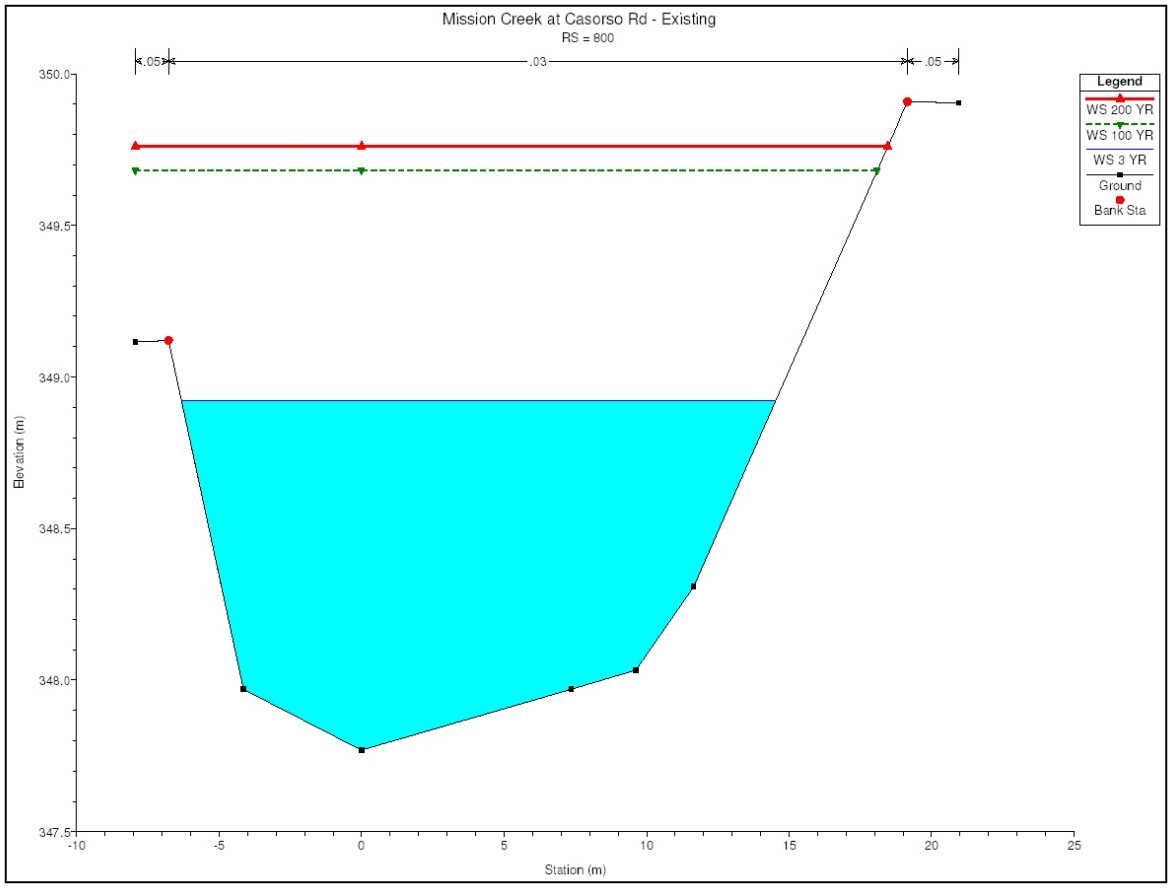

Mission Creek at Casorso Rd - Existing
RS = 200
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
349.5
349.0
348.5
348.0
347.5
347.0
346.5
346.0
-25
-20
-15
-10
-5
0
5
10
15
20


Mission Creek at Casorso Rd - Existing
RS = 350
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
349.5
349.0
348.5
348.0
347.5
347.0
346.5
-10
-5
0
5
10
15
20
25
30


Mission Creek at Casorso Rd - Existing
RS = 050
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
349.0
348.5
348.0
347.5
347.0
346.5
346.0
345.5
-20
-10
0
10
20
30


Mission Creek at Casorso Rd - Existing
RS = 500
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
350.0
349.5
349.0
348.5
348.0
347.5
347.0
346.5
-20
-10
0
10
20


Mission Creek at Casorso Rd - Existing
RS = 650
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
350.0
349.5
349.0
348.5
348.0
347.5
347.0
-30
-20
-10
0
10
20


Mission Creek at Casorso Rd - Existing
RS = 800
.05
.03
.05
Legend
WS 200 YR
WS 100 YR
WS 3 YR
Ground
Bank Sta
Elevation (m)
Station (m)
350.0
349.5
349.0
348.5
348.0
347.5
-10
-5
0
5
10
15
20
25