



**CORPORATION OF THE  
DISTRICT OF SAANICH**

**ENVIRONMENTAL RESTORATION  
CONCEPT PLANS FOR BOWKER  
CREEK: TRENT STREET TO PEARL  
AVENUE**

P.A. Harder and Associates Ltd.



# **CORPORATION OF THE DISTRICT OF SAANICH**

## **ENVIRONMENTAL RESTORATION CONCEPT PLANS FOR BOWKER CREEK: TRENT STREET TO PEARL AVENUE**

**Prepared for:**

**Corporation of the District of Saanich  
Environmental Planning Section**

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## **1.0 INTRODUCTION**

P.A. Harder and Associates Ltd. were retained by the Corporation of the District of Saanich to identify and assess environmental restoration options for the lower Bowker Creek. The scope of this study extended from the invert of the culvert at St. Patrick School (boundary between City of Victoria and District of Saanich) upstream to the outlet of the culvert at Pearl Avenue. An assessment of biophysical conditions was made for this section including observations on bank form, stability, channel characteristics and riparian vegetation characteristics.

Specific objectives of this study were to:

1. Describe biophysical characteristics of Bowker Creek between St. Patrick's School and Pearl Road including bank form, bank stability, channel form and riparian vegetation characteristics.
2. Review environmental objectives and interests of various stake holders within this section of the watershed.
3. Review previous studies and summarize all environmental initiatives that may affect the section of creek.
4. Identify potential constraints to future environmental restoration and flood control initiatives within the study area.
5. Present environmental design options for achieving increased bank stability and enhanced riparian and floodplain habitat conditions.
6. Identify environmental restoration opportunities and provide recommendations.

### Background

Bowker Creek is approximately 8 km long and flows through the District of Saanich, City of Victoria and District of Oak Bay. The creek channel has been highly modified through the catchment basin. Extensive sections of the creek have been enclosed within conduits and culverts. Most open sections of the creek channel are deeply entrenched, confined by steeply sloping clay banks. There is no natural floodplain area remaining within the catchment basin except for minor areas in the headwater reaches near the University of Victoria and the Cedar Hill golf course. The highly developed nature

of the watershed lands into residential and commercial areas, coupled with an extensive road network, has resulted in high rates of run-off during storm events. These conditions, coupled with flow conveyance constraints in several of the open and enclosed sections of the channel, have led to periodic flooding problems in some areas.

Reid Crowther (2000) identified the undersized culvert downstream of Trent Street and the absence of floodplain area as the two most significant constraints to flow capacity in the system. The flow constriction at Trent Street has resulted in major flood events on at least two occasions where significant property damage occurred within the District of Saanich.

The District of Saanich has conducted annual maintenance activities on the creek channel between St. Patrick's School and Pearl Avenue. These activities have included selective vegetation removal to maintain the hydraulic capacity of the channel, debris removal, bank stabilization work and noxious weed removal along the St. Patrick School boundary in response to student allergy concerns.

In recent years the District's channel maintenance activities have been designed in context with evolving environmental strategies for the drainage. Annual stream side vegetation clearing has been minimized with selective removal of plants choking the active portion of the channel. The District has examined the feasibility of constructing storm water detention facilities in the watershed including sites at Gordon Head Road (headwater reach), the BC Hydro property north of Haultain Street and at Richmond Elementary School (Reid Crowther, 2000). The District has also been promoting a municipal-wide requirement for storm water control and installation of oil separators in the Bowker Creek drainage. There has not been any systematic work aimed at restoring natural riparian vegetation along the creek channel between Trent Street and Pearl Avenue.

Several groups have been actively involved in the preservation and promotion of environmental values along the Bowker Creek drainage. These groups include the Provincial Capital Commission, Capital Regional District, Capital Health Region, Friends of Bowker Creek Society and Camosun Community Association. Reid Crowther (2000) has provided a comprehensive summary of the



activities promoted by these groups. These activities are supported by the Shelbourne Local Area Plan as part of the Saanich Official Community Plan. Examples of the initiatives supported by these groups are the development of a public access to green space areas, expansion of parkland, and enhancement of plant and animal habitat along the open sections of the creek channel.

The present challenge is to implement a comprehensive strategy that will adequately address existing flood control issues in the area without precluding the environmental objectives supported by the various stakeholders. It is also important that the various environmental initiatives under consideration do not preclude or compromise available flood control options

## **2.0 REVIEW OF ENVIRONMENTAL ISSUES**

A coordinated approach to watershed management in the Bowker Creek drainage has been complicated by the multiple jurisdictions between the District of Saanich, City of Victoria and the District of Oak Bay. In addition, there are a number of stakeholder groups that have also been involved in watershed management activities and environmental initiatives. A comprehensive overview of the watershed management problems and available solutions has been presented in Reid Crowther (2000). Other environmental studies include Norris (1978), Lopez (1997) and Barlow (1998). A summary of the environmental information pertaining to watershed management issues in Bowker Creek between Trent Street and Pearl Avenue is provided below:

### **2.1 Flooding**

- Flow capacity constraints in the existing culvert downstream of St Patrick's School has resulted in periodic flooding and property damage in the section of channel between Trent Street and Haultain Avenue (Reid Crowther 2001).
- Vegetation growth within the active channel and debris accumulations have contributed to past flooding problems (A. Johnson, District of Saanich).

### **2.2 Flood Control**

- Effective implementation of appropriate flood control measures in the Bowker Creek watershed has been complicated by the multi-municipal jurisdiction.

- The risk of property damage claims and proposed property development plans are factors under consideration by District of Saanich with respect to flood control initiatives in Bowker Creek (Alex Johnson, District of Saanich).
- The primary cause of periodic flooding within the study area is the flow capacity constraint in the Trent Street culvert enclosure within the City of Victoria (Reid Crowther 2000).
- Potential remedies to the existing flow constraint in the city culvert are limited and would entail high capital expenditures (Reid Crowther 2000).
- It may be possible to attenuate the effects of flooding within the study area by constructing storm water retention areas. Three potential sites have been identified, two of which are located within the immediate study area (Reid Crowther 2000).
- Saanich Public Works is responsible for maintaining the existing flow capacity of the channel so that flooding potential does not increase due to obstructions. This requires annual vegetation clearing in some sections of the channel.

### **2.3 Riparian Vegetation**

- The steep, clay banks along Bowker Creek are unsuitable for the establishment of a diverse community of native riparian vegetation (Ship Environmental, 2000).
- Non native plants, including Scotch Broom, blackberry and golden willow, dominate the existing riparian community over extensive sections of the open channel area between Trent Street and Pearl Avenue (Ship Environmental, 2000).
- Golden willow growth within the active channel zone decreases hydraulic capacity of the stream channel and presents significant risk that root materials could contribute to an event driven blockage to stream flow (Ship Environmental, 2000).
- It has been reported that unidentified herbaceous plant species growing along Bowker Creek at St. Patrick's School have contributed to public health complaints (B. Grey, District of Saanich).

### **2.4 Aquatic Community**

- Fish are not present in the section of Bowker Creek between Trent Road and Pearl Avenue (Ship Environmental, 2000).
- The only fish found in Bowker Creek have been sculpins and three spined stickleback. These fish were found in the tidal section of the creek in the District of Oak Bay (Norris 1978).

- Amphibians have not been reported within the study area in recent years (Ship Environmental, 2000).

## **2.5 Aquatic Habitat Limitations**

Fish habitat capabilities in the section of Bowker Creek between Trent Street and Pearl Avenue are extremely low. Low instream habitat diversity, low summer flow and periodic changes in water quality contribute to low habitat capabilities. There are physical barriers to potential upstream fish migration located in the lower section Bowker Creek within the District of Oak Bay. Other known constraints to aquatic habitat capabilities in Bowker Creek include:

- Available water quality data indicate that Bowker Creek has poor to good water quality throughout most of the year. Parameters considered in this conclusion included water temperature, pH, conductivity (nutrients) and turbidity (Ship Environmental, 2000).
- Existing benthic invertebrate communities in Bowker Creek are indicative of stressed water quality environment (Ship Environmental, 2000).
- It is suspected that water quality is degraded during storm events due to mobilization of hydrocarbons and other toxic waste (Ship Environmental, 2000).
- The extensive network of storm drains flowing into Bowker Creek creates a high risk for environmental impact associated with accidental spills and illegal discharges in upland areas of the watershed (A. Johnson, District of Saanich).

Existing aquatic and riparian habitats in Bowker Creek are recognized as important areas for waterfowl and birds of prey.

### **3.0 ENVIRONMENTAL RESTORATION STRATEGY**

The successful implementation of a long term environmental strategy for this section of Bowker Creek will necessitate consideration of watershed management goals, flood control objectives, channel maintenance requirements and land use constraints. The environmental prescriptions discussed in this report will need to be evaluated and implemented in concert with longer term flood control initiatives that may be undertaken. Critical elements of an environmental restoration plan for Bowker Creek are identified and discussed below.

#### **3.1 Public Involvement and Watershed Management Planning**

There are several public interest groups and property owner who have a vested interest in improving environmental conditions in Bowker Creek. An important aspect to the successful implementation of an effective watershed management plan will be to involve these interest groups and property owners during the detailed design phase of the project. It is recommended that the District coordinate an open house meeting where property owners and public interest groups have an opportunity to express their concerns and objectives. Potential goals of a public involvement meeting would be:

- Identify watershed management and flood control objectives.
- Outline the District's proposed plan of action.
- Solicit input from property owners.
- Identify areas where public interest groups such as the Friends of Bowker Creek could become involved in the proposed channel and riparian vegetation restoration work.

Provincial and federal regulatory authorities would also need to be consulted prior to final design and application for permits for all work affecting the creek.

#### **3.2 Non-Native Riparian Vegetation Control**

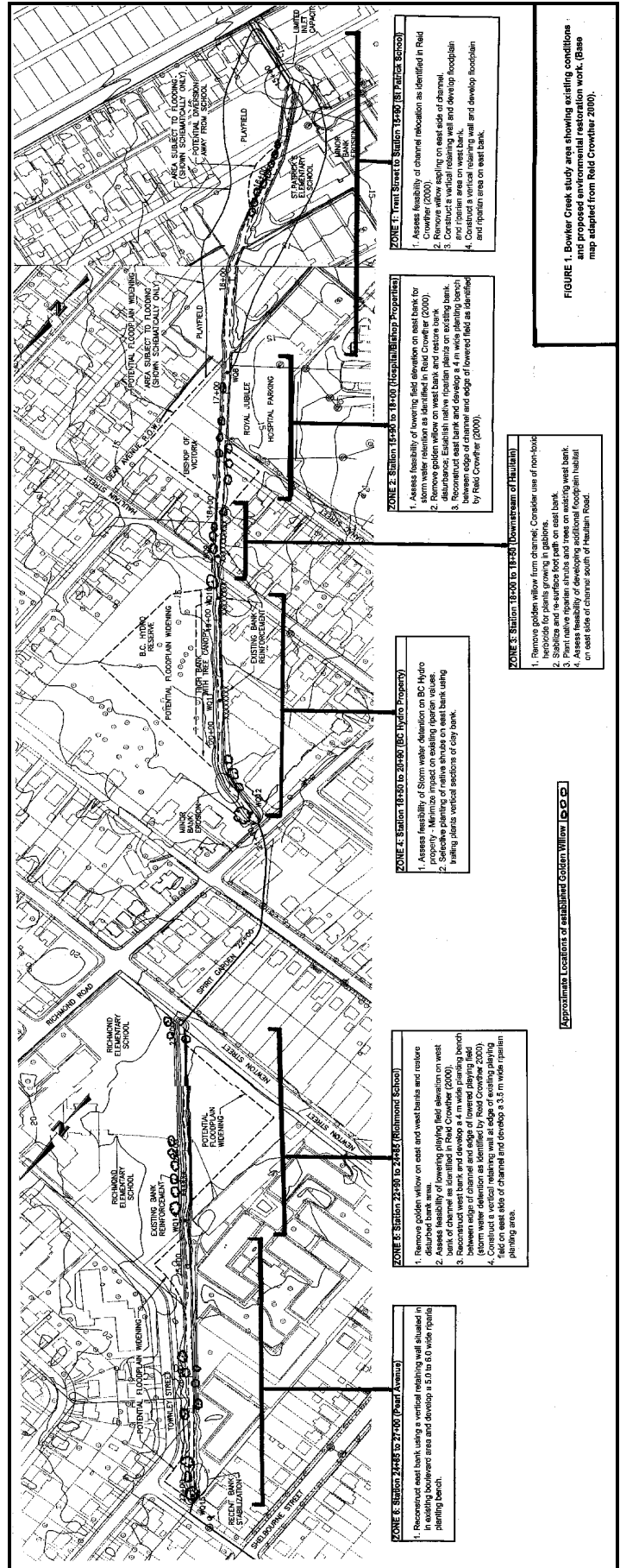
Non-native vegetation is well established throughout much of the study area. The predominant nonnative vegetation includes golden willow (*Salix babylonica*), blackberry, Scotch broom and unidentified thistle species. The golden willow is problematic in that the root structures are large and tend to spread across the wetted channel. The well established nature of the blackberry and

Scotch broom, coupled with poor soil conditions on steep banks, precludes the establishment of most native riparian plant species.

Golden willow are well established in localized areas of Bowker Creek between Trent Street and Pearl Avenue (Figure 1). The District of Saanich has periodically cut the willow trees in order to maintain the hydraulic capacity of the stream channel. However, the cut willow are able to regenerate over a short time period and the root mass continues to grow and expand. Continued growth of the golden willow will further impede flow capacity constraints in the Bowker Creek channel. It is recommended that a systematic willow removal program be undertaken between Trent Street and Pearl Avenue as a first priority for the Bowker Creek riparian vegetation management plan. Mechanical excavation of the root structures will be required for effective control in most locations. Bank restoration work will be necessary where the willow plants have been excavated. Several clumps of golden willow are growing out of the rock filled gabions located downstream of the Haultain Road culvert. Mechanical removal will not be practical here unless the gabion walls are reconstructed. It may be necessary use a non-toxic herbicide on these plants for effective removal.

The proposed golden willow eradication work could be done in phases using the identified stream zones as project areas. It is recommended that Zone 1 (Figure 1) be completed as a first priority since the willow in this area are still in sapling stage and bank disturbance would be minimal. Additional willow removal work in Zones 2 to 6 should be further assessed in context with other riparian restoration work that may be undertaken in these zones.

The feasibility of removing Scotch broom and blackberry cane from the existing bank and then replanting native vegetation is considered to be low in most areas unless extensive bank reconstruction is undertaken at the same time. Existing soil and slope conditions favor these species and it is highly unlikely that native plants could be successfully established under existing slope conditions.



**FIGURE 1. Bowker Creek study area showing existing conditions and zone designation for proposed environmental restoration work.**  
 (see pages 46-47 for a larger version of this map).

### **3.3 Water Quality**

Several initiatives have been undertaken in recent years to improve water quality in Bowker Creek. These initiatives include the reduction of sewage discharges into the creek due to faulty hook-ups, an improved storm water drainage network and installation of oil separators on storm water drainages. Further improvements to water quality are likely possible if these initiatives are continued and expanded. Accidental spills and unauthorized discharges of toxic fluids into the storm water drainage system continue to be a very significant threat to the environmental health of Bowker Creek. It is recommended that potential pollutant sources and high risk areas be identified in the watershed and an extensive public awareness program undertaken. Land use management practices in the watershed should also be investigated including the use of herbicides, pesticides and fertilizers.

Existing riffle habitats are an important factor to maintaining water quality due to aeration capabilities. Developing additional riffle areas would increase water oxygen levels in the stream thereby enhancing water quality.

### **3.4 Flood Control Strategy**

Reid Crowther (2000) provided a comprehensive overview of the factors contributing to stream flooding in Bowker Creek between Trent Avenue and Pearl Street. Alleviating existing flooding problems within the section of Bowker Creek addressed in this report will likely require cooperation and approval from provincial, federal and three levels of municipal governments. Available initiatives will likely be costly and may require extensive negotiation and agreement between several levels of government.

A number of potential flood control initiatives were identified and discussed by Reid Crowther (2000). Potential flood control initiatives that would have a direct effect on habitat areas within the present study area include the construction of storm water retention facilities and channel diversions. Four areas were identified where flood control initiatives could be undertaken within the present study area (Figure 1). The potential sites are located within Zone 1 (channel diversion) and Zones

2, 4 and 5 (storm water retention). Additional engineering feasibility and design work is required for all of these potential initiatives.

It is important that other environmental restoration initiatives that may be undertaken in the study area do not compromise the feasibility of potential storm water retention projects that may be required in the future. Therefore, it is recommended that all environmental restoration work be planned in concert with a comprehensive watershed management plan.

### **3.5 Riparian Restoration and Floodplain Development**

A more functional riparian community could be developed by reconstructing existing banks and providing expanded floodplain area. An expanded floodplain area would increase flood water storage capacity and provide a better environment for native riparian species, such as red osier dogwood, snowberry and big leaf maple. These species would eventually form a canopy cover over the creek channel and provide a moderating influence on water temperatures. Recreational and esthetic values would also be enhanced with an expanded floodplain area and restored native vegetation community.

The most effective approach to increasing functional floodplain area would be to excavate existing bank materials (clay) and construct vertical retaining walls. The vertical retaining walls could be placed in line with the top of the existing banks to avoid impacts to existing land use. However, additional floodplain area could be achieved by locating the retention walls further back from the bank tops in those areas where existing land use would not be adversely affected. The retention walls could be constructed with concrete lock blocks or a masoned stone wall. However, it would be important to maintain the existing wetted width of the channel so that the creek flow is not subjected to excessive solar radiation during the summer months. It is recommended that any floodplain widening work within Zones 1 to 6 of Bowker Creek include provisions for distinct active channel and vegetated floodplain zones. Vertical retention walls may not be required in areas where more extensive storm water storage work is planned.



#### **4.0 EXISTING CONDITIONS AND PRESCRIBED TREATMENTS**

The total length of channel between the culvert invert at St. Patrick School near Trent Street upstream to the culvert outlet at Pearl Avenue is approximately 1,150 m. This includes a 190 m long section of channel that is enclosed in a conduit running between Richmond Avenue and Newton Street, and a 10 m long box culvert at the Haultain Road crossing. The open sections of Bowker Creek between Trent Street and Pearl Avenue have been divided into six zones based on prevailing channel characteristics, land use and property ownership (Figure 1). Existing conditions, prescribed treatments and environmental design concepts are described for each zone in the following sections, starting from the downstream boundary of the study area.

##### **4.1 Zone 1: St Patrick School - Trent Street**

This zone is approximately 140 m long and extends from the invert of the Trent Street culvert upstream to the property boundary between St. Patrick School and the Royal Jubilee Hospital.

###### **4.1.1 Channel and Bank Characteristics**

The excavated channel has a total width of 9.4 m from top of bank to top of bank. The active channel bottom is approximately 3.9 m wide. Total depth of channel averages 2.6 m. Average water depth was approximately 25 cm and the average wetted width was 3.6 m at the time of inspection. There are numerous small silt bars that have formed in the active portion of the channel. The bottom of channel is characterized by exposed clay with silt deposits in some areas. There is no gravel or cobble in this zone. The stream channel is characterized by shallow run habitat; there is no pool or riffle area and instream habitat diversity is low.

The total average width of the west bank (school side) from the wetted edge to the top of bank is approximately 2.8 m. The lower 0.8 m of the bank is close to vertical throughout most of this zone. The total height of the bank is approximately 2.5 m. A moderate degree of bank erosion is evident throughout this zone (Plate 1). The District has periodically stabilized banks in this area using concrete filled sand bags. Additional bank restoration is required to alleviate existing erosion on the west bank.



**PLATE 1: Zone 1 of Bowker Creek adjacent to St. Patrick School showing eroding west bank and golden willow growth in channel at base of east bank.**



**PLATE 2. Upstream section of Zone 1 showing steep bank conditions and adjacent playing field on east side of creek.**

The total average width of the east bank (playing field side) from the top of bank to the wetted edge is approximately 2.7 m. There is a 0.6 m wide bench at the base of the bank. The existing bank above the bench is stable.

#### **4.1.2 Riparian Vegetation**

The slopes of the west and east banks are vegetated with grasses and herbaceous plants. Thick clumps of young golden willow have established on the bench at the base of the east bank (Plate 1). There is very little over hanging bank vegetation throughout this zone (Plate 2).

The former school principle has reported that there is an unidentified plant growing along side the creek that causes allergic/respiratory reactions in some students (B. Grey, pers. comm.). The District of Saanich routinely cuts these plants during the summer.

There is very little vegetation shading in this zone and the stream channel is exposed to direct sun exposure.

#### **4.1.3 Land Use and Property Constraints**

St. Patrick School is situated on the west side of the channel and the existing building encroaches onto the top of the stream bank in two locations. The surrounding school ground is paved up to the top of the stream bank and used as parking lot. The St. Patrick School playing field is situated on the east bank. Field grass extends up to the fence situated on top of the east bank. Both sides of the creek are fenced. The fenced creek corridor is 9.5 m wide.

There is a foot bridge over Bowker Creek approximately 50 m upstream of the Trent Street culvert invert. This foot bridge provides access from the school to the adjacent playing field. There is an informal path along the top of the west bank that extends upstream to Haultain Avenue and beyond. The foot bridge and path are used by the public.

#### **4.1.4 Completed and Planned Environmental Initiatives**

The school yard and playing field have been inundated during past flood events (1975 and 1982; A. Johnson, pers. comm.). The inlet of the Trent Street culvert was modified in 1990 to improve flow conveyance through the culvert. There are no proposals for widening the active floodplain in this zone. Reid Crowther (2000) identified a potential channel diversion on the east bank adjacent to the upstream end of the school building. This potential channel diversion is approximately 40 m long and would encroach into the existing playing field. The diversion would necessitate excavation and reconstruction of the west bank.

The Friends of Bowker Creek Society have undertaken small scale riparian plantings at selected locations in this area (K. Jancowski, pers. comm). The Society proposed to undertake more extensive riparian vegetation restoration work along this section of creek in 1998 but the proposal was not funded (K. Jancowski 1998).

#### **4.1.5 Environmental Design Concepts**

##### West Bank

The existing bank along the west side of the channel has no significant environmental values and is actively eroding. Soil conditions and slope characteristics of the existing bank slopes are not suitable for the establishment of a native riparian plant community. Re-constructing the bank using a vertical retention wall along the existing fence line would provide an opportunity for reclaiming up to 2.0 m of active floodplain habitat that could be planted with native plant species. This approach would require excavation of the existing bank back to the existing fence line, installation of vertical retaining wall and installation of a 0.6 m high planting bench. The planting bench would require a layer of rip rap placed at the existing wetted edge of the channel and back-filling with organic soils on the back side of the rip rap up the vertical retaining wall (Figure 2).

##### East Bank

Golden willow is becoming established along the lower bench of the east bank. This species grows and spreads rapidly and the root systems tend to encroach into active stream channel areas. These

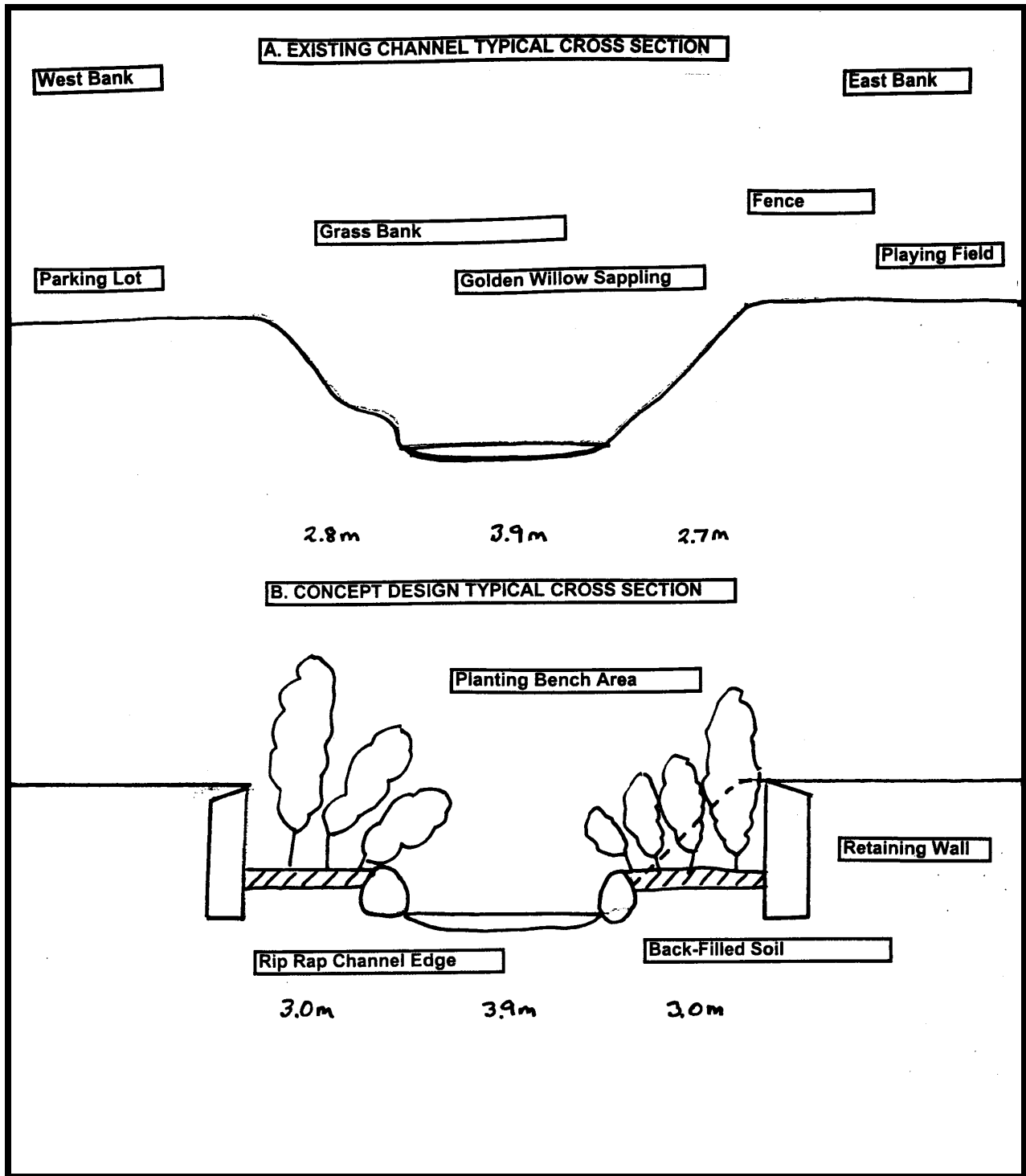


FIGURE 2. Typical cross section of Bowker Creek in Zone 1 showing concept design for proposed bank reconstruction and riparian restoration work.

willow plants should be removed throughout the entire length of Zone 1. Mechanical excavation will be required to effectively remove the root structures. Construction mitigation measures would be required to ensure downstream water quality is maintained. This work would not compromise any other flood control initiatives in this zone.

Reid Crowther (2000) identified a potential channel relocation on the east side of the existing channel. This potential channel relocation would alleviate some of the flood damage potential to the school buildings. The potential work would necessitate the reconstruction of a portion of the existing east bank and there would be an encroachment into the playing field affecting existing land use. Existing land use constraints may affect the feasibility of this potential work.

The slope of the east bank is vegetated with grasses and herbaceous plants, some of may be responsible for cause allergic reaction. Existing soil and slope conditions are marginal for the establishment of native riparian plants. If the previously discussed channel relocation work is feasible and desirable to the property owner, then it may be possible to consider additional floodplain reclamation work along the length of the east bank channel throughout Zone 1 using a similar design to that described for the west bank (Figure 2). This would allow for the establishment of additional active floodplain area and a native riparian plant community. Estimated quantities and costing guidelines for the bank excavation and reconstruction work are presented in Appendix 1.1

## **4.2 Zone 2: Royal Jubilee Hospital - Bishop Property**

This zone is 120 m long and extends from the upstream property boundary of St. Patrick School upstream to north side of the Bishop of Victoria property.

### **4.2.1 Channel and Bank Characteristics**

The excavated channel has a total width of approximately 8.0 m from top of bank to top of bank. The active channel bottom is approximately 3.0 m wide and the total depth of channel averages 2.8 m. Average water depth was approximately 25 to 30 cm and the average wetted width was 3.5 m at the time of inspection. The bottom of channel is characterized by exposed clay with silt deposits in

some areas. There is no gravel or cobble in this zone. The stream channel is characterized by shallow run habitat; there is no pool or riffle area and instream habitat diversity is low.

The total average width of the west bank from the wetted edge to the top of bank is approximately 3.0 m. There were no signs of active erosion on the west bank at the time of inspection.

The total average width of the east bank from the top of bank to the wetted edge is approximately 2.0 m. There is a 15 m long section of the east bank that is actively eroding approximately 60 m downstream of Haultain Road (Plate 5). There are no bank reinforcement structures in this zone.

#### **4.2.2 Riparian Vegetation**

The slope of the east bank is vegetated with a dense growth of Scotch broom and an under-storey of tall grasses (Plate 3). Playing field grass extends to the top of the bank on the east side of the channel. The west bank has a diverse riparian community including hawthorn, golden willow and aspen trees and some snowberry. Approximately 30% of the east bank is covered with Scotch broom. Close to 80% of the west bank is vegetated with broom. There are 16 golden willow trees present in this section. These trees are up to 6 m in height with stem diameters of 12 cm and most are growing close to the channel edge (Plate 4). Overhanging vegetation provides shading to approximately 40% of the stream channel in this zone (Plate 3).

#### **4.2.3 Land Use and Property Constraints**

The lower 70 m of this zone flows through the Royal Jubilee Hospital property. The east side of the property is unoccupied and consists of a grass field. A portion of the property on the west side of the creek is used for parking and a helicopter landing pad. The District has a 20 m right-of-way (ROW) access along Adanac Street immediately upstream of the hospital property. The ROW is undeveloped. The Bishop of Victoria owns the property on both sides of the creek from the Adanac Street ROW to the upstream end of this zone. This property is undeveloped on both sides of the creek. There have been proposals to develop this property as residential area, however, development approvals were denied due to flooding concerns.



**PLATE 3. Zone 2 of Bowker Creek adjacent to Royal Jubilee Hospital showing eroding east bank and existing riparian vegetation community.**



**PLATE 4. West bank of Bowker Creek in Zone 2 showing golden willow growth along edge of channel.**



#### **4.2.4 Completed and Planned Environmental Initiatives**

Reid Crowther (2000) identified extensive potential for floodplain enlargement throughout this zone and recommended that additional feasibility evaluation be undertaken (Figure 1).

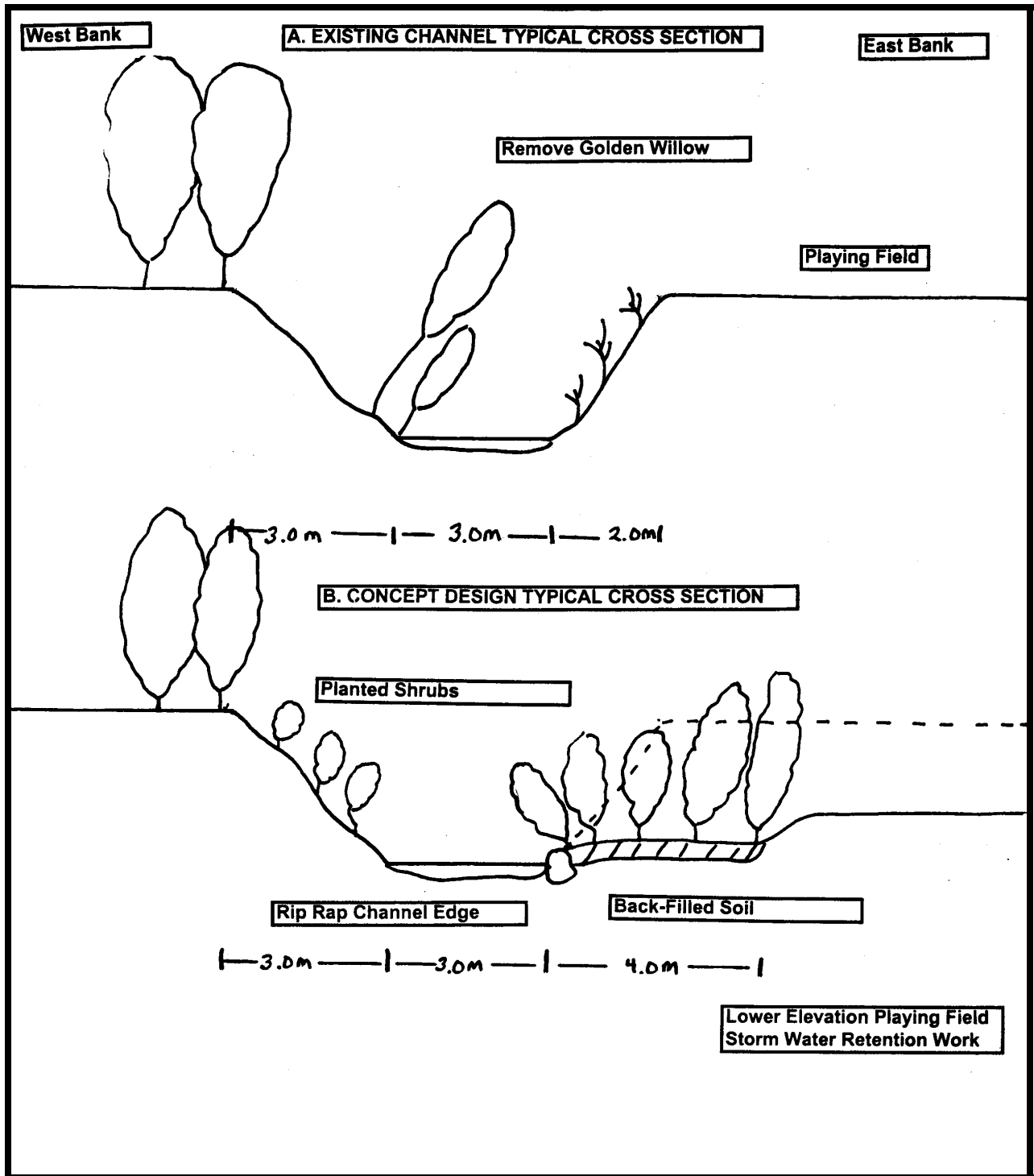
The Royal Jubilee Hospital commissioned Barlow (1998) to conduct an environmental assessment of the section of creek channel flowing through hospital property. Barlow (1998) identified a number of areas where stream side planting would be advantageous and also suggested storm water treatment facilities before discharge into Bowker Creek. The Friends of Bowker Creek Society have undertaken small scale riparian plantings at selected locations in this area (K. Jancowski, pers. comm). The Society had proposed to undertake more extensive riparian vegetation restoration work along this section of creek in 1998 but the proposal was not funded (K. Jancowski 1998).

#### **4.2.5 Environmental Design Concepts**

##### West Bank

The west bank is well vegetated and there is no sign of significant erosion. Existing riparian vegetation on the west bank is moderately diverse and provides partial shading to the creek channel. Approximately 30% of the west bank is vegetated with broom. It may be feasible to control further spread of the broom on the west bank with a systematic removal program using hand labour. There are several young golden willow trees growing along the base of the west bank (Plate 4). Future growth of these trees may result in further constraints on the hydraulic capacity of the channel. Therefore, consideration of tree removals may be warranted.

Existing bank and riparian conditions on the west bank have moderately high environmental values. Therefore, there is a lower priority to reconstruct the existing bank and completely restore riparian vegetation on this side of the channel. However, additional floodplain area and an improved riparian plant community could be achieved if the bank was reconstructed (Figure 3). Property owner approval and cooperation would be required for this potential work. Estimated quantities and costing guidelines for the bank excavation and reconstruction work are presented in Appendix 1.



**FIGURE 3. Typical cross section of Bowker Creek in Zone 2 showing concept design for proposed bank reconstruction and riparian restoration work**

### East Bank

The east bank is very steep and is actively eroding in some sections. Riparian vegetation on the clay bank slope is limited to Scotch broom and grass. The feasibility of effective riparian vegetation restoration on the existing east bank is low due to the widespread extent of the broom and the steep nature of the clay banks. The adjacent east bank property has been identified as a potential area for storm water retention. Reconstructing this bank and re-establishing a native riparian vegetation community would increase floodplain area and improve environmental values (Figure 3). This work could be done without affecting the feasibility of future storm water retention work that may be required at the site. Property owner approval and cooperation would be required for this potential work.

### **4.3 Zone 3: Downstream of Haultain Road**

This zone is 55 m long and extends downstream from the outlet of the Haultain Road culvert.

#### **4.3.1 Channel and Bank Characteristics**

The channel is highly confined and constricted throughout this zone. The west bank is reinforced with rock filled gabions. The gabions are stacked vertically and the wall is approximately 2.2 m high. The east bank is steeply sloped clay bank with areas of minor erosion. The total width of the east bank between the edge of the active channel and the top of the bank is approximately 6.5 m. The upper most section of the east bank immediately downstream of the Haultain Road culvert is reinforced with vertically stacked gabions and rip rap over a distance of approximately 6.5 m.

There is a concrete sill that extends across the outlet of the culvert. The downstream end of the concrete sill slopes down and creates a 40 cm drop in the water elevation from the culvert to the downstream section of channel. This drop creates some water turbulence in a shallow plunge pool at the downstream side of the concrete sill. The downstream section of channel is characterized by shallow run habitat with an average wetted width of approximately 2.5 m. There is very little instream habitat diversity in this zone.

### **4.3.2 Riparian Vegetation**

The west bank is vegetated with grasses on top of the rock filled gabions. A thicket of blackberry canes is present approximately 1.0 m back from the edge of the gabions (Plate 5). The east bank is vegetated with Scotch broom, blackberry canes and grasses. Golden willow are well established on a 10 m long section of the east bank downstream of Haultain Road box culvert. The willow growth extends downslope into the active channel. These willow trees are approximately 4.5 m high with stem diameters of 10 cm (Plate 6). Several willow trees are growing amongst the rock filled gabions. Photographs taken at this site by the Friends of Bowker Creek Society in 1997 show the same trees when they were less than 1 m high (letter from K. Jancowski to District of Saanich, January 29, 1998).

The steep banks and willow growth provide some stream side shading in this zone.

### **4.3.3 Land Use and Property Constraints**

Developed residential properties exist on both sides of the channel in this zone. There are narrow foot paths on both sides of the channel. A section of the east bank foot path is perched immediately on top of the bank edge and is unstable. The foot path is confined to this location by the close proximity of a residential property. The stream banks are not fenced in this zone.

### **4.3.4 Completed and Planned Environmental Initiatives**

No environmental initiatives were identified for this creek zone in the Reid Crowther (2000) report. The District of Saanich has periodically cleared vegetation from the active channel and installed the bank stabilization structures.

The Friends of Bowker Creek Society have undertaken small scale riparian plantings at selected locations in this zone (K. Jancowski, pers. comm). The Society had proposed to undertake more extensive riparian vegetation restoration work along this section of creek in 1998 but the proposal was not funded (K. Jancowski 1998).



**PLATE 5. Zone 3 of Bowker Creek showing vertical retaining wall and existing riparian vegetation on west bank.**



**PLATE 6. East bank of Bowker Creek in Zone 3 showing golden willow growth along gabion wall at the outlet of the Haultain Road culvert.**

### **4.3.5 Environmental Design Concepts**

Existing land use constraints and property ownership severely constrain environmental enhancement opportunities in this zone. Golden willow trees growing along the edge of the channel have the potential to further restrict the hydraulic capacity of the stream channel. Removal of the root structures could not be accomplished without significant disturbance to the existing gabion wall.

A section of the existing east bank path is unstable and is perched immediately on top of an eroding stream bank. It is recommended that the eroding bank be stabilized using red osier dogwood cuttings and transplanted native shrub species. The path should be stabilized and resurfaced to lessen potential risks to pedestrians.

It is recommended that selective planting of native plants be undertaken on the bank top and slopes. Existing non-native riparian vegetation would need to be removed by hand. Suitable plant species for the restoration work would include red osier dogwood, snowberry and alder trees.

## **4.4 Zone 4: BC Hydro Property - Haultain to Richmond**

This zone is 207 m and extends from the invert of the Haultain Road culvert upstream to the culvert outlet at Richmond Avenue.

### **4.4.1 Channel and Bank Characteristics**

The average height of the west bank is approximately 3.0 m and the width of the bank between the wetted edge and the bank top is 1.8 m. The bank slope is steep (1.5: 1) in most sections and there are vertical sections in two locations where rock gabions and concrete filled sand bags have been used to stabilize the bank (Plate 7). There are several areas of active minor bank erosion in this zone. The east bank is approximately 2.9 m high and has an average width of 3.5 m between the wetted edge and the bank top. The bank slope is similar to the west bank and there are some near vertical sections of the bank that are being actively eroded (Plate 8).



**PLATE 7. Zone 5 of Bowker Creek showing cement filled sand bags and mature golden willow growth on west bank adjacent to apartment building complex.**



**PLATE 8. Mid-section of Zone 4 Zone 4 showing eroding east bank (right side of photo) and existing riparian vegetation.**

Two sections of the west bank have been reinforced with rock filled gabions and rip rap forming vertical banks. These sections are approximately 2.2 m high.

The stream channel in Zone 4 has a moderately high degree of instream habitat diversity with several short riffle sections, shallow pools and moderately deep runs. There is some large rock and cobble in the channel.

#### **4.4.2 Riparian Vegetation**

The west bank is predominantly vegetated with blackberry cane and grasses. Golden willow are present in some locations growing near to the wetted edge.

The east bank slope is vegetated with blackberry cane and grasses and the occasional native shrub species including snowberry and red osier dogwood. The top of the east bank is vegetated with a planted grove of coniferous fir trees including cedar, fir and pine. These trees are approximately 15 m in height with stem diameters ranging between 25 and 35 cm. There are a number of smaller indigenous deciduous trees growing on the crest of the bank top. There is a large, mature weeping willow tree growing in the active channel near the outlet of the Richmond Road culvert. The root mass from this tree and some nearby smaller willow trees encroaches into the wetted portion of the channel.

The channel has a well developed riparian canopy throughout this zone.

#### **4.4.3 Land Use and Property Constraints**

The west bank is occupied by single and multifamily residential developments throughout this zone. This side of the channel is fenced at the top of the bank.

The east bank is undeveloped land reserve owned by BC Hydro. The BC Hydro property is used as informal parkland. There is a well developed stream side trail along the top of the east bank. The trail has recreational values and is used as an access route between Haultain Road and Kings Road. A



poorly developed foot path leads down to the stream channel near the outlet of the Richmond Road culvert. There is a swing that is used by playing children in this area.

#### **4.4.4 Completed and Planned Environmental Initiatives**

Reid Crowther (2000) identified the BC Hydro property as a potential site for large scale storm water detention. The District of Saanich has installed bank stabilization structures in the lower sections of this zone.

The Friends of Bowker Creek Society have undertaken small scale riparian plantings at selected locations in this section, however, there was limited success due to bank conditions (K. Jancowski, pers. comm). The Society proposed to undertake more extensive riparian vegetation restoration work along this section of creek in 1998 (Jancowski 1998).

#### **4.4.5 Environmental Design Concepts**

Extensive environmental restoration work on the west bank is likely not feasible due to existing land use and property ownership constraints. Small scale riparian planting and bio-engineered treatments on unstable sections of the bank may be warranted. Existing high riparian values on the top of the east bank preclude the environmental feasibility of extensive bank reconstruction work in this zone. The feasibility of additional riparian planting on the east bank is low due to existing bank conditions. Bank top planting of trailing plants may improve bank stability in areas where there is existing erosion.

### **4.5 Zone 5: Richmond School Property**

This zone extends from Newton Road upstream along the Richmond School property over a distance of 210 m.

#### **4.5.1 Channel and Bank Characteristics**

This section of the channel is fenced on both sides at the top of the banks. The average channel width from top of bank to top of bank is 15 m. The total width of the east bank is approximately 4.3 m

from the top of bank to the wetted edge of the channel and the bank is 4.5 m high. There is a 1.0 to 1.5 m wide bench approximately 30 cm below the top of bank elevation. The slope of the east bank is moderately steep. There is no significant erosion on the east bank. The west bank is approximately 2.5 m wide between the top of bank and edge of wetted channel. This bank is steeper than the east bank and there are several short eroding sections. Clay is the predominant bank material on both sides of the channel. The stream channel has a low gradient and is characterized by shallow run habitat with a bed material of silt. There is a rock constriction at the upstream end of this zone that creates a short riffle area.

#### **4.5.2 Riparian Vegetation**

The east and west banks of the channel downstream of the footbridge are vegetated with a dense growth of Scotch broom and blackberry cane (Plate 9). There are a few young golden willow growing adjacent to the channel immediately upstream of the Newton Road culvert. Scotch broom and blackberry growth persists on both sides of the channel upstream of the foot bridge along with a well established band of golden willow trees (Plate 10). There are very few native plants growing in this zone. Small numbers of red osier dogwood are present.

#### **4.5.3 Land Use and Property Constraints**

The east and west sides of the channel corridor are developed playing fields owned and used by Richmond School. There is a foot bridge across the channel linking the two playing fields. Public access along the creek channel is restricted by the school.

#### **4.5.4 Completed and Planned Environmental Initiatives**

Reid Crowther (2000) identified the west bank playing field as a potential site for large scale storm water retention.

The Friends of Bowker Creek Society had proposed to undertake selective riparian vegetation restoration work along this section of creek in 1998 but the proposal was not funded (K. Jancowski 1998).



**PLATE 9. Existing bank conditions in Zone 5 of Bowker Creek showing predominance of Scotch broom and slumping bank on west side of channel.**



**PLATE 10. Zone 5 of Bowker Creek looking upstream from footbridge showing Scotch broom on west bank and golden willow growth on east bank.**

#### **4.5.5 Environmental Design Concepts**

Existing riparian habitat values are low on both sides of the creek. Riparian vegetation restoration opportunities on the existing bank slopes are extremely limited due to existing bank conditions and a predominance of broom.

Functional floodplain habitat and a restored native riparian vegetation community could be restored if the existing banks were reconstructed. Floodplain and riparian planting area on the east bank could be maximized without affecting existing land use if a vertical retaining wall design was used (Figure 4). The same effect could be achieved on the west bank if the bank was excavated and reconstructed with a low elevation planting bench. It may be possible to complete this work without using a vertical retaining wall if the work was incorporated into a design for the proposed storm retention work at this site (Figure 4). Estimated quantities and costing guidelines for the bank excavation and reconstruction work are presented in Appendix 1.

Existing golden willow growth may affect flow capacity in the channel as these trees mature. Therefore, a stand alone tree removal program may be warranted if the proposed bank reconstruction work is not undertaken. An excavator would be required to effectively remove the root structures. Site restoration and bank stabilization work would likely be required in those areas where trees are removed.

#### **4.6 Zone 6: Downstream of Pearl Avenue**

Zone 6 extends over a distance of 225 m from the upstream boundary of the Richmond School property to the culvert outlet at Pearl Avenue.

##### **4.6.1 Channel and Bank Characteristics**

The average channel width from top of bank to top of bank is approximately 9.0 m and the active channel width is approximately 2.8 m. The total width of the east bank is approximately 3.0 m from the top of bank to the wetted edge of the channel and the bank is approximately 3.0 m high. The slope of the east bank is moderately steep. There is no significant erosion on the east bank.

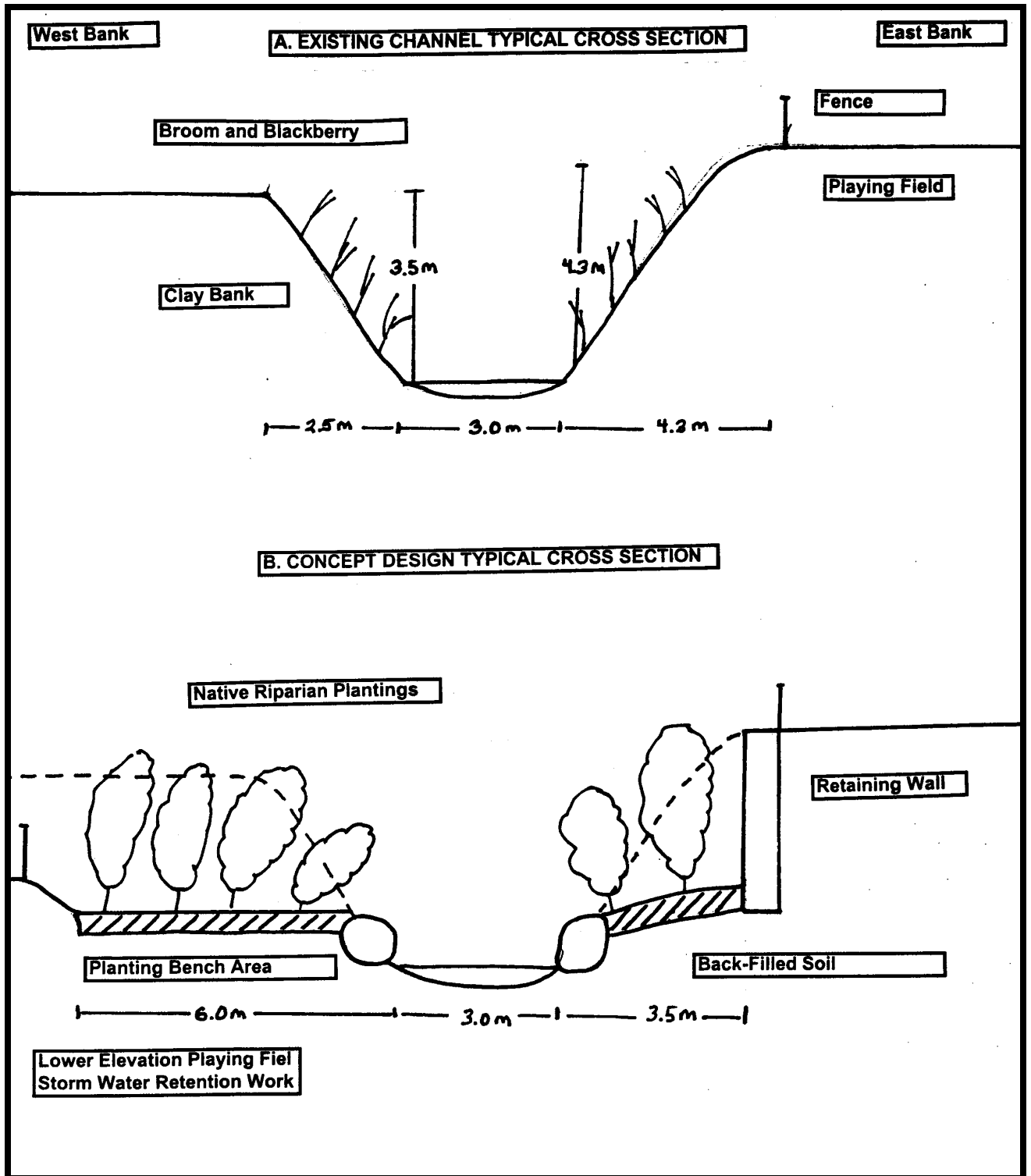


FIGURE 4. Typical cross section of Bowker Creek in Zone 5 showing concept design for proposed bank reconstruction and riparian restoration work

Sections of the west bank have been stabilized using rock filled gabions and rip rap (Plate 11). The west bank is approximately 2.8 m high. The width of the west bank from top of bank to the edge of water is generally less than 1.5 to 2.0 m. There are a some areas where the existing bank is prone to channel erosion.

Clay is the predominant bank material on both sides of the channel. The stream channel is primarily characterized by shallow run habitat with a bed material of clay and some gravel and cobble. There is a shot riffle section at the outlet of the Pearl Street culvert.

#### **4.6.2 Riparian Vegetation**

A laurel hedge has been planted along the top of the west bank throughout most of this zone. Blackberry canes are well established throughout the length of the west bank. There are two golden willow growing on the west bank downstream of the footbridge. Planted snowberry, red osier dogwood and pacific willow are present on the west bank immediately downstream of the culvert outlet. The downstream end of the east bank is heavily vegetated with blackberry. Several golden willow are present on the east bank upstream of the foot bridge (Plate 12). There are two large golden willow growing at the edge of the channel near the culvert outlet. There are three clumps of golden willow growing at the channel edge approximately 25 m downstream of the footbridge. A few unidentified poplar trees are present on the east bank downstream of the footbridge.

#### **4.6.3 Land Use and Property Constraints**

The west bank of the channel is developed multi-family residential area. Apartment buildings are situated very close to the top of the bank in some areas. The area on the east side of the channel is District property and has been landscaped as grass boulevard. Deciduous trees have recently been planted along the boulevard between the creek channel and Townley Road. There is a foot bridge that crosses the channel in the mid-section of this zone. The Townley Road sidewalk is situated 5 m back from the top of the stream bank (Plate 12).



**PLATE 11. Zone 6 of Bowker Creek showing gabion wall on west bank downstream of foot bridge with planted laurel hedge on top of bank.**



**PLATE 12. Zone 6 of Bowker Creek showing blackberry thicket and golden willow growth along east bank of channel adjacent to Townley Street boulevard.**

#### **4.6.4 Completed and Planned Environmental Initiatives**

Reid Crowther (2000) identified the east bank as a potential site for floodplain widening. The District of Saanich reconstructed a failed section of the west bank immediately downstream of the Pearl Street culvert outlet using rip rap bio-engineered stabilization techniques. This area was replanted with native vegetation.

#### **4.6.5 Environmental Design Concepts**

Property constraints preclude the possibility of bank reconstruction work and floodplain development on the west bank. The east bank could be reconstructed to provide new floodplain and riparian area. The existing east bank could be reconstructed using a similar design concept to that presented for the east bank of Zone 5. New floodplain area would be maximized if the vertical retaining wall was situated near the edge of the existing sidewalk. This would necessitate excavation of the existing bank materials on the stream side of the fence and a 3 to 4 m wide section of boulevard area between the existing fence and sidewalk (Figure 5). Estimated quantities and costing guidelines for the bank excavation and reconstruction work are presented in Appendix 1.

There are several areas where the removal of golden willow would improve flow conveyance in the existing channel (Figure 1).



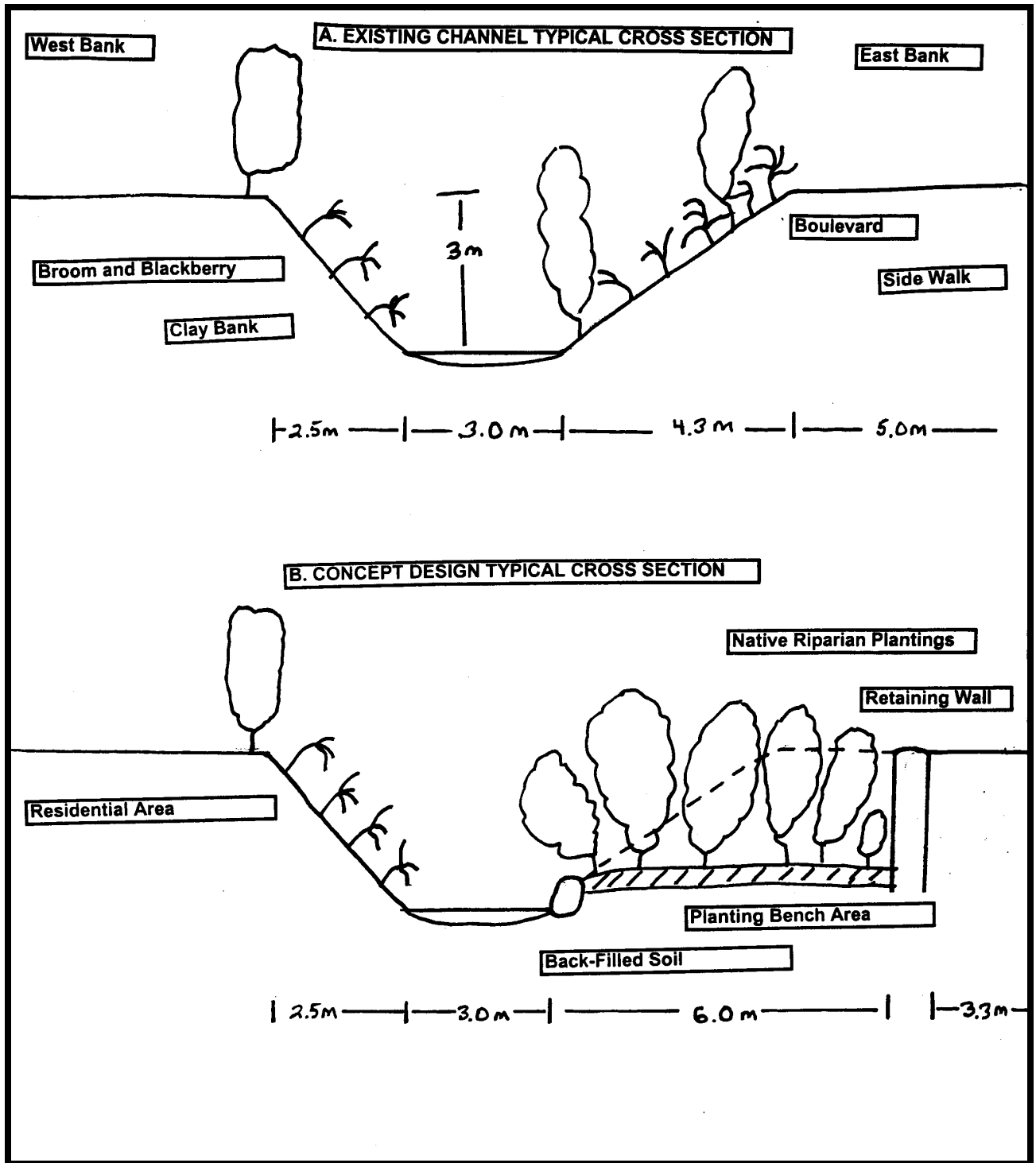


FIGURE 5. Typical cross section of Bowker Creek in Zone 6 showing concept design for proposed bank reconstruction and riparian restoration work.

## **5.0 SUMMARY**

The section of Bowker Creek between St. Patrick School and Pearl Street is characterized by a highly confined channel with no significant floodplain habitat. The banks are steep and largely consist of clay with very little soil. Several sections of the bank have been reconstructed using rock filled gabions and cement filled sand bags. There is very low instream habitat diversity. Fish habitat capabilities are further constrained by low summer flows and poor water quality. Fish are not found in this section of the creek. In several areas the existing riparian vegetation community is predominated by broom and blackberry. Golden willow are well established in some zones of the creek. These plants can affect the hydraulic capacity of the channel. The District of Saanich periodically cuts and removes plants to maintain the hydraulic capacity of the channel. Highest riparian habitat values in the present study area are found in Zone 4 adjacent to the BC Hydro property.

This section of Bowker Creek is prone to periodic flooding and there has been property damage in the past. The absence of floodplain habitat has compounded flooding problems. A planning study identified several sites within the present study area that may be suitable for floodplain widening and detention of storm water. A comprehensive watershed management plan will be required to address flood issues and environmental restoration objectives. This will necessitate consultation between several levels of government, property owners and local interest groups who have been involved in stream side restoration initiatives.

Previous studies have identified that Golden willow has a significant constraint on the flow capacity of the channel. The District of Saanich periodically removes vegetation growth in the channel as part of their channel maintenance program. The location of golden willow growth in this section of Bowker Creek has been mapped as part of this assessment. Since this species grows and spreads rapidly, the District should implement an effective control strategy as a high priority.

Design concepts for environmental restoration work that would be compatible with future storm water retention projects have been presented for six stream zones between Trent Street and Pearl

Avenue. Bank reconstruction and floodplain widening have been proposed for four of the six stream zones. It may be possible to complete some of the proposed floodplain widening and riparian restoration work without affecting existing land use in upland areas. Further assessment work is required to determine engineering feasibility and land use suitability where floodplain widening has been recommended.

A number of general recommendations have been made for the watershed. These include:

- A. Coordinate an "open-house" meeting where property owners and public interest groups can express their concerns and objectives to the District.
- B. Undertake a systematic willow removal program between Trent Street and Pearl Avenue as a first priority for the Bowker Creek riparian vegetation restoration plan.
- C. It is recommended that the District outline the long term vegetation management plan for Bowker Creek to DFO including the strategy for the removal and control of Golden Willow and include this as part of their annual stream maintenance program. .
- D. Identify potential pollutant sources and high risk areas and develop a an extensive public awareness program related to land use management practices including the use of herbicides, pesticides and fertilizers.

A summary of the proposed environmental prescriptions for each stream zone is provided below:

**Zone 1:**

- 1. Assess feasibility of channel relocation as identified in Reid Crowther (2000).
- 2. Construct a vertical retaining wall along edge of school parking lot on west bank of channel and develop a riparian planting bench.
- 3. Remove willow sapling growing beside wetted edge on east side of channel.
- 4. Construct a vertical retaining wall at edge of existing playing field and develop a riparian planting bench.

**Zone 2:**

5. Assess feasibility of lowering field elevation on east bank for storm water retention as identified in Reid Crowther (2000).
6. Remove golden willow on west bank and restore bank disturbance; Establish native riparian plants on existing bank slope.
7. Reconstruct east bank and develop a 4 m wide planting bench between edge of channel and edge of lowered field (storm water detention as identified by Reid Crowther 2000).

**Zone 3:**

8. Remove golden willow from channel; Consider use of non-toxic herbicide for those plants growing in rock-filled gabions.
9. Stabilize and resurface foot path on east bank.
10. Plant native riparian shrubs and trees on existing west bank
11. Assess feasibility of developing additional floodplain and riparian planting area on east side of the channel south of Haultain Road.

**Zone 4:**

12. Assess feasibility of storm water retention pond on BC Hydro property as identified in Reid Crowther (2000); Storm water retention should be designed to minimize impact on existing east bank riparian vegetation.
13. Selective planting of native riparian shrubs on east bank using trailing plants for vertical sections of clay bank.

**Zone 5:**

14. Remove golden willow on east and west banks and restore areas of bank disturbance.
15. Assess feasibility of lowering playing field elevation on west bank of channel as identified by Reid Crowther (2000).
16. Reconstruct west bank and develop a 4 m wide planting bench between edge of channel and edge of lowered playing field (storm water detention as identified by Reid Crowther 2000).
17. Construct a vertical retaining wall at edge of existing playing field on east side of channel and develop a 3.5 m wide riparian planting bench.

**Zone 6:**

18. Reconstruct east bank using a vertical retaining wall situated in existing boulevard area and develop a 5.0 to 6.0 m wide riparian planting bench.

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- Friends of Bowker Creek Society, 1998. Proposal to District of Saanich to undertake riparian restoration work in Bowker Creek.
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- Siska, M. Report on Bowker Creek impacts, St. Patrick School, Victoria. Prepared for St. Patrick's School Board, April 1983.

## **PERSONAL COMMUNICATIONS**

- Grey, B. District of Saanich, personal communication
- Jancowski, K. Friends of Bowker Creek, personal communication.
- Johnson, A. District of Saanich, personal communication

**APPENDIX 1.**

**Preliminary Cost Guidelines for Bank Reconstruction and  
Riparian Restoration Work in Zones 1 to 6 of Bowker  
Creek: Trent Street to Pearl Avenue.**

**TABLE 1. Estimated quantities and cost guidelines for proposed environmental treatments for Zone 1: St. Patrick School Property.**

<b>East Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	4.0 m	\$32.00
Excavation/Hauling	8 m <sup>3</sup>	\$160.00
Lock Block Wall	2.5 m high	\$1,400.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Filling Organics	1.5 m <sup>3</sup>	\$45.00
Erosion Control/Surface Treatment	3.0 m <sup>2</sup>	\$60.00
Riparian Restoration	3.0 m <sup>2</sup>	\$45.00
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$1,817.00
Length of Prescription (m) and Cost	145	\$263,465.00

<b>West Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	Salvage	\$0.00
Excavation/Hauling	3 m <sup>3</sup>	\$60.00
Lock Block Wall	2.5 m high	\$1,400.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Filling Organics	3 m <sup>3</sup>	\$45.00
Erosion Control/Surface Treatment	3 0 m <sup>2</sup>	\$60.00
Riparian Restoration	4.5 m <sup>2</sup>	\$45.00
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$1,685.00
Length of Prescription (m) and Cost	145	\$244,325.00

**NOTES:**

1. Lock block wall installation has been priced at \$700 per linear meter for a 2.5 m high wall.
2. Lock block walls would be situated on existing fence line to avoid land use impacts.



**TABLE 2. Estimated quantities and cost guidelines for proposed environmental treatments for Zone 2: Bishop of Victoria/Royal Jubilee Properties.**

<b>East Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	4 m	\$32.00
Excavation/Hauling	28 m <sup>3</sup>	\$200.00
Lock Block Wall*	Benched	\$0.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Filling Organics	2 m <sup>3</sup>	\$60.00
Erosion Control/Surface Treatment	4 m <sup>2</sup>	\$80.00
Riparian Restoration	4 m <sup>2</sup>	\$60.00
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$507.00
Length of Prescription (m) and Cost	130	\$65,910.00

<b>West Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	NA	\$0.00
Excavation/Hauling	NA	\$0.00
Lock Block Wall	NA	\$0.00
Rock Placement	NA	\$0.00
Back Filling Organics	NA	\$0.00
Erosion Control/Surface Treatment	4 m <sup>2</sup>	\$80.00
Riparian Restoration	4 m <sup>2</sup>	\$60.00
Fencing	NA	\$0.00
Total Cost per Linear Meter		\$140.00
Length of Prescription (m) and Cost	130	\$18,200.00

**NOTES:**

1. East bank design assumes a lock block wall would not be required if the work was done in conjunction with lowering elevation of playing field.
2. No bank reconstruction work has been proposed for the west bank; Selective riparian clearing and restoration has been prescribed.

**TABLE 3. Estimated quantities and cost guidelines for proposed environmental treatments for Zone 5: Richmond School Property.**

<b>East Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal (m)	6 m	\$48.00
Excavation/Hauling/Disposal (m <sup>3</sup> )	9 m <sup>3</sup>	\$180.00
Lock Block Wall: Materials, Prep and Installation	3 m high	\$2,400.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Fill Planting Soil (0.5 m deep)	3 m <sup>2</sup>	\$45.00
Erosion Control/Surface Treatment	3.5 m <sup>2</sup>	\$70.00
Riparian Restoration	3.5 m <sup>2</sup>	\$52.50
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$2,870.50
Length of Prescription (m) and Cost	185	\$531,042.50

<b>West Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	3 m	\$40.00
Excavation/Hauling	15 m <sup>3</sup>	\$260.00
Lock Block Wall*	NA	\$0.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Filling Organics (0.5 m deep)	3 m <sup>2</sup>	\$90.00
Erosion Control/Surface Treatment	6 m <sup>2</sup>	\$120.00
Riparian Restoration	6 m <sup>2</sup>	\$90.00
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$675.00
Length of Prescription (m) and Cost	185	\$124,875.00

**NOTES:**

1. West bank design assumes a lock block wall would not be required if the work was done in conjunction with lowering elevation of playing field.

**TABLE 4. Estimated quantities and cost guidelines for proposed environmental treatments for Zone 6: Townley Street/Pearl Avenue**

<b>East Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal (m)	5 m	\$40.00
Excavation/Hauling	15 m <sup>3</sup>	\$300.00
Lock Block Wall	3 m high	\$2,400.00
Rock Placement	1 m <sup>3</sup>	\$50.00
Back Filling Organics	3 m <sup>2</sup>	\$90.00
Erosion Control/Surface Treatment	6.0 m <sup>2</sup>	\$120.00
Riparian Restoration	6.0 m <sup>2</sup>	\$90.00
Fencing	1.5 m high	\$25.00
Total Cost per Linear Meter		\$3,115.00
Length of Prescription (m) and Cost	220	\$685,300.00

<b>West Bank Treatment</b>	<b>Quantities</b>	<b>Costs/m</b>
Stripping/Disposal	NA	\$0.00
Excavation/Hauling	NA	\$0.00
Lock Block Wall*	NA	\$0.00
Rock Placement	NA	\$0.00
Back Filling Organics	NA	\$0.00
Erosion Control/Surface Treatment	4 m <sup>2</sup>	\$80.00
Riparian Restoration	4 m <sup>2</sup>	\$60.00
Fencing	NA	\$0.00
Total Cost per Linear Meter		\$140.00
Length of Prescription (m) and Cost	110	\$15,400.00

**NOTES:**

1. Extent of east bank excavation may be restricted by underground Municipal services.
2. No bank reconstruction work has been proposed for the west bank; Selective riparian clearing and restoration has been prescribed.
3. Length of prescription area on west bank has been adjusted to reflect accessibility excludes area with existing retaining structures.

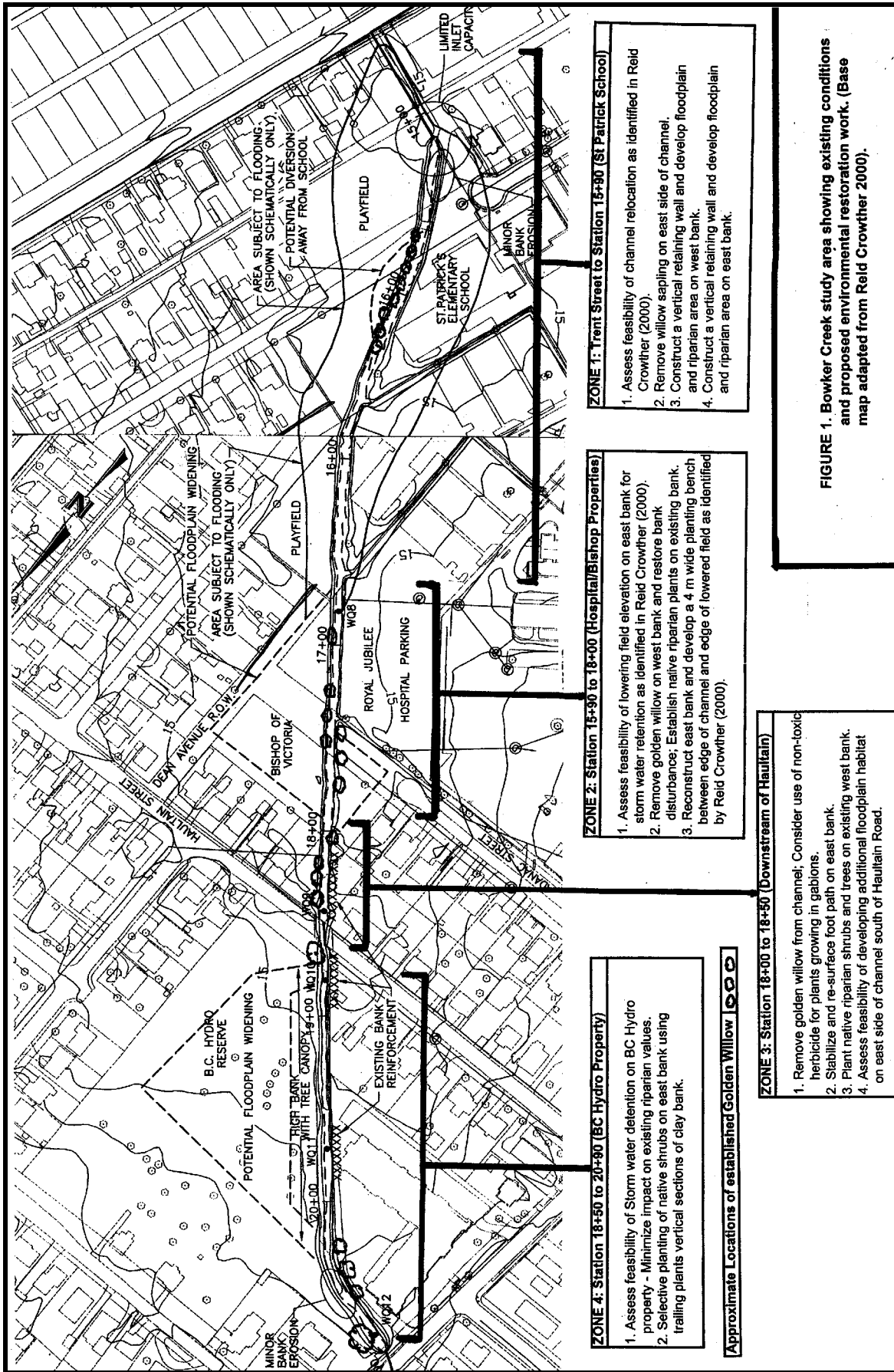


FIGURE 1. Bowker Creek study area showing existing conditions and proposed environmental restoration work. (Base map adapted from Reid Crowther 2000).

FIGURE 1a: Bowker Creek study area (lower portion) showing existing conditions and zone designation for proposed environmental restoration work.

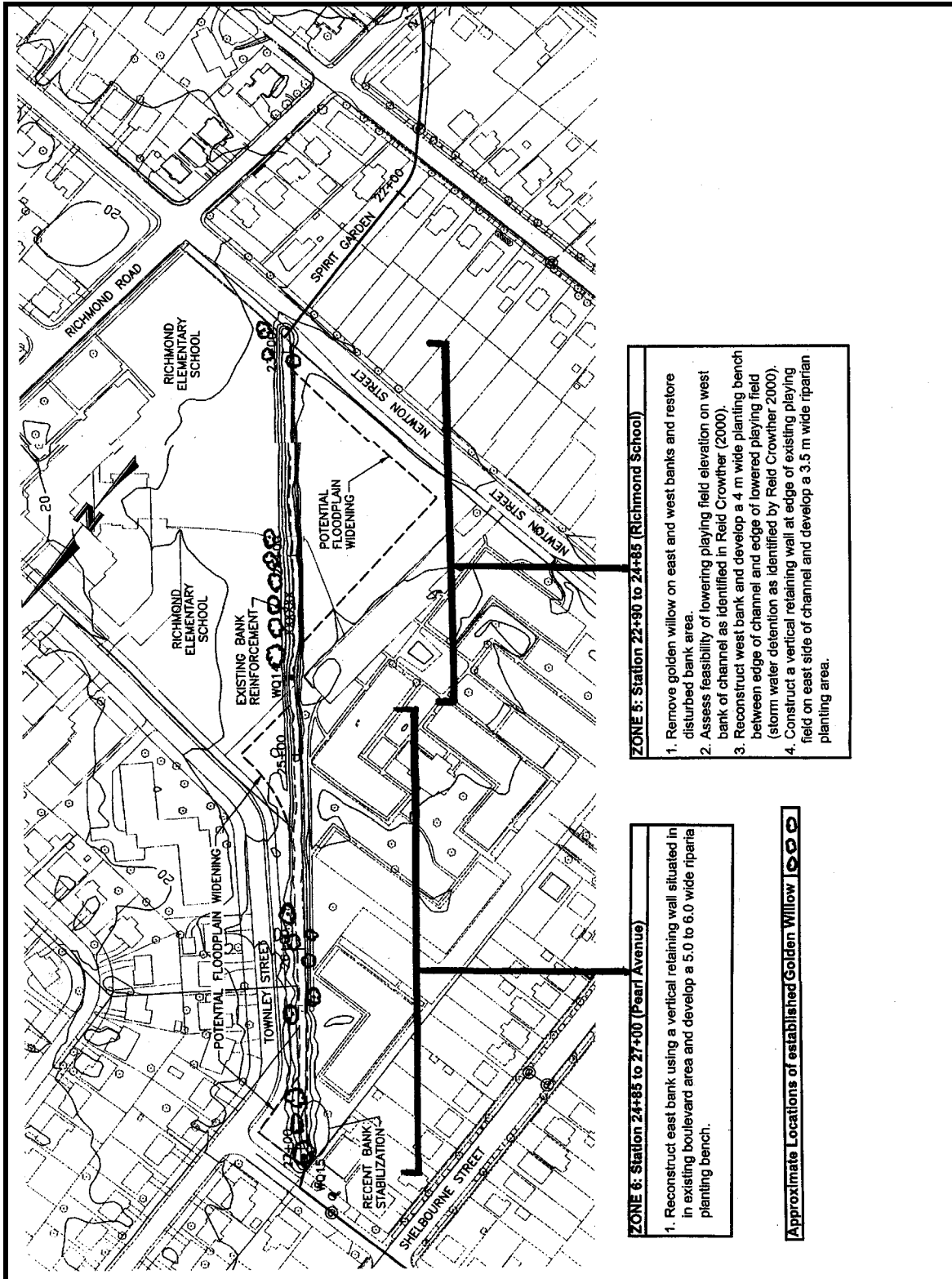


FIGURE 1b: Bowker Creek study area (upper portion) showing existing conditions and zone designation for proposed environmental restoration work.