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SAVING THE HEART OF THE FRASER

Addressing Human Impacts to the Aquatic Ecosystem of the
Fraser River, Hope to Mission, British Columbia

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Saving the Heart of the Fraser: Addressing Human Impacts to the Aquatic Ecosystem of the Fraser River, Hope to Mission, British Columbia

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EXECUTIVE SUMMARY

The lands adjacent to and influenced by the hydrology of a stream, termed riparian areas, include some of the most bio-diverse ecosystems on earth. They are also some of the most vulnerable and endangered habitats in the world.

By any measure, the floodplain and channels of the lower Fraser River between Hope and Mission, British Columbia represent some of Canada's most biologically significant riparian and aquatic ecosystems. This area is currently under extreme stress as a result of human activities relating to urbanization, ongoing resource extraction, agriculture and industrial development. Still, despite 150 years of impacts associated with human perturbation, the remaining in-stream and riparian biodiversity of the lower Fraser River reach remains considerable. This is all the more remarkable given that this part of the river lies at the doorstep of over two million people who reside in the lower mainland of British Columbia.

From a technical perspective, this part of the Fraser is often referred to as the "gravel reach". This reflects the predominant sediment size washed into this part of the river forming the substrate of the active channel.

There are extraordinary environmental values associated with this section of the river and aspects therein that profoundly affect the productivity of the river and much of the rest of the greater watershed. As a result, the ecologically-functioning area between Hope and Mission is referred to as the "Heart of the Fraser", a term used synonymously with the "Fraser gravel reach". The geographic boundary of the Heart of the Fraser is roughly delineated by the current floodway dike system in the eastern Fraser Valley.

The exceptional aquatic-ecosystem values found in the gravel reach includes thirty or more different species of fish that spawn, rear and/or migrate through this part of the lower Fraser River. This also includes the largest spawning population of salmon in British Columbia—in some years exceeding 10 million pinks. Each year, on their seaward journey, hundreds of millions of juvenile salmon migrate through the Heart of the Fraser from upstream habitats, often delaying to feed in the gravel reach before going to the sea.

The Heart of the Fraser also contains one of the greatest concentrations of sturgeon of any stock or species in Canada. Until several decades ago, spawning eulachon (an anadromous smelt) were historically abundant in the lower Fraser River downstream of Hope, and a remnant still return here each year to reproduce. Nonetheless, these three taxa of fish are but a small representation of the fish biodiversity in this reach of the Fraser River.

It should be noted that the exceptional aquatic attributes of this area are not confined to fish species. There is an extra-ordinary diversity of plants and animals that rely on this watercourse and its riparian habitats. A number of the organisms, including fishes, that reside in the gravel reach are now classified as species at risk and this is largely due to the effects of human activity upon them.

Since European settlement, the instream and floodplain areas of the Heart of the Fraser have been modified dramatically as a result of resource extraction as well as agricultural and development activities. This extensive and significant change has compromised the expansive habitats that many species rely upon. Impacts continue to occur as a result of land clearing, diking, watercourse draining, forest harvest (pulpwood), mining, agriculture and industrial, commercial and urban development. Thus, the remaining environmental and ecological integrity of the instream and riparian areas of the Heart of the Fraser is at imminent risk.

A vital question is: **What can be done to prevent irreparable damage to this extra-ordinary ecosystem?** The rapid acceleration of impacts to the environment within the Heart of the Fraser, particularly over the last decade, is largely due to economic expansion. A particularly pertinent issue centers around the private rights on riparian properties and the lack of incentives to protect and maintain high environmental values on these landscapes. The increased resource extraction and development within the Heart of the Fraser is also directly related to growing

human populations in the area and there is no sign that this will abate any time soon. Moreover, all levels of government continue to be pressured to permit new activities within this sensitive ecosystem. This includes, as examples, numerous recent re-zoning applications to local governments and the Agricultural Land Reserve to circumvent even the minimum development restrictions on the river side of the gravel reach floodway dikes.

It has now become clear to many that environmental law, policy and regulation, at all levels of government, are insufficient to protect this environmentally unique and economically valuable Canadian ecosystem. In other cases, where applicable legislation does exist it has not always been enforced to the extent that it could be. The bias towards development and the momentum generated by the growing population in the region are further compromising this crucial Fraser gravel reach.

In recognition that these ecosystem losses must be halted, a number of private individuals, institutions and Environmental Non-Governmental Organizations are working together to provide a living legacy for future generations of Canadians. They have come forward and created an informal coalition with the objective of saving the "Heart of the Fraser". The first and foremost activity of this coalition is an attempt to secure properties having extraordinary environmental values within the gravel reach. This activity is now being pursued through private-land purchases and donations. These properties are now being protected through the auspices of The Nature Trust, a non-governmental environmental land-management agency. Significant start-up gains have recently been made through the donation and acquisition, from Canfor Corporation, of an extensive and exceptional parcel of land, known as Harrison Knob, at the confluence of the Fraser and the Harrison rivers. Other properties, such as the Tom Berry Ranch near Hope have now been purchased or are in negotiation status. Nevertheless, while these individual efforts are laudable, it is clear that not all required properties can be purchased outright and saved through private interests alone due to the extensive cost. Partnerships are needed between the private and public sectors. Thus, all four levels of government—First Nations, local, provincial, and federal—must become more involved in the acquisition (or similar protection through other means) of key lands from within the Heart of the Fraser if these ecosystems are to be sustained.

Some sensitive properties within the Heart of the Fraser may never be available for purchase due to legal and/or other constraints. For such riparian landscapes within the gravel reach that will continue to be impacted, whether private lands or crown lands which are managed through license, the development and implementation of a meaningful management plan is needed if these parts of the river are to be saved from further destruction. Creative approaches may also be needed to compensate riparian landowners within the Heart of the Fraser in order to encourage them to conserve key lands.

Finally, political accountability is required to ensure that existing and relevant laws, policies and regulations relating to land usage are properly enforced. This will help achieve the already-stated environmental goals that exist for the responsible levels of government in order to protect this fragile environment and promote sustainability within the Heart of the Fraser.

This report describes the various attributes that comprise the biology, hydrology, geography and land use practices within the gravel reach of the Fraser River. It describes how human activities have damaged much of this rich ecosystem and we provide a partial accounting of the impacts and what remains. It then provides an overview of a unique and progressive attempt by non-government interests to protect and restore the gravel reach ecosystem through the Heart of the Fraser initiative. Through these efforts sensitive lands are now being secured for protection. This report also discusses the need for First Nations, local, provincial and federal governments to engage in the protection of the gravel reach. It also takes the position that a collaboratively developed, enforceable management plan is also required to link the various aspects of land purchases and habitat protection into one complete synthesis.

Ultimately, the goal of the Heart of the Fraser effort is to identify, conserve, protect and restore key portions of the Hope to Mission gravel reach of the Fraser River in order to sustain and secure the biological and ecological integrity of the area for future generations. A crucial aspect is to inform and educate British Columbians about the situation and options. At the outset, however, there is an urgent need to find the financial support to purchase sensitive lands that are already under imminent threat of development.

The authors recommend a set of specific measures and a comprehensive course of action at the conclusion of this report. The approaches and strategies they suggest to the Pacific Fisheries Resource Conservation Council and British Columbia public are the following:

1. All levels of government—federal, provincial, local and First Nations—must do more in terms of recognizing the exceptional environmental values of the Fraser gravel reach, and the need to protect remaining key riparian areas within the Heart of the Fraser. There is an urgent need to move quickly given that the extraordinary environmental attributes of the Heart of the Fraser are rapidly disappearing under the pressures of continued development and resource extraction.
2. Agreements must be forged amongst the four levels of government to establish the basis for concerted action to ensure that the Heart of the Fraser landscape is protected from unsustainable land development including urban, commercial, agricultural or industrial.
3. A multi-stakeholder task force needs to be struck to undertake dialogue and devise a consensus-based action plan of immediate measures to stem the losses of irreplaceable ecosystems now occurring within the Heart of the Fraser reach.
4. A comprehensive collaborative management plan needs to be developed in order to provide long-term protection and restoration of this extraordinary ecosystem. The Fraser River Estuary Management Program and its planning approach may be appropriate models for the gravel reach. It may also be appropriate to extend the governance of that program into the Fraser gravel reach.
5. An essential element of this plan is to provide a coordinating level of governance and support that facilitates the purchase, or designation, of landscapes of high ecological values, or, alternatively, facilitates protective actions (e.g., covenants) for those areas of the Fraser gravel reach that cannot be secured.
6. The sites within the Fraser gravel reach needing immediate protection need to be determined through primary research that would inventory and assess the remaining ecosystem attributes of the Heart of the Fraser. Because the 1998 British Columbia Protected Area Strategy Fraser Lowlands study has already identified a number of crucial areas for protection, this additional research should not preclude initiating quick action for those key areas already identified.
7. Crucial crown lands need to be designated as protected habitats within the gravel reach. As part of this activity, First Nations treaty negotiations must be fully respected. Within that context, if there is agreement amongst the parties that certain key lands be protected, innovative solutions such as land trades should be explored. As an example, where First Nations land and interests are concerned, including both reserve and crown land, opportunities should be investigated to determine if other lands of equal or greater value could be provided as a trade-off for protecting sensitive areas within the Heart of the Fraser. Note that this should not preclude the relevant First Nations group from continuing to own and otherwise have jurisdiction over the protected land and continuing to use the property for agreed-upon non-destructive activities (c.f., New Zealand Maori agreements).

8. Where purchasable, private lands of high ecosystem value should be acquired (or protected via covenant) and placed in trust for protection. This may be undertaken through the auspices of an organization such as The Nature Trust or the Stó:lō Trust. Where appropriate some of these lands might also be folded into federal, provincial or local park systems.
9. Policies need to be adjusted, or clarified, to account for the impacts of current human activities on fish and other ecosystem values within the region's riparian areas. For instance, detrimental habitat impacts should be considered serious violations of legislation and/or regulation on many of British Columbia's smaller streams with more rigorous enforcement.
10. There needs to be a greater recognition that rip-rap armouring of the banks of the gravel reach often destroys fish habitat. The extensive placement of this material has largely disrupted natural fluvial processes and the proper functioning condition of many of the outer banks between Hope and Mission. A solution could involve purchases and decommissioning of existing, but not critical, locations of riprap bank protection within the reach in order to provide compensation under the *Canada Fisheries Act*, the *Canadian Environmental Assessment Act* and the No-Net-Loss Policy, for areas where the placement of new rip-rap is unavoidable.
11. The leeway for the holder of Tree Farm License 43, for those areas within the Heart of the Fraser, to mechanically disrupt up to 100% of its harvestable landscape must be modified to a proportion of the landscape that is much more reasonable and sustainable in order to protect biodiversity. Riparian protection boundary widths within Tree Farm License 43 must also be reviewed from a scientific basis to meet the public's expectation for stream and fish protection for forest harvesting in British Columbia.
12. There needs to be clear direction from the Government of British Columbia that it will stem the removal of designated agricultural land from within the Heart of the Fraser for development purposes.
13. There must be a much more thorough examination of the impacts associated with "deep pit" aggregate extractions within the gravel reach floodway. This activity on key riparian lands, which differs from the more traditional scalping of gravel bars, is exceptionally destructive to the ecosystem insofar as it causes a major ecological footprint while also disrupting the natural wandering processes of the stream.
14. The importance of the role of large woody debris as habitat in the lower Fraser River downstream of Hope has not been properly recognized. Furthermore, the extent of habitat loss as a result of the removal of this material due to the operation of woody debris trap at Laidlaw has not been appropriately acknowledged. While the debris trap does provide boating benefits it would be valuable to have a detailed assessment of the role of large woody debris in the lower Fraser River that addresses not only boating safety requirements but the habitat needs of fish as well. Removal methods, amounts and locations are crucial factors, and the science to back up the decision making in this regards needs to be undertaken in order to mitigate the impacts. Innovative options such as the cabling of large woody debris in strategic habitat locations should also be explored.
15. Future aggregate-removal operations within the Fraser gravel reach must take place in the context of an overall stream and fish protection plan, based on all of the factors in regards to their value to flood control or erosion mitigation. This should then be explicitly explained to the public and opened for discussion. Where gravel removal for flood protection is demonstrated to be warranted, the impacts of these extractions on fisheries resources need to be mitigated and timed to avoid disrupting developing pink salmon eggs which should not be onerous given that pink salmon spawn only in odd numbered years in the Fraser River. Gravel removal for erosion should not take place where the natural degradation is already extensive or where hydraulic models show little or no benefit to the removals. Private

properties that are subject to extensive natural erosion could be considered for purchase and maintained to serve natural ecosystem processes. Finally, decisions relating to gravel removal need to be transparent and technically defensible.

16. An enhanced program of enforcement of existing laws and regulations is absolutely essential to protect the environmental attributes in this section of the river. To date, enforcement actions have been lax or ineffective to protect sloughs, riparian habitats and river gravel beds that support many fish species. The Canada *Fisheries Act* provides the mandate and legislated authority, but requires greater diligence in the application of its fish habitat provisions.
17. Over many decades, due to an array of human induced activities, many of the Fraser's side-channel habitats have been degraded. An enhanced large-river restoration program must be designed and implemented to reverse some of the damage that has been done.

RÉSUMÉ

On appelle zones riveraines les terres qui bordent les cours d'eau et qui sont influencées par leur hydrologie. Certaines sont parmi les écosystèmes les plus biodiversifiés de la planète. Mais elles comptent aussi parmi les habitats les plus vulnérables et les plus menacés du monde.

La plaine d'inondation et les chenaux du cours inférieur du fleuve Fraser entre Hope et Mission, en Colombie-Britannique, renferment certainement quelques-uns des écosystèmes riverains et aquatiques les plus importants au Canada du point de vue biologique. À l'heure actuelle, la région subit un très grand stress à cause de l'urbanisation, de l'exploitation continue des ressources et du développement agricole et industriel. Quoique les perturbations anthropiques durent depuis 150 ans, la biodiversité riveraine et fluviale du bas Fraser demeure considérable. C'est d'autant plus remarquable que cette partie du fleuve avoisine le Lower Mainland de la Colombie-Britannique, où vivent plus de deux millions de personnes.

D'un point de vue technique, cette portion du Fraser est souvent appelée le *gravel reach* ou « tronçon graveleux ». Ce nom renvoie à la taille dominante des sédiments qui sont entraînés dans cette partie du fleuve et qui forment le substrat du chenal actif.

Des valeurs environnementales extraordinaires sont associées à ce tronçon, dont certains aspects jouent beaucoup sur la productivité du fleuve et presque tout le reste du grand bassin versant. C'est pour cette raison que la région écologique entre Hope et Mission est appelée *Heart of the Fraser* ou « cœur du Fraser », terme synonyme de « tronçon graveleux du Fraser ». La frontière géographique du cœur du Fraser est à peu près définie par le réseau de digues de la partie est de la vallée du fleuve.

Les valeurs exceptionnelles de l'écosystème aquatique dans le tronçon graveleux comprennent une trentaine et plus d'espèces de poissons qui pondent, croissent et migrent dans cette partie du bas Fraser. On y trouve aussi la plus grande population de saumons géniteurs de la Colombie-Britannique—certaines années, il y a plus de 10 millions de saumons roses. Chaque année, pour leur avalaison vers l'océan, des centaines de millions de jeunes saumons quittent leurs habitats d'amont et migrent en passant par le cœur du Fraser, où ils s'arrêtent souvent pour se nourrir sur le lit de gravier avant de continuer vers l'océan. Le cœur du Fraser comprend aussi une des plus importantes concentrations d'esturgeons de toute population ou espèce au Canada. Il y a plusieurs décennies, les eulakanes (éperlans anagrammes) géniteurs abondaient dans le Fraser en aval de Hope, et quelques-uns reviennent chaque année pour s'y reproduire. Ces trois taxons ne représentent qu'une petite partie de la biodiversité des poissons du tronçon graveleux du fleuve.

Il est à remarquer que les attributs aquatiques exceptionnels de la région ne se confinent pas aux espèces de poissons. Une extraordinaire diversité de plantes et d'animaux dépendent de ce cours d'eau et de ses habitats riverains. Certains organismes, y compris des poissons, qui vivent dans le tronçon graveleux figurent désormais parmi les espèces en péril, en grande partie à cause des effets de l'activité humaine.

Depuis l'arrivée des Européens, le cours d'eau et la plaine d'inondation dans le cœur du Fraser ont subi de profonds changements occasionnés par l'exploitation de ressources, l'agriculture et l'urbanisation. Ces changements très importants ont perturbé les habitats d'un grand nombre d'espèces. Le défrichement, la présence de digues, le drainage du cours d'eau, les récoltes forestières (bois à pâte), l'exploitation minière et agricole et l'expansion industrielle, commerciale et urbaine continuent d'apporter des effets nuisibles. Ce qui reste de l'intégrité écologique et environnementale des zones fluviales et riveraines du cœur du Fraser court donc un risque imminent.

Une question essentielle se pose : **Que faire pour éviter des dégâts irréparables à cet extraordinaire écosystème?** L'accélération rapide des effets sur l'environnement dans le cœur du Fraser, en particulier au cours de la dernière

décennie, est due en grande partie à la croissance économique. Au centre du problème, il y a les droits privés sur le biens riverains et le manque d'incitation à protéger la grande valeur environnementale de ces sites.

L'intensification de l'urbanisation et de l'exploitation des ressources au cœur du Fraser est aussi directement liée à la croissance de la population dans la région, qui ne donne aucun signe de ralentissement. De plus, on continue de presser tous les ordres de gouvernement d'autoriser de nouvelles activités dans cet écosystème fragile. Par exemple, de nombreuses demandes de rezonage ont été déposées récemment auprès des administrations locales et des responsables de la réserve de terres agricoles afin de faire échouer les moindres restrictions d'aménagement du côté fluvial des digues situées dans le tronçon graveleux.

Il est désormais évident pour bien des gens que les lois, les politiques et les réglementations des différentes administrations ne sont pas suffisantes pour protéger cet écosystème canadien unique et d'une grande valeur économique. Dans certains cas, la législation voulue existe, mais n'est pas appliquée comme elle devrait l'être. L'attitude favorable au développement et l'impulsion que donne la croissance de la population dans la région ajoutent à la menace qui pèse sur cet essentiel tronçon de graviers du Fraser.

Reconnaissant qu'il faut mettre fin aux pertes au sein de l'écosystème, des particuliers, des institutions et des organisations environnementales non gouvernementales collaborent afin de laisser un patrimoine vital aux futures générations de Canadiens. Ils ont décidé de créer une coalition à caractère non officiel dans le but de sauver le cœur du Fraser. L'activité principale de cette coalition est de tenter de protéger les terrains du tronçon graveleux qui présentent d'extraordinaires valeurs environnementales. La coalition procède par l'achat et l'acceptation de dons de terrains privés. Les terrains acquis seront désormais protégés sous les auspices de la Nature Trust, organisme non gouvernemental d'écogestion des terres. L'activité a bien démarré récemment grâce au don et à la vente par Canfor Corporation d'un terrain exceptionnel et vaste connu sous le nom de Harrison Knob, situé au confluent de la rivière Harrison et du Fraser. D'autres terrains, comme le Tom Berry Ranch près de Hope, ont été achetés ou sont en voie de l'être. Ces efforts sont méritoires, mais il est clair que les terrains ne pourront pas tous être achetés et protégés par des intérêts privés, vu le coût considérable. Il faut constituer des partenariats entre le secteur privé et le secteur public. Afin de préserver ces écosystèmes, les quatre ordres de gouvernement—Premières nations, administrations locales, autorités provinciales et fédérales—doivent s'engager davantage dans l'acquisition (ou d'autres moyens de protection) de terrains cruciaux dans le cœur du Fraser.

Certains terrains sensibles du cœur du Fraser ne pourront peut-être jamais être achetés à cause de contraintes légales ou autres. Pour préserver de la destruction ces terrains privés ou terrains publics exploités sous permission, il faut élaborer, puis mettre en œuvre un plan de gestion. Il faudra peut-être aussi trouver des moyens imaginatifs pour dédommager les propriétaires riverains et de cette façon les inciter à préserver les terrains cruciaux.

Enfin, il faut une responsabilité politique pour que les lois, les politiques et les réglementations en matière d'utilisation des terres soient correctement appliquées. Cette obligation de rendre compte aidera les autorités compétentes à atteindre les buts environnementaux déjà énoncés afin de protéger cet environnement fragile et de favoriser le développement durable dans le cœur du Fraser.

Le rapport décrit les différents attributs qui définissent la biologie, l'hydrologie, la géographie et l'utilisation des terres dans le tronçon graveleux du fleuve Fraser. Ses auteurs décrivent aussi comment les activités humaines ont endommagé une bonne partie de ce riche écosystème; ils recensent une partie des effets et de ce qu'il reste de l'écosystème. Ensuite, ils récapitulent l'action progressiste et originale entreprise par des intérêts non gouvernementaux qui tentent de protéger et de rétablir l'écosystème par l'initiative « Heart of the Fraser ». Grâce à cette action, des terres fragiles seront maintenant protégées. Il est aussi question dans ce rapport du besoin que les autorités—Premières nations, administrations locales, autorités provinciales et fédérales—participent à la protection du tronçon graveleux. Les auteurs soutiennent qu'un plan de gestion élaboré en collaboration et

exécutable est nécessaire pour relier les différents aspects de l'acquisition de terrains et de la protection des habitats en une synthèse complète.

En fin de compte, l'action pour le cœur du Fraser vise à reconnaître, à protéger et à restaurer des parties cruciales du tronçon graveleux du fleuve entre Hope et Mission afin d'assurer la viabilité et l'intégrité biologique et écologique de la région pour les générations à venir. Un élément fondamental est d'informer et d'éduquer les Britannico-Colombiens de la situation et des options qui s'offrent. D'entrée de jeu, cependant, il faut trouver le soutien financier qui permettra d'acquérir les terrains sensibles qui risquent d'être aménagés sous peu.

Dans la conclusion du rapport, les auteurs font les recommandations précises suivantes au Conseil pour la Conservation des Ressources Halieutiques du Pacifique et à la population britanno-colombienne :

1. Tous les ordres de gouvernement—fédéral, provincial, local et des Premières nations—doivent reconnaître davantage la valeur environnementale exceptionnelle du tronçon graveleux du fleuve Fraser et la nécessité de protéger les zones riveraines cruciales qui subsistent dans le cœur du Fraser. Il est urgent d'agir, puisque les caractéristiques environnementales extraordinaires du cœur du Fraser disparaissent rapidement sous les pressions incessantes de l'exploitation des ressources naturelles et du développement.
2. Les quatre ordres de gouvernement doivent concerter l'action pour que le cœur du Fraser soit protégé contre le développement urbain, commercial, agricole et industriel écologiquement irrationnel.
3. Un groupe de travail réunissant de multiples parties prenantes doit être créé pour amorcer le dialogue et élaborer un plan consensuel qui énoncera les mesures à prendre immédiatement pour faire cesser la perte d'écosystèmes irremplaçables dans le tronçon graveleux du fleuve Fraser.
4. Un plan de gestion détaillé doit être élaboré afin d'assurer la protection à long terme et la restauration de l'extraordinaire écosystème du tronçon graveleux. Le Plan d'action de l'estuaire du Fraser, et la démarche de planification qui s'y rattache, pourrait servir de modèle. On pourrait également étendre la gouvernance du programme de l'estuaire au tronçon graveleux.
5. Un élément essentiel du plan de gestion est d'assurer un niveau de gouvernance et de soutien qui facilite l'acquisition ou la désignation de terrains ayant une valeur écologique élevée; ce plan peut également faciliter des mesures de protection (par exemple, par covenant) des parties du tronçon graveleux qui ne peuvent être acquises.
6. Les sites du tronçon graveleux du fleuve Fraser nécessitant une protection immédiate doivent être déterminés par une étude originale qui recenserait et évaluerait les attributs restants de l'écosystème du cœur du Fraser. Étant donné que l'étude de 1988 sur la stratégie britanno-colombienne de protection des basses-terres du Fraser a déjà indiqué plusieurs endroits à protéger, la nouvelle étude ne devrait pas empêcher d'agir promptement pour protéger ceux-ci.
7. Les parties cruciales du territoire domanial dans le tronçon graveleux doivent être désignées habitats protégés, dans le respect des traités avec les Premières nations. Si les intéressés s'entendent pour protéger certains terrains cruciaux, ils devraient envisager des solutions novatrices telles que des échanges; par exemple, s'agissant des terres et des intérêts des Premières nations, dans les réserves ou en territoire domanial, il faudrait étudier les possibilités d'échange contre des terrains de valeur égale ou supérieure afin de protéger les sites fragiles dans le cœur du Fraser. Il est à noter que cela n'empêcherait pas les Premières nations de posséder des terres protégées, d'en avoir la responsabilité et de continuer à les utiliser aux fins non destructives convenues (à l'exemple de ce que prévoient les ententes des Maoris de la Nouvelle-Zélande).

8. Lorsque possible, les terrains privés de grande valeur écosystémique devraient être acquis (ou protégés par covenant) et placés en fiducie. Cela pourrait être fait par l'entremise d'organisations telles que la Nature Trust ou la fiducie Stó:lō. Certains terrains pourraient éventuellement devenir partie intégrante des parcs fédéraux, provinciaux ou locaux.
9. Les politiques doivent être modifiées ou clarifiées pour tenir compte de l'effet des activités humaines sur les poissons et autres éléments valorisés de l'écosystème des zones riveraines de la région. Par exemple, on devrait considérer la production d'effets dommageables pour les habitats le long de nombreux ruisseaux de la Colombie-Britannique comme des violations graves des lois et des règlements, et appliquer la législation avec plus de rigueur.
10. On doit mieux reconnaître que l'enrochement des rives du tronçon graveleux entraîne souvent la destruction des habitats des poissons. L'enrochement à grande échelle a perturbé les processus fluviaux naturels et la fonction des rives entre Hope et Mission. Une solution possible serait d'acquérir les sites où l'enrochement n'est pas essentiel et de démanteler celui-ci, afin de compenser pour les endroits où l'enrochement est inévitable, comme le prévoient la *Loi sur les pêches*, la *Loi canadienne sur l'évaluation environnementale* et le principe d'« aucune perte nette ».
11. La liberté d'action dont jouit le titulaire de la concession forestière n° 43 à l'égard des terrains situés dans le cœur du Fraser et qui lui permet de perturber mécaniquement jusqu'à 100 % du territoire exploitable, doit être restreinte à une portion beaucoup plus raisonnable du territoire afin de protéger la biodiversité. La largeur protégée des rives du territoire de la concession forestière n° 43 doit également être revue scientifiquement afin de respecter les attentes de la population en ce qui concerne la protection des cours d'eau et des poissons contre les effets de l'exploitation des forêts en Colombie-Britannique.
12. Le gouvernement de la Colombie-Britannique doit clairement faire savoir qu'il compte empêcher les pertes de terres agricoles dans le cœur du Fraser au profit de l'urbanisation.
13. Il doit y avoir un examen beaucoup plus approfondi des effets causés par les extractions profondes d'agrégats dans le canal de crue du tronçon graveleux. Contrairement au scalpage traditionnel des bancs de gravier, ce procédé est beaucoup plus destructif pour l'écosystème, car il laisse une profonde empreinte écologique tout en modifiant les processus naturels liés aux méandres du cours d'eau.
14. On apprécie mal l'important rôle d'habitat que jouent les gros débris de bois dans la vallée du bas Fraser en aval de Hope. De plus, l'étendue de la perte d'habitat due à l'enlèvement de ces débris dans la station de captage située à Laidlaw n'est pas assez reconnue. S'il est vrai que ce captage profite à la navigation de plaisance, il serait utile de faire une évaluation détaillée qui rende compte non seulement des exigences de la navigation, mais des besoins d'habitat des poissons. Les méthodes, le volume et les lieux de captage sont tous des facteurs cruciaux; les prises de décision en la matière doivent être basées sur des études scientifiques afin de limiter les effets négatifs. Des méthodes novatrices, telles que l'encâblage des gros débris de bois dans des endroits propices, devraient également être envisagées.
15. L'enlèvement futur d'agrégats du tronçon graveleux du Fraser doit faire partie d'un plan de protection du cours d'eau et des poissons basé sur tous les facteurs qui influent sur la maîtrise des crues et la réduction de l'érosion. Ce plan devrait ensuite être présenté à la population et débattu. Dans les endroits où l'enlèvement du gravier est justifié pour se protéger des inondations, il faut en atténuer les effets sur les ressources halieutiques et choisir le moment de façon à perturber le moins possible le développement des œufs des saumons roses, ce qui devrait être facile puisque ces derniers fraient uniquement les années impaires dans le Fraser. On devrait éviter l'enlèvement du gravier pour des raisons d'érosion là où la dégradation naturelle est déjà importante ou lorsque les modèles hydrauliques prévoient peu ou pas

d'avantages à le faire. Les terrains privés soumis à une érosion naturelle importante pourraient être achetés et entretenus pour optimiser les processus naturels de l'écosystème. Enfin, les décisions qui ont trait à l'enlèvement du gravier doivent être transparentes et se défendre sur le plan technique.

16. Une mise à exécution plus vigoureuse des lois et des règlements est absolument essentielle pour protéger les caractéristiques environnementales de cette portion du fleuve. Jusqu'à maintenant, l'application des lois a été insuffisante et inefficace pour protéger les marécages, les habitats riverains et les lits de gravier où vivent de nombreuses espèces de poissons. La *Loi canadienne sur les pêches* attribue un mandat et des pouvoirs clairs, mais il faut appliquer avec plus de diligence ses dispositions sur les habitats des poissons.
17. Un éventail d'activités humaines sur des décennies ont dégradé nombre des habitats des cours latéraux du Fraser. Un programme amélioré de restauration de tout le lit du fleuve doit être élaboré et exécuté pour réparer certains des dommages causés.

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"The Fraser's experience with man, while short, is filled with adventure, toil, treasure and war. Yet, unlike other great rivers, it has produced no songs, no myths, not even a special type of river-man...[f]or song and story, for the record of men's labour, wealth and defeat, for any intimate association with his business, the Fraser is too violent, hurried and solitary. But man...can never escape the Fraser."
Bruce Hutchinson The Fraser (1982)

"Nothing under heaven is softer or more yielding than water; but when it attacks things hard and resistant there is not one that can prevail."
Lao Tzu Tao Te Ching (300 BC)

"E pur si muove" Galileo (1633)

GLOSSARY

| | |
|---------------------------|---|
| Abiotic | Non living components of an ecosystem such as nutrients, air and sunlight. |
| Agency | For government, this includes administrative institutions and entities as defined through legislation. |
| Aggradation | When sediment supply exceeds the ability of a stream to transport the sediment, and deposition of this material occurs. |
| Alevin | The developmental life stage of young salmonids that are between the embryo and fry stage. The alevin has not yet completely absorbed its yolk sac and has not emerged from the spawning gravels as a free-swimming fish. |
| Alluvial | Sediment deposited by flowing water, such as in a stream bed. |
| Anadromous | Fish that largely live their lives in the sea and migrate to freshwater to spawn. |
| Armour (bank) | The use of hard material placed on the perimeter, or within a stream bank, to prevent erosion. |
| Armour layer (stream bed) | The relatively coarser surface layer of a stream bed which acts as a control to the movement of sediments beneath it. |
| Asynchronous | Not synchronized, or not occurring at predetermined or regular intervals. |
| Avulsion | The sudden movement of sediment from one location to another as a result of a shift in the course of a stream channel. |
| Bar scalping | The removal of sand or gravel from a stream bar, usually done during either summer or winter low-flow periods. |
| Biosolids | Solid materials resulting from sewerage treatment that meet agency standards for beneficial use. These materials are often used for fertilizer due to their high nutrient content. |
| Biotic | Having to do with life, especially to characteristics of entire populations or ecosystems. |
| Braided stream | Stream in which the main channel is braided with multiple paths that split and join frequently and is usually a gravel or sand bed stream. |
| Catchment | The land area drained by a stream and its tributaries. |
| Clastic | Sedimentary rocks that are formed from pre-existing pebbles, stones, and other fragments. |
| Entrained | Carried along in a stream. |
| Entrainment | Mobilization, by flowing water, of sediment or organic debris from the bed or banks of a stream channel. |
| Ephemeral | Short lived, having the characteristic of lasting a very short time, transitory. |
| Floodway | The channel of a stream, and flood plains adjoining the channel, which normally carry and discharge the peak flows of the stream. The perimeter of the modern floodway in the gravel reach of the Fraser River is delineated by a diking system whose capacity is designed around the known flood of record which occurred in 1894. |
| Fluvial | Of, relating to, or inhabiting a river or stream. |

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| Freeboard | The distance between the dike-design elevation (plus a safety margin) and the stream's water-surface elevation. |
| Freshet | The large increase in water flow down a stream, typically from heavy rains or melting snow. |
| Geomorphology | Concerned with the study of the form and development of the earth's landscape. |
| Hyporheic | Comprises the zone near to, and under, the bed of a stream where groundwater and surface water mix. This is a key part of a stream for many aquatic insects and species of incubating fish embryos and alevins. |
| Littoral | That portion of a lake that is less than 6 meters in depth and is home to most of the rooted aquatic plant life. The high amount of sunlight reaching these plants permits significant photosynthetic activity. |
| Natal | Relating to the place of birth. |
| Periphyton | A broad assemblage of attached algae, bacteria, their secretions, associated detritus, and various species of micro-invertebrates on the bottom of a stream or lake. |
| Reach (of a stream) | A part of a stream with homogeneous characters (e.g., similar gradients, widths, braiding, etc.). A sub-reach is a physical division of a reach. |
| Refugia | Locations in which species have persisted while becoming extinct elsewhere. |
| Riffle | A shallow area of a stream in which water flows rapidly over the stream-bed substrates creating a broken or choppy surface. |
| Riparian | Relating to, or living within, or located on the bank of a natural watercourse. |
| Rip rap | Large angular rock set along or embedded into a stream bank to prevent erosion. |
| Saltation | Material bounced along the bed of a stream. |
| Sediment | Particles and/or clumps of particles of cobbles, gravel, sand, clay, silt, and plant or animal matter carried in water. |
| Silviculture | The art and science of growing and tending a forest. |
| Smolt | A sea-going juvenile salmonid migrating from freshwater to saltwater. |
| Species at risk | A plant or animal which has been designated by an agency or group which is at some risk of extinction. In British Columbia species are listed by both the provincial Conservation Data Centre (CDC), and the federal Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Species on these lists may be formally recognized under law in Canada, and this legislation includes the federal Species at Risk Act. |
| Thalweg | Deepest part of a stream. |
| Trophic | Having to do with levels in a food chain. |
| Wing dike | Is a flood-protection structure constructed along a stream extending from the upstream design-flow river bank elevation, or other structure such as a dike, but not connected into a design-flow elevation bank or structure at the downstream end. |

1.0 INTRODUCTION

For every great river of the world there is a specific geographic reach or location that defines it in the public eye. For the Amazon, it is where the dark water meets the light at the confluence of the Rio Negro near its famous river port of Manaus, Brazil. For the Nile River, it is at Luxor, Egypt, where the white-sailed feluccas dance lightly over its solemn waters overlooked by the ancient tombs at the Valleys of the Kings and Queens. For the Yangtze River in China, it is the stunning Three Gorges, in all of their verdant splendour, now vanishing as a result of damming. For the River Ganges, the area at Varanasi, considered by some to be India's most holy city, is the most memorable.

Similarly, the Fraser River falls within the envelope of "the world's great rivers", and the reach between the communities Mission and Hope, British Columbia, constitutes the defining or hallmark section of this waterway. This 100 kilometer section of river (Figure 1-1), known as the *gravel reach* in recognition of its predominant stream-bed sediment, starts where the Fraser spills out of a narrow, single-thread gorge called the Fraser Canyon and onto a broad alluvial floodplain. Flowing onwards to its terminus near Mission, the gravel reach of the Fraser River is bounded by the stunningly lush Fraser Valley which is rimmed by turquoise-blue mountains, making it one of the most visually alluring parts of Canada (Figure 1-2).

Indeed, this part of the country was viewed by the early explorers as something particularly special and they wrote eloquently of its beauty and richness. Imbert Orchard (1983), in his book titled "Floodland and Forest" which describes many of the attributes of the gravel reach, provides the following quotes from the members of the 1885 Canada/United States International Boundary Commission who were surveying the area:

"...The British party had a depot near the mouth of the Chilliwack River [*which at that time still flowed northward in multiple channels from the present-day Vedder Crossing to confluence with the Fraser River at the eastern end of Chilliwack Mountain*]. Two of its members, seeing the valley in all its primeval glory, went into raptures about it. "I think that this is the most beautiful place I was ever in," wrote Lieutenant Charles Wilson in his diary...And John Keast Lord, the Commission's naturalist, had this to say: "...we pitched our tents on the edge of a lovely stream. Waterfowl were in abundance; the streams were alive with fish; the mules and horses reveling in grass knee deep—we were in a second Eden!...The scenery is romantic and beautiful beyond description. Towering up into the very clouds, as a background, are the mighty hills of the Cascade range, their misty summits capped with perpetual snow—their craggy sides rent into chasms and ravines, whose depths and solitudes no man's foot has ever trodden...the Chilukweyuk [*Chilliwack*] river...washes one side of the prairie. Silvery-green and ever-trembling cottonwood trees, ruddy black-birch, and hawthorn, like a girdle, encircle the prairie, and form a border, of Nature's own weaving, to the brilliant carpet of emerald grass, patterned with wild flowers of every hue and tint—all shading pleasantly away, and losing their brilliancy in the dark green pine-trees"...The picture is right out of J.M.W. Turner. And these were traveled men, familiar with many a beautiful landscape."

The gravel reach of the Fraser River and the eastern Fraser Valley through which it runs is unquestionably scenic, but it is also a landscape rich in geological, historical, cultural and biological values. To this end, some now refer to the Fraser gravel reach as the "Heart of the Fraser" in recognition of its abundant resources, its profound influence on upstream ecosystems, and its position as one of the most biologically productive stretches of river found anywhere in Canada.

One of the keys to the biodiversity found in this part of the Fraser River and its floodplain is the influence of the U-shaped post-glacial valley bottom through which the stream wanders. The Fraser gravel reach and the eastern Fraser Valley were shaped by the power of a succession of massive glaciers, acting over millions of years, carving out the large trench that now forms the Heart of the Fraser.

The last wave of glaciers receded from southern British Columbia 12,000 years ago. Once the great sheets of ice melted after the end of the Pleistocene Era, the water from the large catchment area in the central part of British Columbia that comprises the Fraser River could be funnelled through a large canyon upstream of Hope and then on through its gravel reach. The colonization of plants, animals and humans followed from the south, southeast and north, as the landscape became bereft of ice and made conditions habitable. Because the post-glacial colonization of biota arose from a variety of different directions across western North America, the biodiversity of the area tends to be diverse compared to other parts of British Columbia (e.g., for fish, Beacham *et al.* 2003, Hass and McPhail 2001, Smith *et al.* 2001, Smith *et al.* 2002, McPhail and Taylor 1999).

Along with the unique geographic location and morphology of the eastern Fraser Valley, the biological productivity and diversity of the plants and animals of the gravel reach, living within the stream and on the floodplain, is a function of adaptation to a flow regime that comprises periodic flooding over the annual hydrological cycle (Figure 1-3). The Fraser River drains approximately one-quarter of the geographic area of the province of British Columbia, and the vast amount of water that flows through its gravel reach can be substantial at times. For the Fraser River, the greatest discharges occur in late spring and early summer, and this freshet is comprised predominantly of the meltwaters of the accumulated interior snowpack.

The Fraser's large discharge volume during freshet causes a dramatic change in the stream's water-surface elevation (Figure 1-4) as floods inundate the accessible lower-lying areas of the gravel reach, spread across the landscape, and then subside over this period. This has allowed many organisms that are adapted to live in periodically-flooded riparian habitats to thrive in the gravel reach. This is also a dramatic illustration of the dynamic nature of the river and, thus, the habitats that it creates and the opportunity for the diversity of species that live here. They are adapted to, and now require, this temporal variation of their habitats. Anything that alters this pattern, human or natural, can have large-scale effects on the ecosystem and biodiversity.

While much of the natural floodplain in the gravel reach of the Fraser River is routinely inundated, the form of the landscape is also not static. For example, the heavy flows that occur during the spring months provide hydraulic power for the water to continually create, destroy and re-create a myriad of channels, bars, islands and other niches within the stream bed and the riparian area of the gravel reach. This is accomplished through erosion, deposition, and conveyance of sediments, as well as recruitment and loss of large-woody debris. The extensive community of organisms uses these diverse physical features as habitats.

Part of the physical diversity and associated habitat complexity includes the extensive range and abundance of sediment sizes found here, including clays, silts, sands, gravels and cobbles. These sediments are deposited and eroded by the strength of the powerful flows of the stream. Many fish are adapted to spawn and rear over and within specific sub-components of these sediments and segregate ecologically according to whether sand, gravel or cobble are available. These sediments are comprised of both material of ancient ancestry left by retreating glaciers, and material recruited yearly from within and upstream of the gravel reach.

Silt and sand deposition (and erosion) continually occurs in the gravel reach due to the large volumes entrained in the water column and/or moved as bedload from both upstream areas and locally throughout the year, particularly during freshet. These volumes range from several million tonnes a year to tens of millions, depending upon the grain size. Some gravel-sized and cobble sediments are recruited each year from above Hope and are deposited throughout the gravel reach upstream of Mission. Some of these coarser sediments are moved only a short distance each year and re-deposited. Thus, their configuration is regularly re-arranged by the floodwaters.

Large-woody debris, scattered along the valley bottom and recruited from both local and upstream sources through erosion is facilitated by the enormous power of the river and is also a significant part of the material load.

Large woody debris is thought to be important in trapping sediments and initiating sand and gravel bar, and island formation, as well as providing habitats for organisms (Bratty 2001, Ham 2005).

Following closely behind the post-glacial colonization of plants and animals was the settlement of human beings. First Nations have been part of the eastern Fraser Valley landscape since shortly after the last glacier ice retreated. They have lived in this extra-ordinary ecosystem for thousands of years, utilizing its resources. Over time, highly complex indigenous cultures evolved within the eastern Fraser Valley, facilitated by the easily-accessible and abundant salmon and other aquatic resources, right at their doorstep (Siemens 1968).

What may have been a relatively stable and sustainable co-existence amongst human beings and the indigenous plants and animals that occupied the Fraser gravel reach came to an abrupt end with the European settlement of the area. Following the gold rush in the late 1800s, colonization of the eastern Fraser Valley occurred and the pace of settlement gained momentum into the first half of the twentieth century. Much of the natural wealth of the eastern Fraser Valley and the gravel reach was quickly exploited through timber harvest and land clearing for agriculture. In order to convert the floodplain of the gravel reach into fields for growing food, extensive diking, draining and levelling of the large and very moist floodplains occurred rapidly throughout the early 1900s. The largest of these impacts included the diking and draining of Sumas Lake for agriculture (Rosenau and Angelo 2005).

As a result of these land-development activities for agriculture, many of the riparian areas of the Fraser gravel reach became isolated from the all-important natural inundation of the spring/summer freshets (Figure 1-5). The processes that permitted the movement of water, plants and animals, nutrients, sediments, and woody debris from the stream channel, and across the floodplain, became interrupted by dikes and channelization (Ellis *et al.* 2004); this activity and the clearing of the native vegetation resulted in massive ecological losses (Rosenau and Angelo 2005). Thus, what remains of the riparian and wetted channels outside of the dikes is only a remnant of the expansive historic aquatic ecosystem in the lower Fraser Valley (Langer 1999, Figure 1-5). The result is that by the early part of the twentieth century almost all of this once-vast aquatic and riparian community of fish, plants and other animals was destroyed, or re-arranged, with only small habitat remnants remaining in a narrow band along the active river channel. Thus, over the last 150 years the gravel reach has been physically and biologically re-organized in a way not seen since the last Ice Age.

The losses within this remnant ribbon of green-space along the river, however, have not abated and persist to this day as human activities continue to expand onto the remaining undiked portion of the floodplain (Langer, in press). Following from the initial extensive development of farming in the eastern Fraser Valley, the floodplain areas on the wetted side of the dikes continue to be increasingly exploited for urban, commercial and industrial development. Furthermore, land clearing for agriculture has not stopped in the remaining riparian areas and there has also been an acceleration of other resource-extraction activities such as pulpwood harvest, and instream and floodplain gravel mining.

The losses of habitat that have occurred and continue in the floodplain areas of the gravel reach are not unique to the lower Fraser River despite their ecological importance. Tockner and Stanford (2002) state that natural floodplains are amongst the most biologically productive and diverse ecosystems on earth but they cover only two million square kilometres (0.4%) of the planet's surface. Floodplains are also amongst the most threatened of ecosystems because they are among the most nurturing places on the globe for humans to live and the activities of people invariably disrupt these natural environments. The human disturbance of floodplains is now linked to the rapid decline in the diversity of freshwater ecosystems that we are now observing around the world. Tockner and Stanford (2002) also suggest that for Europe and North America up to 90% of floodplains are already 'cultivated' and therefore functionally extinct; these authors take the position that there is an urgent need to preserve existing, intact flood-plain rivers as strategic global resources. In their opinion this requires the restoration of hydrologic dynamics, sediment transport and riparian vegetation to those rivers that retain some

level of ecological integrity. Tockner and Stanford (2002) also state that if action is not quickly taken, dramatic extinctions of aquatic and riparian species and of ecosystem services will unfold across the planet within the next several decades. The situation facing the Heart of the Fraser clearly falls within this category. Given the area's proximity to urban Vancouver and the emerging economic powerhouse of the Pacific Rim, pressures to develop and exploit this remaining sliver of habitat along the Fraser River are intense. Furthermore, it will be difficult to protect this environment because, despite the statutory requirements, and verbal and written commitments by governments and First Nations to protect the ecosystems of the Fraser River, habitat losses continue to the point that, in the very near future, the Fraser gravel reach will bear no resemblance at all to its natural form and ecosystem of 150 years ago.

While the impacts to this highly diverse and unique aquatic ecosystem have been extensive, the remnant riparian and instream ecology of the Heart of the Fraser is, nevertheless, still remarkable beyond anything of its kind in western North America. The crucial question that remains: **Is there any way that we can save or protect these last remaining components of this unique ecosystem in the Fraser gravel reach?** From an optimistic viewpoint, it is believed that Canadians still value environmental diversity and sustainability and are willing to save these kinds of habitats if provided with a sense of direction and leadership and with confidence that the task will not be futile.

To counter the current ecological deterioration in the Fraser River gravel reach some decisive steps are being taken in what is now being referred to as the "Heart of the Fraser initiative" comprising a coalition of individuals and Environmental Non-Governmental Organizations. Their aim, in the short term, is to secure and protect key habitats in the Fraser gravel reach through privately funded land purchases and donations. The objective of this initiative is to protect these sensitive habitats, in perpetuity, in order to leave an ecological legacy for future generations. However, because it is unreasonable to expect that all of the necessary habitats can be purchased in the near future by private interests, it is also imperative to adopt a workable collaborative management plan that makes sense from both an economic and an ecological perspective, and involves all relevant stakeholders. This plan needs to also be developed and implemented into the concept of protecting instream and riparian habitats of the remaining critical areas of the gravel reach. All levels of governments and stakeholders must be involved in fashioning and implementing it.

This report is intended to contribute to public understanding and expedite action for the Heart of the Fraser initiative. It is meant to help instigate broad public discussion and government agency action. This report describes the environmental and ecological aspects of the Fraser gravel reach, explains the historic and current human-related impacts to this ecosystem, and then discusses how the Heart of the Fraser can be sustained and repaired in light of the expanding rates of development and resource exploitation now occurring in the eastern Fraser Valley. To achieve this, the report's contents are presented in the following sequence:

1. After introducing the subject, some of the physical and hydrological attributes of the gravel reach are described. These features are key to the extraordinary biodiversity found in the area.
2. This biodiversity, with a particular focus on the fisheries values, is then profiled. This provides the essential perspective and basis as to why the Heart of the Fraser is important to protect.
3. The report then documents, in detail, the extent of the historical and current impacts by humans to the instream and riparian ecosystem of the gravel reach.
4. It also profiles the statutory and regulatory responsibilities of the various levels of government. At some level, governments have a crucial role to play in initiating much of the discussion and providing some of the resources to achieve the objective of protecting the Heart of the Fraser.

5. The Heart of the Fraser initiative is then portrayed, examined and explained and the example of a current acquisition is profiled. Also described is the need for a collaborative management plan that protects existing ecosystem values for the Heart of the Fraser that is inclusive and makes sense to the broader British Columbian and Canadian public.
6. Finally, this report proposes approaches and strategies that will be fundamental to implement the Heart of the Fraser initiative and save the remaining ecosystem values of the gravel reach.

Figure 1-1. Map of the Fraser River watershed, British Columbia, and location of the gravel reach.

Figure adapted from a Fraser River map of the Pacific Salmon Commission web page
http://www.psc.org/info_fisheriesmap.htm.

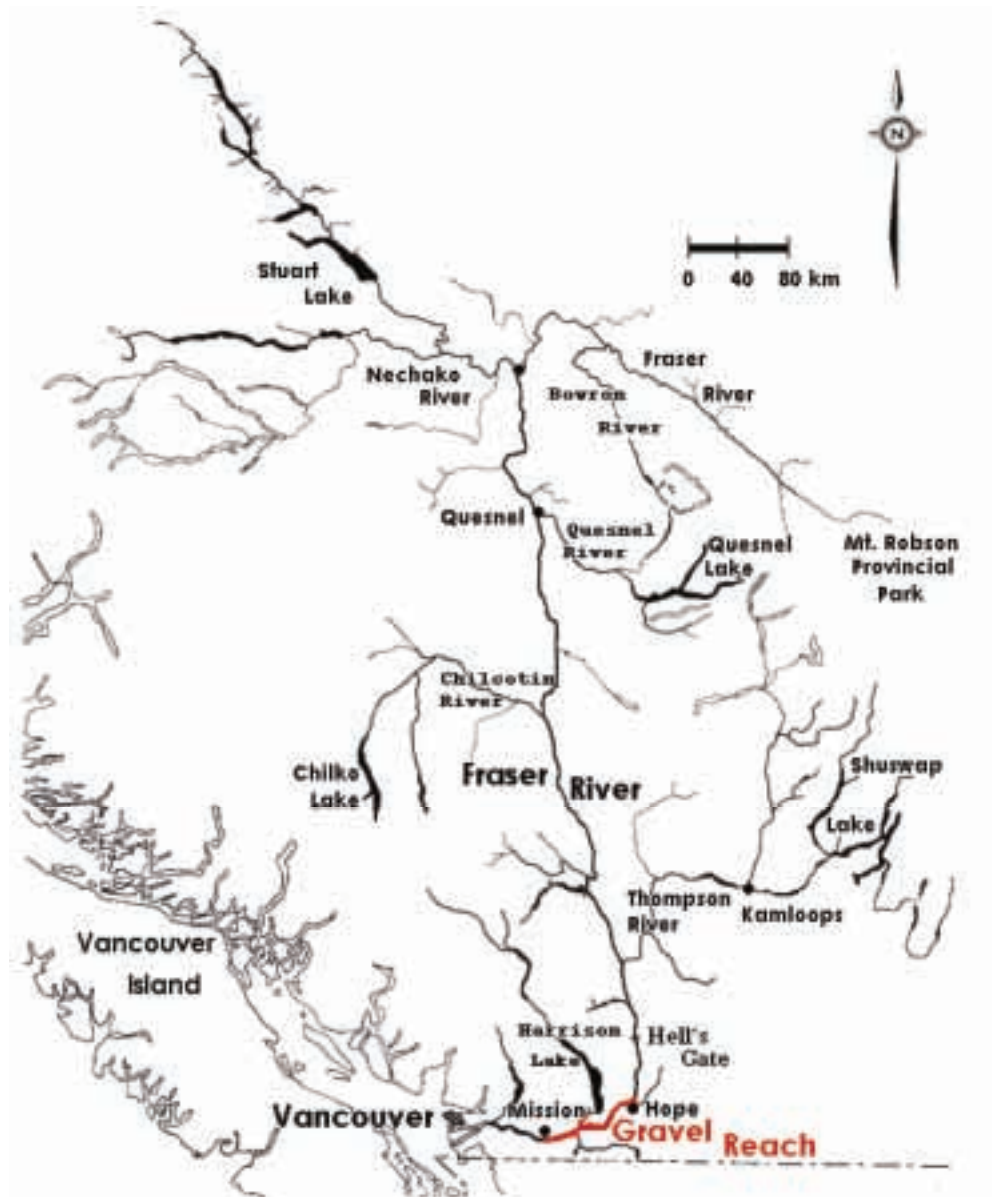


Figure 1-2. The Fraser River, in the gravel reach from Hope to Mission, in many of its various moods.
Bottom left photo D. Catt.

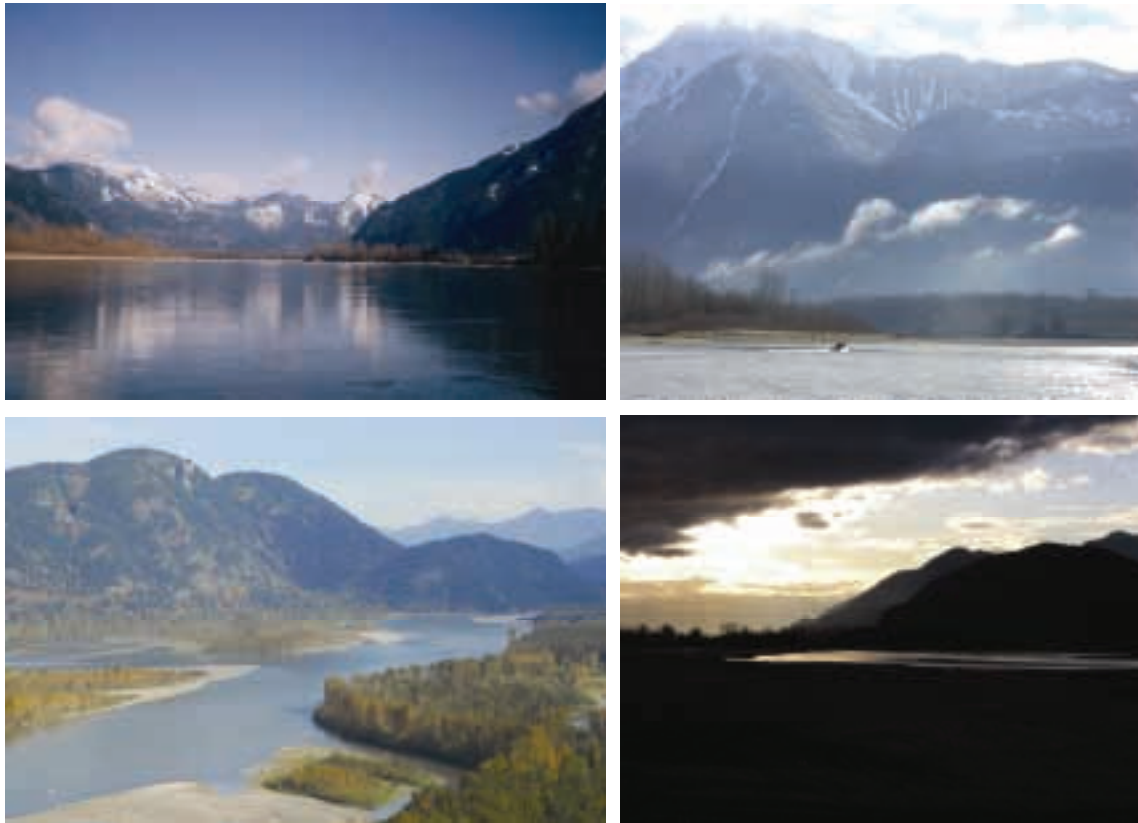


Figure 1-3. Minimum, mean and maximum Fraser River daily flows for the yearly hydrograph over the period of records, Water Survey Canada gauge at Hope.
Adapted from Water Survey of Canada (2003).

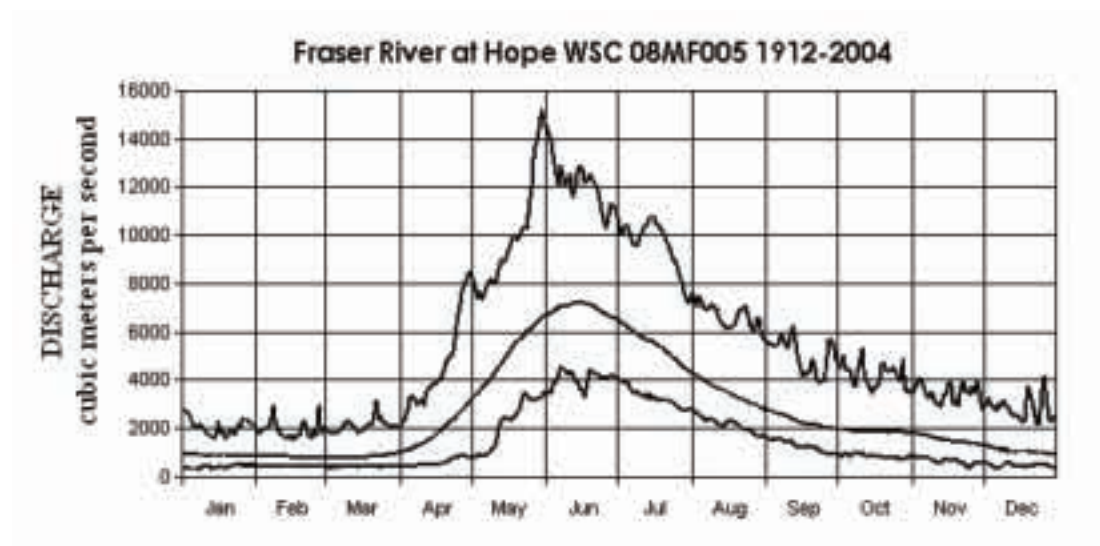


Figure 1-4. Minimum, mean and maximum Fraser River daily flow water levels for the yearly hydrograph over the period of records, Water Survey Canada gauge at Hope, Agassiz and Mission.
Adapted from Water Survey of Canada (2003).

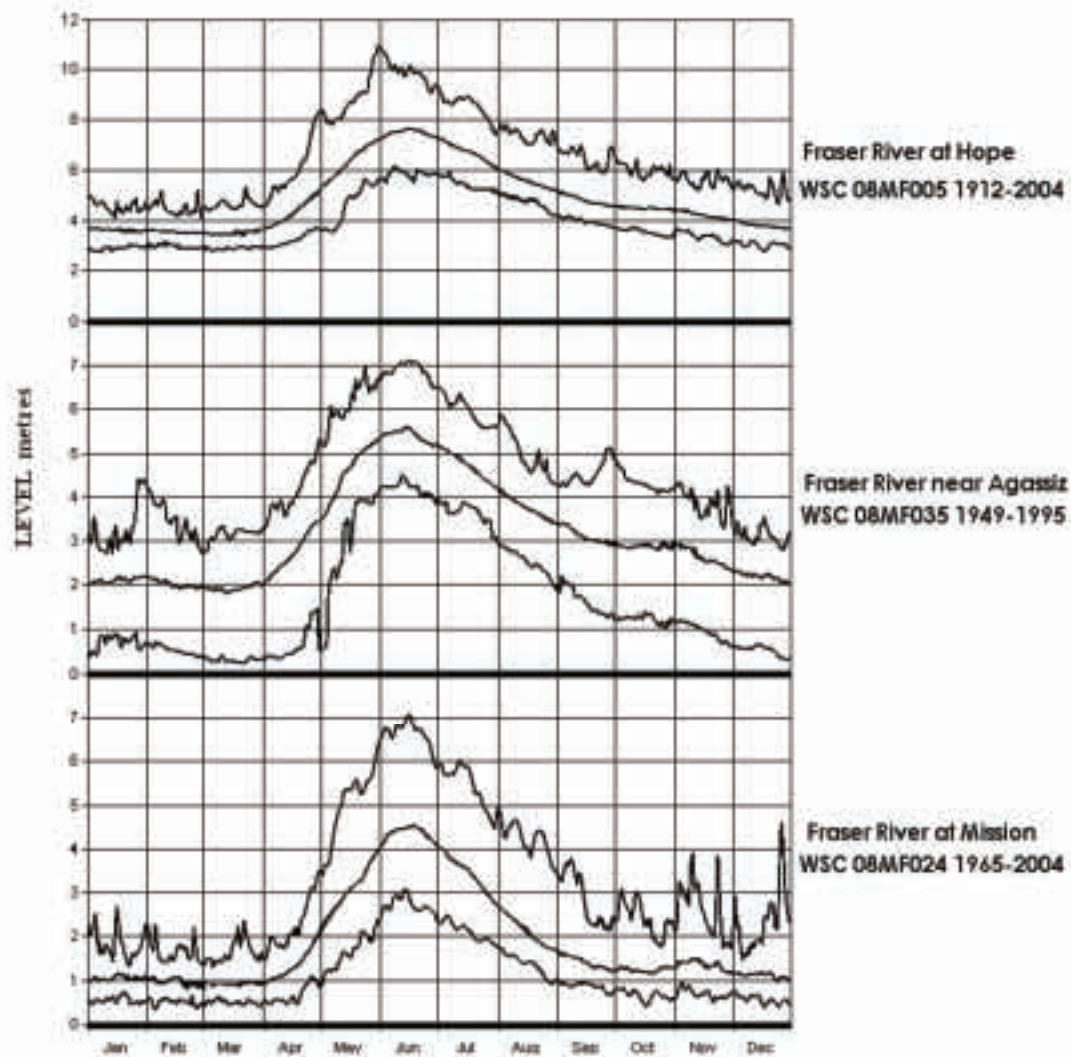


Figure 1-5. Map of the diked and un-diked floodplain of the gravel reach of the Fraser River, British Columbia.

Adapted from Church and Ham (2004); note that the floodplain has been almost completely isolated with the exception of a small number of large islands within, or directly adjacent to, the main river. See Figure 1-1 for geographic location within the Fraser River watershed, British Columbia.



2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

ORIGIN OF FLOWS IN THE FRASER RIVER

The Fraser River is the largest waterway contained almost completely within British Columbia's boundaries (Figure 1-1). It originates from the slopes of Mount Robson Provincial Park in the east-central part of our province and is 1,370 kilometres long from its most upstream source to the Pacific Ocean at Vancouver. Over this distance the Fraser River drains 236,000 square kilometres (91,000 square miles), or about one quarter of the province. Prior to the Nechako River diversion in the upper watershed, the Fraser River catchment area was even larger. The vastness of the Fraser River drainage area provides the opportunity for this river to gather the substantial discharge volume that eventually flows into the ocean.

The elevation of the land in the Fraser River catchment area ranges from sea level at its confluence with the Strait of Georgia to 3600 metres in the mountains at its headwaters. As a result, winter precipitation stored as snowpack melts over a protracted spring and summer period in the wide range in elevations where the snow is deposited. The expansive east-west and north-south geographic distances that the Fraser River watershed covers, from the milder-climate coast to the more-extreme interior, and from the 49th to the 56th latitudes, also affects and extends the rate and timing of the snowmelt.

While the Fraser River starts out as a small stream flowing northwards from Mount Robson Provincial Park, it soon increases in size as tributaries contribute to its flows. Immediately downstream of its origin, the Bowron, McGregor and Nechako rivers bolster the Fraser River with significant discharges upstream of Prince George. Once the Fraser flows past the northern portion of the great central plateau, and turns southwards through Prince George, large streams such as the Quesnel, Chilcotin, Bridge and the Thompson rivers feed into it. The final major stream substantially affecting flows in the gravel reach of the Fraser River, and contributing over 10% of the total discharge during peak freshet, is the Harrison River. It is located in the centre of the Heart of the Fraser and enters the Fraser River roughly midway through the eastern Fraser Valley. Only the Pitt, Stave and Vedder-Chilliwack rivers provide significant additional flows between the Harrison River and the sea.

HYDROGRAPH THROUGH THE GRAVEL REACH

The unique flow patterns occurring throughout the gravel reach of the Fraser River, annually and within each year, influence the breadth and complexity of the biodiversity in its aquatic and riparian ecosystems. The Fraser River has a mean annual discharge of 3,540 cubic metres per second, as measured at the Hope Water Survey of Canada gauging station at the head of the gravel reach (Water Survey of Canada 2003); these discharges are averaged over a long term taken from measurements from 1912 to 2004.

Compared to many of the local streams in the lower mainland as well as to a less degree for the streams in the central interior of British Columbia, Fraser River flows within the gravel reach are relatively stable throughout the period of the year. The Fraser River experiences its greatest discharges when water from the snow-melt of the central, south central, and northern interior makes its way downstream as a result of the warming influence of the spring and summer melting temperatures on the snow pack. The smaller tributary streams in the interior of the province have hydrographs that reflect this as they usually peak in flows during the mid to late spring. The timing of the Fraser River's spring-dominated freshet hydrograph is unlike the flow patterns seen in our smaller coastal streams which have their greatest discharges when large, but warm, late-autumn or early-winter rainfall events fall on snow which has already accumulated in the local watersheds and melt it; the combination of the snowmelt and rain waters often cause severe flooding in coastal British Columbia streams.

Discharges in the gravel reach normally have a relatively narrow range of about ten times the difference between low-winter flows and peak freshet (Figure 1-3). In contrast, small streams along the coast can easily have a range of one hundred to one thousand times magnitude between very low summer flows and extreme rain-on-snow flood events in the late fall or early winter. Furthermore, in contrast to the much flashier and erratic coastal streams which can vary widely from year to year, the maximum-estimated freshet flow of 17,000 cubic metres per second in 1894 is only about 50 times the minimum discharge ever recorded in the Fraser River at Hope (Water Survey of Canada 2003; Figure 1-3).

In contrast to the large spring and early summer flows, the gravel reach can also experience minor freshets during the fall and early winter due to intense warm rains and melting snow events in local watersheds in the lower mainland and southern interior of British Columbia (Figure 1-3). Compared to spring freshet, however, the flows at this time of year are of significantly lower volumes and of substantially shorter duration. Changes in run-off patterns may be the result of climate change (c.f., Morrison *et al.* 2002). Ham (2005) provides evidence for this phenomenon and suggests that recent peak-flood flows in the Fraser River have declined nearly five percent. If this phenomenon is persistent, it has the potential of changing the structure of the biological community in the gravel reach.

While the Fraser River's yearly difference in flows—from the normal minimum in the winter to average peak flows in June-July—as expressed as a ratio is modest, the absolute volumetric change among seasons is large (Figure 1-3). Late winter discharges normally range between 500 and 1000 cubic metres per second. In contrast, the average spring flood discharge is 8,750 cubic metres per second at Hope and, including 2007, has equaled or exceeded 10,000 cubic metres per second four times since 1997 (Water Survey Canada 2003). The greatest-measured Fraser River flood occurred in 1948 and reached 15,200 cubic metres per second at Hope. A much higher discharge, estimated to reach 17,000 cubic metres per second, occurred in the great historical flood of 1894, although this flow happened long before modern hydrographic equipment was in place to take such measurements¹.

A significant feature of the Fraser River freshet flows, and one that clearly strongly affects the behavior and composition of the riparian ecosystem, is the substantial change in water surface elevation, from low winter flows to freshet discharges. Where the river widens and spills out onto the remaining floodplain between Hope and Mission, the annual change in the elevation of water normally increases 3.5 to 4 metres from winter-low flows to spring freshet (Figure 1-4, Table 2-1). This change has been known to reach eight metres in the peak of the flood in 1948 (Figure 1-4) and inundate vast areas when the dikes were breached in that year (Figure 2-1). For contrast, in the narrow Fraser Canyon at Hell's Gate, the change in elevation is usually about 20 metres from low flow to maximum freshet, but reached 30 metres during the 1948 flood (Saxvik 2006).

Prior to the gravel reach being extensively diked for agriculture in the first half of the twentieth century (Figures 1-5, 2-2), the river inundated large parts of the floodplain whenever the spring freshet exceeded the bank-full capacities of its main channel and major side channels. Indeed, the pre-diking freshet of the Fraser River was so extensive it would normally flood as far inland as the present location of the centre of downtown Chilliwack: *"When I was a boy, living on the old homestead, which lies out here just a mile south of the Five Corners, there never was a spring during high water season in which that front field (which lies between the farm home building and the highway), was not a lake. It was in that field at high water time that I learnt to swim at a very early age..."* (Orchard 1982). Even today much of existing un-diked floodplain of the gravel reach is still routinely flooded during larger freshets (Figure 2-3), although not a drop of river water has ever come near downtown Chilliwack

¹ Note that under the identical weather and snowpack scenario of 1948, the discharge at Hope would now be significantly lower as both BC Hydro's Bridge River and Alcan's Nechako River hydro-electric generation systems and storage reservoirs are now required by the provincial water management authorities to draw down their storage in advance of an anticipated flood, and then store water during the peak flood.

since 1948 due to the extensive diking system now in place (Figures 1-3, 2-2). While not all riparian areas are flooded every year (depending on the size of the freshet), they are zones of high aquatic biological productivity when inundated, and show extensive movements of water-adapted organisms occupying these spaces as a result of lateral movement of a wide variety of species (Figure 2-4).

From a biological perspective, a key aspect in maintaining a diverse instream and riparian ecosystem in this gravel reach is the regular and routine seasonal flooding of the lowland stream-side landscapes (c.f., Welcomme 2003). Nutrients, sediment, water and organisms are transferred laterally in all directions—both inland away from the main channel, and back out into the river from the vegetated floodplain—and this can only occur where the stream is not constrained by dikes (Stanford 1998, Ward *et al.* 2002). Thus, the back-and-forth movement of nutrients and biota in the Fraser gravel reach is a function of the hydraulic pathway provided by the rising flood waters and must be maintained along the undiked portions of the river if this ecosystem is to be maintained.

Figure 2-1. Inundation across the floodplain of the Fraser gravel reach during the great freshet of 1948 when the dikes were breached in a number of places.

This photo provides an illustration of extreme re-watering of the historic floodplain both inside and outside of the dikes. Photo adapted from web site: http://geoscape.nrcan.gc.ca/vancouver/flood_e.php

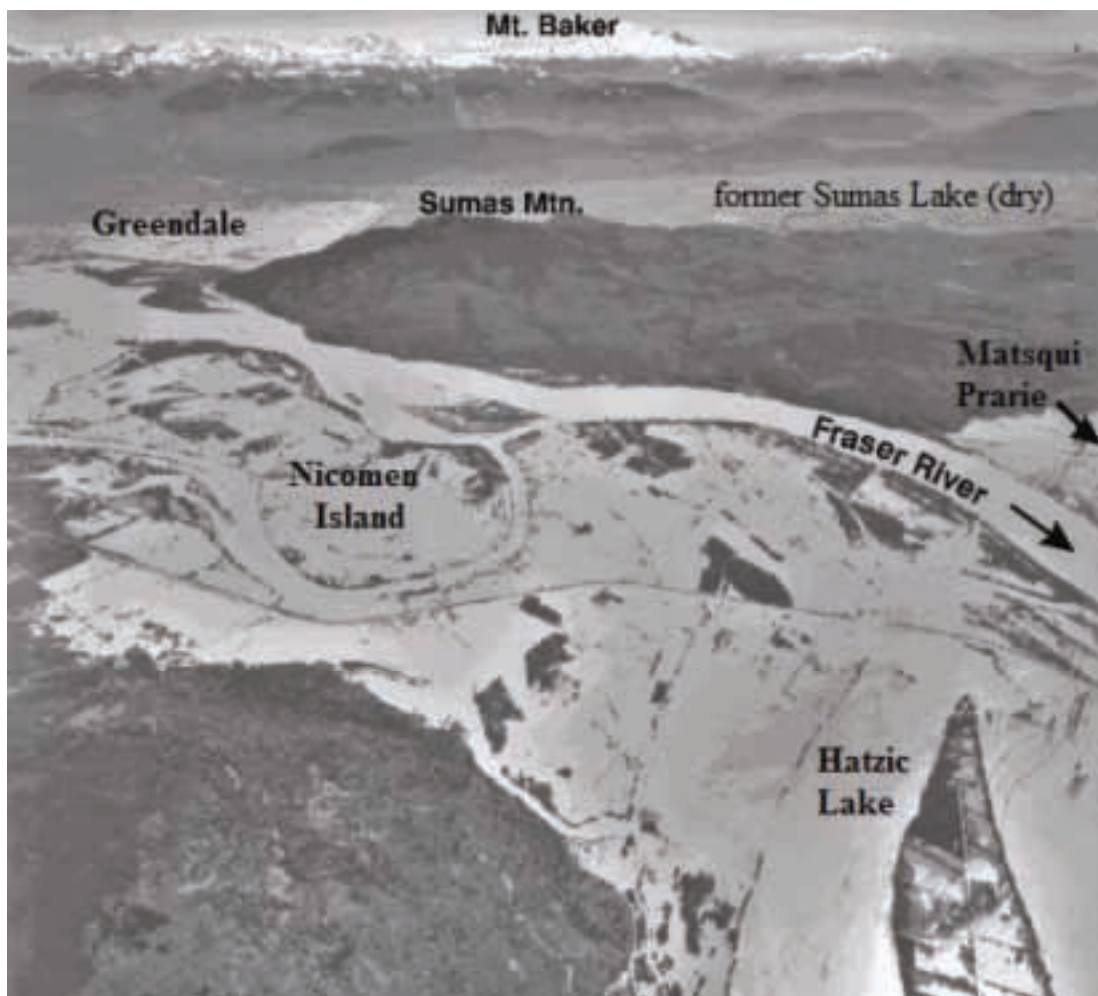
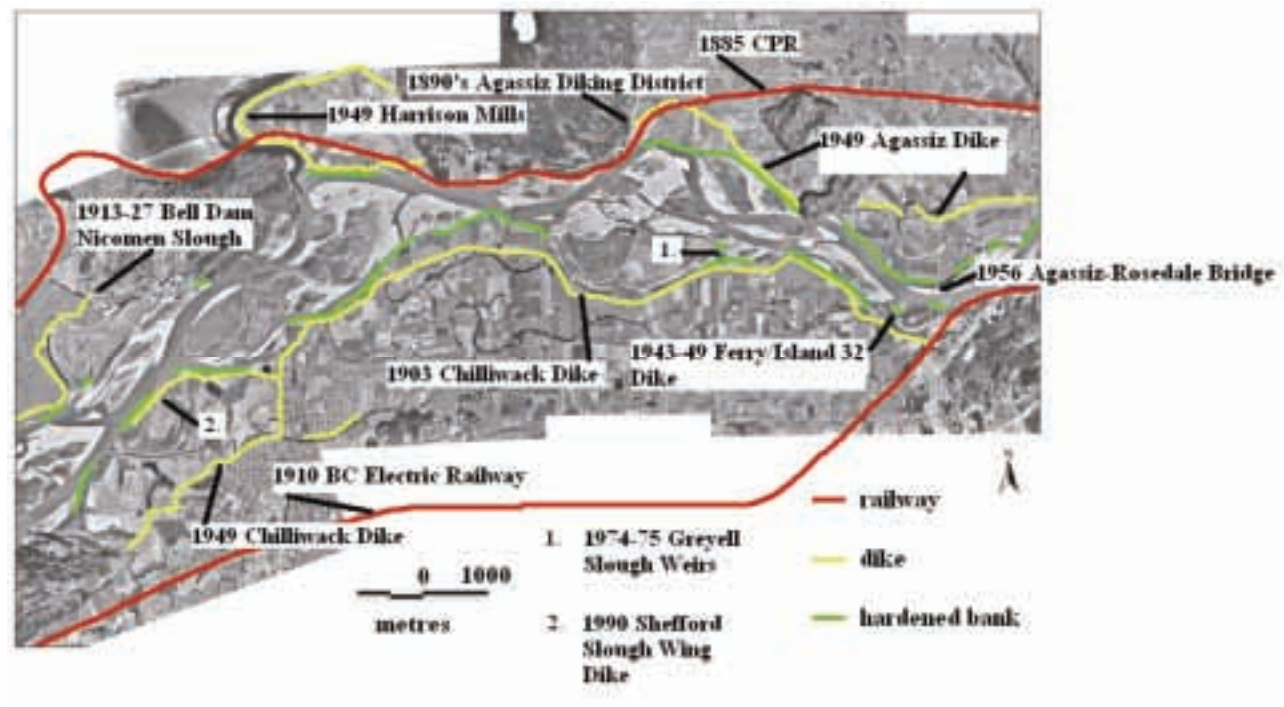


Figure 2-2. Chronology and location of dike construction and bank armouring in the gravel reach.*Figure adapted from Ellis et al. 2004.***Figure 2-3.** Inundation of the Fraser River floodplain at Island 22, freshet 2002.

Looking upstream towards the Harrison River from the lower end of Shefford Slough. Flows at the time of the photograph were around 10,000 cubic metres per second. Sampling the area of the right-hand photo indicated high densities of fish and invertebrates in this seasonally flooded area. This fish-rich and biologically diverse area is slated for extensive resource extraction, agricultural development and dike re-alignment. See Figure 1-5 for location.



Figure 2-4. Small portion of a seine haul comprising high densities aquatic organisms occupying a flooded hay field near the McGillivray Ecological Reserve in the gravel reach during the freshet of 2002.

Largest centre fish is a blue-listed brassy minnow, the rest of the fish are non-native invasive carp. Vast numbers of fish move into this area once inundation occurred, presumably to feed in the abundant invertebrate communities that we found here. This area is now being largely developed for industrial activity (Cannor Road industrial development) as per bottom photo, October 2007. See Figure 1-5 for location. Bottom photo D. Catt.



Table 2-1. Fraser River hydrograph flow-elevation range-differences for historic average, and lowest recorded flows versus highest recorded flows over the periods of records for Water Survey Canada gauges at Hope, Agassiz and Mission.

Data taken visually from Figure 1-4 and rounded to the nearest half metre; periods of record—Hope 1912–2004; Agassiz 1949–1995; Mission 1962–2004.

| Location | Average historic flow-gauge elevations | | Average range | Minimum-recorded flow-gauge elevations | Maximum-recorded flow-gauge elevations | Maximum range |
|----------|--|-------------------------------|---|--|--|---|
| | For winter low-flows metres | For freshet peak-flows metres | Between season range differences metres | For winter low-flows metres | For freshet peak-flows metres | Between season range differences metres |
| Hope | 3.5 | 7.5 | 4 | 3 | 11 | 8 |
| Agassiz | 2 | 5.5 | 3.5 | 0.5 | 7 | 6.5 |
| Mission | 1 | 4.5 | 3.5 | 0.5 | 7 | 6.5 |

GRAVEL REACH GEOMORPHOLOGY

DIVERSITY IN CHANNEL FORM

Rivers are formed in all sorts of shapes and sizes, with many factors affecting the patterns of their channels and floodplains. Streams, such as the Fraser gravel reach, which have unconfined alluvial channels, normally change their stream-bed patterns through the downstream progression of sediments and lateral re-positioning of the deepest channel resulting from bank and channel erosion, and sediment deposition on channel bars (Church 1983). Ham (2005) also suggests that stream morphology “...[a]long the length of a channel network, [and] within a homogenous reach is dominantly influenced by the local flow and sediment regimes (cf. Mollard, 1973; Kellerhals *et al.*, 1976; Richards, 1982; Church, 1992) and by valley gradient (Carson, 1984; van den Berg, 1995). Further, land use patterns (Dykaar and Wigington, 2000; Kondolf *et al.*, 2002), riparian vegetation (Hickin, 1984; Millar, 2000), bank strength (Schumm, 1963; Millar and Quick, 1993) and anthropogenic modifications (Kellerhals and Church, 1989; Collins and Dunne, 1990) have been identified as secondary factors that locally influence adjustments to channel shape, position and pattern. Together, these variables directly influence the entrainment, transport and deposition of clastic sediments, and hence the morphology of alluvial channels.”

The great power of the Fraser River flow facilitates the morphological change of its floodplain, islands and the channels of the gravel reach through erosion and deposition of its sediments (Ham 2005), which in turn continually renews the aquatic and riparian habitats and creates an abundance of physical niches which organisms can use as living space.

Throughout much of its upper 1,370 kilometres length, the channel configuration of the Fraser River is predominantly single-threaded and confined, from its headwaters until it becomes the gravel reach. At Hope, and then downstream to Mission, the Fraser River breaks out of its single thread form to become a wandering or braided gravel-bedded stream (Figure 2-5; Desloges and Church 1989, *c.f.*, Tockner *et al.* 2006).

At Hope, the stream increasingly changes from a single-thread, uni-directional channel, to one which is comprised of irregularly-sinuous multiple-threads which split around large bars and island complexes as the gradient declines from upstream to downstream (Ham 2005; Table 2-2). As the Fraser River shifts across the width of the eastern Fraser Valley, its cross-sectional shape normally includes a single large channel—containing the deepest part of the stream—and a number of smaller side channels (Figures 2-5, 2-6). These channels all vary considerably in size, discharge capacity and stream-bed elevations, as well as habitat attributes.

Tockner *et al.* (2006) suggest that erosion and deposition of sediments, the avulsion of channels, and the production, entrainment and deposition of large woody debris, linked to ground- and surface-water interactions, create a complex and dynamic array of aquatic and terrestrial habitat components, and this can be referred to as the Shifting Habitat Mosaic (SHM) (Stanford 1998, Poole *et al.* 2002, Ward *et al.* 2002, Lorang *et al.* 2004; see also Rosenau and Angelo (2005) for a discussion of this in the Fraser’s gravel reach). The concept of the SHM is a reflection of the dynamic nature of braided rivers.

Many of the historic side channels in the Fraser gravel reach have, over time, become isolated from the main flows as a result of natural stream wandering processes. Furthermore, many of these off-channel features naturally became extensive wetlands throughout the original valley bottom, providing habitat for a large diversity of organisms. However, most of these historically wetted areas within the Heart of the Fraser were drained for agriculture throughout the early twentieth century and were subsequently lost to the aquatic ecosystem. Furthermore, since the arrival of European settlement, many of the regularly-flowing secondary channels have been isolated from the main channel, through the construction of dikes and barriers, with some of them being detached from the mainstream only very recently (Figure 2-7).

Rosenau and Angelo (2000) reported that over 100 kilometres of secondary channels have been blocked by human activity at one or both ends since the turn of the nineteenth century (Appendix 1); this estimate is a minimum as they only measured the major side channels, and many of the more numerous smaller channels were not included in their analysis. Similarly, Ellis *et al.* (2004) calculated the change in total bank-line length of the historic Fraser River in the Chilliwack area floodplain; this measurement is a proxy estimate of side-channel abundance. Ellis *et al.* (2004) showed a substantial decrease of bank-line over the past century of about 44%, down from an estimated maximum of 247.31 kilometres before 1903, to 137.24 kilometres in 1999. The greatest of these losses occurred when the first large dike was constructed near Chilliwack prior to 1903 (Figure 2-2). All of these blocked side channels have lost much or all of their formerly stream-like functioning capacity and appear to have dramatically reduced habitat capacity (Figure 2-8).

ISLAND CHARACTERISTICS

Sandwiched between these large and small channels are small and large vegetated islands whose tops are routinely flooded during freshet (Figure 2-3). The extent of inundation depends on the absolute volume of the flood flows, the elevation of the islands and the channel morphology at that specific location in the gravel reach. Many of the older islands have high-surface elevations that are only flooded at the very greatest of spring freshets (Ham and Church 2002). These flood-prone riparian areas have exceptionally rich biological attributes.

Ecologically, islands in braided streams, such as those occurring in the gravel reach, can be seen as pivotal landscape elements (Tockner *et al.* 2006). Early vegetation succession stages are often represented on river islands, and in many parts of the world they are colonized by a diverse fauna and flora and can provide refugia for endangered species (Tockner *et al.* 2006). Islands can also have far fewer invasive species because they are newly formed and somewhat isolated from the mainland. Where edge habitat is important for an ecosystem, they have a high perimeter-to-area ratio and this provides an abundance of this type of an environment in streams. Islands will also function in providing pathways of migration for small mammals and retain aspects such as large woody debris along their perimeters as is seen in many locations within the gravel reach (Figure 2-9). Tockner *et al.* (2006) suggest that for Europe there are only a few possibilities left for studying the ecology of large riverine islands as most of the streams have been modified by humans; we are rapidly seeing the same trend here in North America.

Over the last 100 years human changes to the large islands in the Fraser gravel reach have been extensive. All of them have been cleared of their native forest to a degree since the arrival of the European, with most being razed for agriculture or forestry since 1900. A large number are no longer recognizable as islands due to the anthropogenic blocking of their side channels at one or both ends (e.g., Fairfield Island in Chilliwack). Indeed, the gravel reach is now 22% narrower since 1913 due to diking, bank armouring, and blockage of the active channel zone (Ham and Church 2002) (Figure 2-10). In other words, the consolidation of many of the islands into a diked and protected part of the “mainland” has resulted in a smaller floodway cross-section and this reduces the capacity through which water can flow through and the local ecology can properly function.

After the extensive isolation of the major islands from the active channel in the gravel reach in the early part of the twentieth century, conditions stabilized to a certain degree. Still, from 1928 onwards the total area of islands within the gravel reach continued to decline until the 1950s, but then they began to increase again up to the latter half of the century. Thus, by 1999 there was not much difference in the total surface area of the large islands in the gravel reach when comparing 1928 with 1999 (Ham and Church 2002).

The waxing and waning of island area in the gravel reach was largely due to sediment erosion and deposition. However, there was one major difference in the structural character of the early islands compared to the later islands. In 1928 the Fraser gravel reach islands had relatively higher surface elevations, and by 1999 these were

substituted with islands having significantly lower-surface elevations (Ham and Church 2002). All other things being equal, it is likely that the ecology and species communities of these island habitats in 1928 differed from similar-sized islands in 1999, being inundated more frequently and hosting a contrasting array of plants and animals.

SEDIMENT COMPOSITION OF THE GRAVEL REACH

Braided gravel-bed rivers such as the Fraser gravel reach are a phenomenon of temperate northern and southern hemisphere mountainous areas (Tockner *et al.* 2006). Braided rivers are normally delineated by banks and stream-beds made up of non-cohesive sediments such as sands, gravels and cobbles (Appendix 2).

For the Fraser River, gravel is the most abundant sediment class in the active channels of this reach; thus, this area is aptly named the “gravel reach”. The gravel is particularly noticeable in this reach during low flows when the bed of the river is exposed and the large bars between the Sumas River confluence and Hope can be seen, especially during winter. Nevertheless, this reach is comprised not only of gravel but of an extensive mixture of other size-classes of sediments arranged according to horizontal and vertical orientation to the active channel and river gradient. The diverse sizes of sediments comprising the stream bed and riparian areas of the gravel reach are sorted by the Fraser River’s flows and show a clear downstream decline in diameter from Hope to Mission (Table 2-2; Figure 2-11). Cobbles tend to predominate in the surface sediments of many of the bars and in the active channel at Hope, while sand is the major component of the stream bed by the time the river reaches Mission. The sorting of sediments, from coarse to fine, over the length of the Fraser gravel reach is clearly related to the reduction in gradient from upstream to downstream (Table 2-2) and the progressive widening of the floodplain as one gets further below Hope (Figure 1-5).

Vertical stratification of sediments by size also occurs for any given location in the Fraser’s gravel reach. The finest sediments are generally found on the highest elevation banks within the current and historical floodway. Old, high-elevation islands, or over-bank areas, often will have one to several metres of fine material covering a base of coarser gravel mixtures (Ham 2005; Figure 2-12). These strata can be exposed and eventually mobilized as the stream erodes its banks in lateral and vertical directions. Once these stream-bank sediments are entrained into the moving water of the Fraser River, the various size classes of material are sorted by size and differentially re-deposited, or washed out of the gravel reach, depending on the magnitude of the size of the individual particles and the power of the flows.

ORIGIN AND MOVEMENTS OF THE SEDIMENTS IN THE GRAVEL REACH

The sediments seen today on and below the surface of the stream bed of the Fraser gravel reach have arrived from both near and far. They are the result of both present-day stream processes and ancient glacial deposits (Armstrong 1981). Some of these sediments moving within the active floodplain are derived locally from within the gravel reach channel and riparian areas, while others are recruited from upstream of Hope. While many of the *in situ* coarser sediments in the gravel reach of the Fraser River, such as gravel and cobble, are derived from historic ice age deposition, large amounts of sand, silts and clays are still carried each year from upstream sources suspended in the moving water column as wash, or by saltation (bouncing) along the bottom of the river as bedload (Armstrong 1981). The annual total of all size classes of sediment moving through the Fraser Canyon and on into the gravel reach averages around 20 million tonnes, and the bulk of this is sand and silt. However, the volume of each freshet-year’s sediment entering the gravel reach, whether of small or large diameter, is strongly correlated to the magnitude of the freshet.

The Fraser River has considerable power and much of the material smaller than gravel continues onward through the Heart of the Fraser and is deposited on either the delta or in the Strait of Georgia (McLean *et al.* 1999, Church 2001). However, coarser sediment particles are much more difficult for the stream to move and little or no gravel

is mobilized at stream flows less than about 5,000 cubic metres per second—the threshold for significant gravel transport in the gravel reach as measured at Hope (Ham 2005). Once flows exceed this volume, gravel starts to be mobilized in increasingly greater amounts. Indeed, the functional relationship between the amount of gravel-sized material that is transported into or within the gravel reach can be described by a curvilinear relationship; that is, the incremental amount of gravel moved by the stream increases nonlinearly as the flows increase.

A rating-curve equation describing the relationship between discharge and the amount of gravel mobilized in the gravel reach at Agassiz was developed by Church (2001). The functional relationship between stream flow and the weight of this class of sediment moved is approximately to the power of six, and is described as:

$$G_{\text{tonnes}} = 2.231 \times \text{Maxflow}_{\text{cms}}^{6.037}$$

where:

G—is gravel in tonnes

Maxflow—is the maximum flow of the spring freshet at Hope, with the units (cms) in cubic metres per second.

Thus, small and medium flows do not recruit much gravel into the gravel reach downstream of Agassiz, but flows in years of high-freshet discharges move comparatively larger amounts of this material into, or within, this sub-reach within the Heart of the Fraser.

The ecological consequence of this gravel movement is that it provides the basis for the continual revitalization of habitats for the dynamic ecosystem that is found in this reach. It is also important to note that climate change may be causing lower peak-freshet flows as larger amounts of the snow pack now appear be melting during other times of the year than late-spring early-summer (e.g., 2005 had record-high winter flows; 2006 showed record-low late summer and early fall flows, Water Survey of Canada at Hope). Preliminary analysis of flows through the gravel reach by the authors of this report, and others (Morrison *et al.* 2002), also suggest that changes to flow patterns may have occurred over the past fifty years. The effects on the hydrograph due to climate change may ultimately and significantly reduce the amount of gravel that is mobilized within and into the gravel reach as peak freshet flows may be starting to be attenuated by spreading the discharges over a greater period of the year (c.f., Ham 2005).

While the fraction of the volume of small-sized alluvial sedimentary material (e.g., clay, sand) entering and passing through the gravel reach each year is comparatively large, the amounts of the coarser material such as gravel are relatively small for the size of this stream. The long term (1952–1999) average deposition rate of gravel-sized material for the sub-reach between Agassiz and Mission is estimated at between 200,000 and 300,000 cubic metres per annum (Ham 2005). Because of its weight, gravel-sized material largely and ultimately remains in the gravel reach upstream of Mission as the power of the river is not sufficient to carry it past this point of low gradient and widened channel. Some of the gravel-sized sediments deposited between Agassiz and Mission are from material that is displaced from the gravel reach between Agassiz and Hope; this zone has experienced large-scale losses in sediment from 1952 to 1999 and is a major zone of degradation (Ham 2005). The remaining gravel that ends up depositing between Agassiz and Mission arises from upstream of Hope, although the actual amounts derived from this or the Agassiz-Hope sub-reach still require further study (D. Ham, pers. com.).

Despite the importance of the coarser sediments to this part of the Fraser River, sand also plays a key role in the sediment budget of the gravel reach. About 30% of bulk samples of material taken from any mid-river “gravel bar” located in the centre of the gravel reach is comprised of sand (Church *et al.* 2001). Sand (as well as finer sediments) also constitutes a substantial component of the composition of over-bank areas (Figure 2-12). High-elevation over-bank sand was substantially lost from the gravel reach during the 1952 to 1984 period through natural erosion processes (Ham 2005) but this loss may have been halted through the extensive armouring of natural banks since the 1970s.

While sand and finer sediments are important, components of the more distally located (from the main channel) and higher-elevation banks and islands of the gravel reach, in any given year most of these size-classes of materials entering the Heart of the Fraser from regions upstream of Hope are largely carried past Mission. These fractions of the sediment load are mostly deposited in the Fraser River delta or the Strait of Georgia, with comparatively smaller amounts of these smaller-diameter materials depositing (or eroding) in the gravel reach each year.

Sediments smaller than gravel normally have played a relatively smaller role in the net deposition/erosion volumes of the gravel reach. In some years and at some locations, however, relatively large volumes of sand (for the gravel reach), which have comprised the upper elevations of the topography of the gravel reach's islands and banks, have been lost from this area (Ham 2005). Cumulatively over the past 50 years, this has had the effect of stabilizing the net balance of deposition/erosion of the total sediment volumes in the gravel reach. For example, if all fractions of the sediment budget are considered (i.e., clays to cobbles), there has not been a net positive deposition of sediment in this section of the Fraser River over the last half century (Ham and Church 2002; Figure 2-13). This is because the net deposition of gravel (which is positive downstream of Agassiz) has been largely offset by the erosion of finer materials including sand and silt in this same area. **Thus, the total sediment deposition/erosion is roughly in equilibrium** (c.f., Ham and Church 2002 and Ham 2005). These data counter the "myth" that the gravel reach is rapidly filling up with sediment and that the stream is in imminent danger of overtopping its banks as a result of sedimentation.

INFLUENCE OF THE VARIOUS SIZES OF SEDIMENTS ON THE ECOLOGICAL COMMUNITY OF THE GRAVEL REACH

The deposition of smaller-diameter alluvial sediments, such as the silts and sands, has been expansive across the greater historic floodplain of the gravel reach. These river sediments contribute to the rich topsoils that are the basis for the exceptional biodiversity of the natural vegetation communities found in the gravel reach (North and Teversham 1984, Boyle 2004). They are also the reason why the eastern Fraser Valley became one of British Columbia's most important farming communities; once the natural vegetation was removed and the land was isolated from flood flows, the cultivation of agricultural crops became extensive.

While the distribution and complexity of riparian and instream plant communities in the gravel reach is largely determined by the clays, silts and sands which comprise the primary components of the topsoil, the fish and other species living in these watercourses are also directly affected by the silt, sand, gravel and cobble within the lower Fraser River. For example, rearing fish will often associate with particular sediment sizes and are usually quite discriminating in their choices. Redside shiners (*Richardsonius balteatus*) in the Fraser gravel reach prefer to rear over fine substrates while juvenile Chinook salmon (*Oncorhynchus tshawytscha*) favor coarser material (Rosenau and Angelo 2000). Gravel-sized substrates are also particularly important as a nesting and incubating medium for salmon embryos and alevins in this part of the Fraser River. The gravel reach has had an extremely large pink salmon (*Oncorhynchus gorbuscha*) spawning population in recent years (c.a., 10 million fish) and the abundant gravel beds found here account for the productivity of this spectacularly-sized run. The stable and clean substrates found in some of the gravel reach's side channels also appear to be a key component of white sturgeon (*Acipenser transmontanus*) spawning habitat, which occurs during the spring freshet (Perrin *et al.* 2003). At the same time, the highly turbid water that occurs as a result of suspension of fine sediments in the water column helps hide the embryos from predators while they are incubating on the channel bottom.

LARGE WOODY DEBRIS AS AN IMPORTANT COMPONENT OF THE GRAVEL REACH STRUCTURE

There has been a considerable amount of research throughout the world demonstrating the importance of woody debris to fluvial ecosystems, including large streams like the Fraser River. Large woody debris has a major role in determining the geomorphology and ecological functioning of many braided rivers (Tockner *et al.* 2006). Invertebrates forage on the wood, while juvenile and adult fishes use the physical structure for cover. Embedded large-organic debris also acts as a stream-bed stabilizing feature (see Maser and Sedell 1994, Bratty 2001 for summaries). Despite the extensive science on the importance of this material in other such aquatic ecosystems, almost no information has been gathered regarding its functionality in the gravel reach of the Fraser River despite the inference of its importance both in the gravel reach and further downstream in the sand reach described later (Bratty 2001, Ham 2005).

Channel and island formation of the gravel reach is likely to have been extensively influenced by the deposition of wood prior to the widespread land-clearing across its floodplain. Human interference with the recruitment and function of large woody debris in the gravel reach included clearing perimeter riparian areas, removing snags for navigation in the main channel, and ongoing trapping, removal and burning of instream debris near Hope (Ham 2005; Figures 2-9, 2-14).

Ham (2005) suggested that the removal of woody debris (snags) from the gravel reach dates back to the early 1870s. The Fraser River was then a principal transportation route between upriver communities and New Westminster and by 1894, twenty-three hundred snags were removed to improve navigational safety along the lower channel to Agassiz. An additional thirty-five thousand, four hundred snags were removed by 1949 between the delta of the Fraser River and the Harrison River confluence (Public Works Canada 1949).

Nevertheless, until the late 1970s, woody debris jams still accumulated along the upstream margins and distributary channels of major bar/island units, as visible in historic aerial photographs (Ham 2005). The operation of the debris trap at Laidlaw starting around this time (Thonon 2006) disrupted this important habitat and geomorphic feature of the river. While little is known about the precise extent of the damage from woody debris removal, it is having a visibly destructive effect on this ecosystem (Ham 2005).

THE HYPORHEIC ZONE

A fundamental element contributing to the biodiversity of braided rivers is that the stream channels and riparian areas provide a wide variety of refugia for many organisms. This is pivotal in the face of frequent disturbances, including heavy flooding (Tockner *et al.* 2006). One such important habitat in gravel-bedded streams is the hyporheic zone, or that zone of sub-surface water below the stream bottom that interchanges with the surface water in the channel and groundwater underneath.

Hyporheic zones have many qualities that are important for aquatic ecosystems including flow modification, thermal control, and chemical (e.g., nutrient) exchange. They are a place for invertebrates to hide during floods and drought, and for incubation of embryos and alevins of some fish species (Figure 2-15). For some streams the volume of the hyporheic zone is greater than that of the flows in the surface channel and, furthermore, such attributes can extend laterally for several kilometres in rivers with large alluvial floodplains (Stanford *et al.* 1994).

Given the broadness of the Heart of the Fraser floodplain, the coarseness of the sediments in the active channel, the gradient and the extensive flows of water in the immediate area of the gravel reach, it is likely that its hyporheic zone is extensive. One testimony to this hypothesis is the extent to which chum salmon spawn in the gravel reach every year, likely often exceeding hundreds of thousands or even a million fish. This species of salmon almost exclusively utilizes groundwater-fed habitats in the Fraser gravel reach. Many of the remaining side channels within this area are rich in groundwater.

2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

Unfortunately, little to no scientific research has been undertaken on the Fraser River gravel reach in regards to the character of its hyporheic zone even though this feature is likely to be a key aspect of the sustainability of the exceptional aquatic biodiversity of the river and its riparian areas. As a result of the extensive landscape and channel changes to this area, the hyporheic zone of the gravel reach has unquestionably been highly altered due to these anthropogenic influences.

Figure 2-5. The gravel reach of the Fraser River looking downstream towards the Harrison River from Mt. Cheam. *Note that agricultural activity has stripped most of the riparian vegetation up to the perimeter of the stream bank, with most of the floodway areas with treed vegetation being non-natural, cultured pulpwood plantations.*



Figure 2-6. Schematic of the cross section of a laterally-meandering stream, such as the Fraser River gravel reach. *The development of such a pattern may take decades, centuries and/or millennia of erosion, deposition and stream movement across the floodplain. The higher-elevation relic, flood and side channels each have very different aquatic-ecosystem attributes and vary considerably from the main channel. Note that the vertical is exaggerated relative to the horizontal scale.*

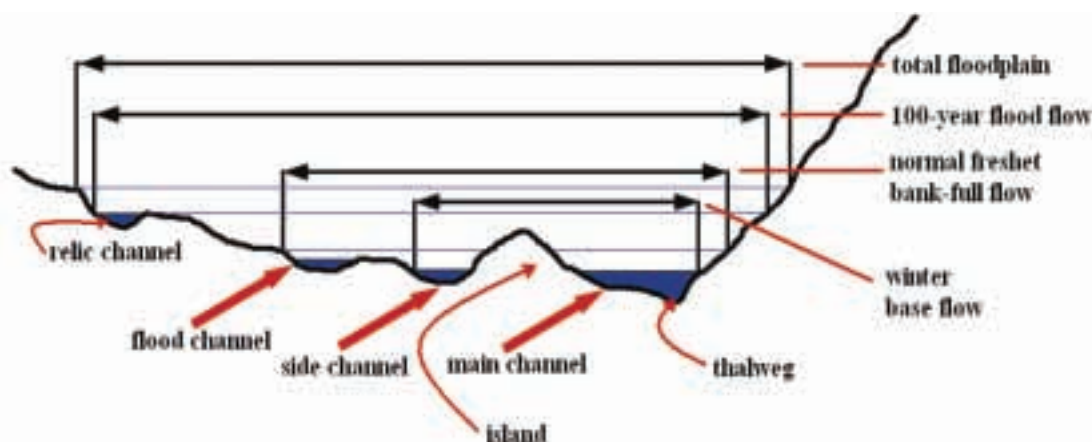


Figure 2-7. Recent loss of a tertiary side channel at Island 22 near Chilliwack resulting from the construction of a wing dike across the upstream end.

This dike was constructed as recently as 1990 and resulted in a major disruption in the local aquatic ecosystem and the hydraulics. See Figure 1-5 for location.



Figure 2-8. A properly functioning unblocked side channel (Herrling Slough—left) compared to an ecologically dysfunctional side channel (Hope Slough—right) which has been dammed at its upstream confluence with the Fraser River.

Sturgeon spawn over the gravel-substrate portions of Herrling Slough during freshet when the water is several metres higher in elevation and the flows are considerably greater, while it is extensively used by other species at other times of the year. In contrast, the Hope Slough, which may have been used for spawning by sturgeon, and was once extensively spawned by chum now functions as a relic channel due to the loss of upstream flows. See Figure 1-5 for locations. Photos D. Catt.



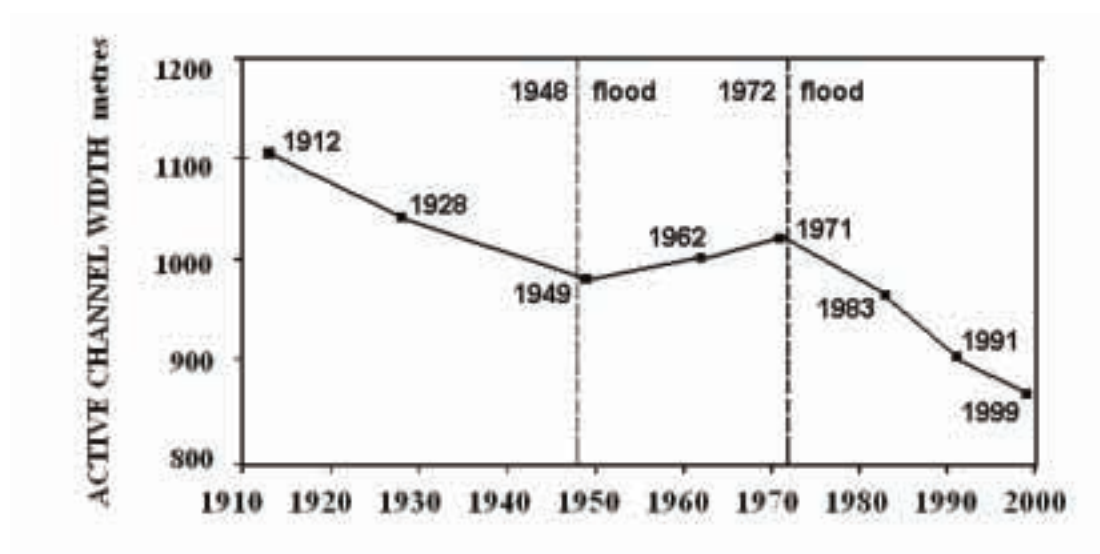
Figure 2-9. Natural fluvial processes assist in creating, destroying and re-creating rich biological attributes through erosion and deposition of sediments and recruitment of large woody debris.

This is a large island in the floodway of the gravel reach and fallen trees act as natural bank protection by slowing down the erosion power of the water against the bank. Photo was taken at the ecological reserve, across the main Fraser River channel at the confluence Chilliwack Slough; see Figure 5-1 for location. Compare with the bank line of Figure 3-7, which is an example of a young silviculture pulpwood forest in the gravel reach which has little erosion-modifying capacity due to the small size of the trees.



Figure 2-10. Variation of active channel zone width for the entire gravel reach over time. Major recent floods (1948, 1972) are indicated.

This figure shows that the active channel of the Fraser River in the gravel reach is becoming increasingly constrained, largely due to human activities. Modified from Ham (2005).



2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

Figure 2-11. Bar at Hope (top) showing an armouring layer of very large cobbles, compared to the gravel-sized bar-surface sediments at the Harrison River confluence (middle), versus sand which comprises the channel composition at Mission (bottom).

Bottom two photos D. Catt.



Figure 2-12. Lateral erosion of Island 22 (left) and an adjacent island (right) near Chilliwack exposing vertical strata of sediment layers comprised of varying grain sizes.

Note the extensive layers of very fine sediments on the uppermost strata of these islands. This layer of very fine sediments can be metres thick, in some cases. This large erosion bank on Island 22 occurred when the main channel shifted its alignment a few degrees towards the left bank and began attacking the perimeter of the island. Note the lack of large vegetation along the edge of the bank having been removed as a result of clearing; and this lack of large woody vegetation has likely exacerbated the erosion; See Figure 1-5 for location. Compare with Figure 2-9 which has significant recruitment of large woody debris along the perimeter of the bank and this appears to help modify the erosion of the sediments.



Figure 2-13. Active stream cross-section area below reference elevation to the stream bed along extracted locations for the gravel reach.

This figure shows the amount of channel cross-sectional area, over time, below a series of standardized elevations and is a proxy measurement for increases or decreases in floodway capacity due to sedimentation or erosion. These data indicate that although the active channel in the gravel reach is changing in regards to its net sedimentation (some areas are greater, some are less (Ham 2005)), the current total floodway capacity of the gravel reach is not decreasing due to deposition, countering the popular myth that the gravel reach is “filling up” with sediment. Data used to construct this figure were taken from Ham and Church 2002.

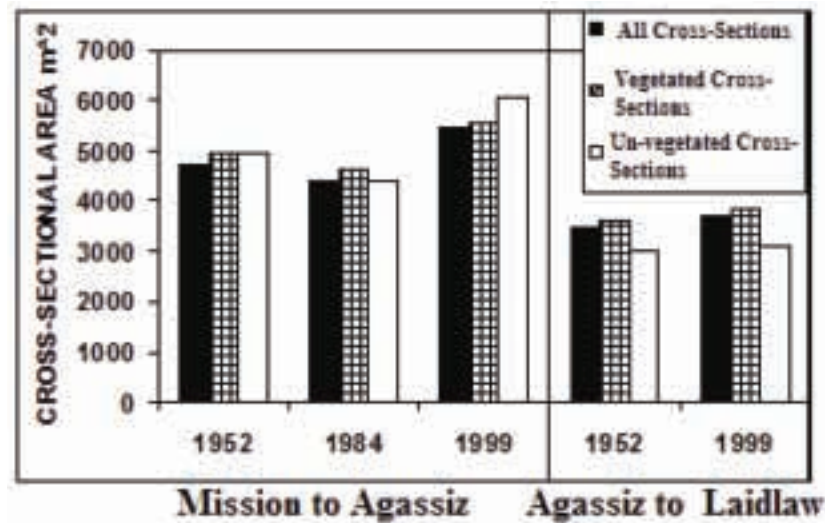


Figure 2-14. The capture, removal and burning of large woody debris from the Fraser River near Hope in the gravel reach constitutes an environmentally destructive activity of an important habitat feature of the gravel reach.

Large woody debris is a key habitat component of large river ecosystems (Maser and Sedell 1994).



Figure 2-15. Example of human influence of hyporheic flows on the aquatic ecosystem in the Fraser gravel reach.

This small side channel, comprising upwelling ground water, was largely deprived of its hyporheic flows when a large-adjacent side channel in the gravel reach was blocked about 1-kilometres upstream of this location in winter 2006 to facilitate gravel removal from a nearby island. In the course of events, chum salmon redds (nests) were dewatered in this channel with an apparently high mortality. Chum salmon in the Fraser gravel reach extensively utilize such hyporheic flows for spawning and embryo and alevin incubation.



Table 2-2. Selected physical characteristics of the gravel reach.*From Church and Ham 2004.*

| Sub reach | Kilometres from Georgia Strait | Gradient | Mean sediment grain size in mm | Major morphological features |
|---|--------------------------------|----------|--------------------------------|---|
| Hope to Jones Creek | 165-149 | 0.00056 | | Single-thread cobble and gravel channel with stable lateral bars |
| Jones Creek to Agassiz Bridge | 149-130 | 0.00052 | 50 | Large, mature islands with surrounding bars; single dominant channel and major secondary channels |
| Agassiz Bridge to Harrison River confluence | 130-118 | 0.00047 | 40 | Multi-thread gravel channel with large island-bar complexes; laterally unstable |
| Harrison River confluence to Sumas River confluence | 118-100 | 0.00018 | 26 | Multi-thread gravel channel with diagonally extending bars and subordinate islands |
| Sumas River confluence to Mission | 100-86 | 0.00009 | 16 | Single-thread, gravel-sand transition; submerged bars |

Table 2-3. Summary of bank armouring in the Chilliwack area of the gravel reach.*Table and explanations from Ham (2005)*

| Reach | Total bank length (m) ¹ | Railway ² | Dikes | Riprap ³ | Bedrock ⁴ | Total protected ⁵ | % protected |
|------------|------------------------------------|----------------------|-------|---------------------|----------------------|------------------------------|-------------|
| Sumas | 31,925 | 4,715 | | 13,760 | 4,873 | 23,348 | 73.1 |
| Chilliwack | 35,739 | | 173 | 14,898 | 6,525 | 21,596 | 60.4 |
| Rosedale | 26,346 | 4,091 | | 14,202 | 833 | 19,126 | 72.6 |
| Cheam | 42,501 | 18,358 | | 11,739 | | 30,097 | 69.2 |
| Hope | 32,202 | 6,207 | | 8,692 | 2,314 | 17,213 | 53.5 |

*1. outer banks of main channel only; does not include island shoreline**2. railway protects many banks that otherwise would be classified as bedrock**3. riprap includes 2,907 m of rock berms, mainly in Cheam reach**4. bedrock includes non-alluvial, non-erodible bank lines (e.g. Mission bend)**5. all categories are exclusive (i.e. any length is counted in one category only); total protected (and % protected) includes bedrock*

VEGETATION AND WETLAND ATTRIBUTES

OVERVIEW

Around the world wetland landscapes and their naturally vegetated riparian communities are known for their high levels of biodiversity. Nevertheless, throughout the history of mankind, wetlands have usually been regarded as non-productive wastelands in need of “enhancement” or “reclaiming”. Over time, human impacts to these key habitats have been largely destructive, in the form of clearing, draining, infilling, and then re-vegetating with non-native monoculture crops for farming and/or developing the land for habitation, commercial or industrial activities.

As wetlands and lowland vegetation have become more and more scarce throughout the world, they are increasingly being recognized for their biological, cultural, spiritual and economic importance. Some of the functions of wetlands include maintaining and improving water quality, providing habitat for fish, wildlife and other species, storing floodwaters, and retaining surface-water flows during dry periods (EPA 2001). Numerous scientific studies are now demonstrating the strong link that often occurs between the extent of wetlands and the size of fishery landings (e.g., Turner 1977, Welcomme 2003).

Wetlands and native riparian vegetation comprise vital components to a properly functioning ecosystem within the Heart of the Fraser. Subsequent sections of this report describe habitats for many important species of fishes, as well as mammals, birds, invertebrates, and other species in southwestern British Columbia.

PLANT COMMUNITIES

Prior to European settlement, the Fraser gravel reach had complex plant communities throughout its riparian areas (Figure 2-16). Over the last 150 years the lower Fraser River area has experienced extensive losses of its natural vegetation as a result of clearing and developing of the landscape (Boyle *et al.* 1997). The removal and destruction of this vegetation has had adverse effects on soil, water, and air quality, as well as to the aquatic life and animal populations that use these types of habitats.

Recently, Boyle *et al.* (1997) conducted a study assessing changes to vegetation landscape characteristics in the lower Fraser basin, of which the gravel reach is a significant part. Boyle *et al.* (1997) found that by the early part of the twentieth century the area covered by coniferous forest in the lower Fraser basin declined to 71% compared to prior to 1827, but then recovered somewhat to 50% in 1930. Small increases in this type of vegetation continued to occur with 54% of the land covered by conifers by 1990.

Boyle *et al.* (1997) also found that the age-class structure of the vegetation in the lower Fraser basin changed considerably over the same time period with the average age of the vegetation generally becoming younger. Prior to 1827, only 27% of the forest was estimated to have been immature (<120 years old) but by 1930, this had increased to 40%. By 1990, 73% of the forest was considered to be young. This statistic reflects the extent of land clearing of the older mature forests.

While non-coniferous water-adapted varieties of plants (Figure 2-16) were also found to be extensive throughout the gravel reach prior to European settlement, they largely disappeared once large-scale clearing took place for crop production, or they were naturally replaced by less-aquatic species due to the drying influence of the new drainage patterns that lowered the water table to facilitate agriculture. Much of the initial historic land-use activity in the gravel reach was due to land clearing for farming (Figure 2-17) and the native vegetation was also subsequently replaced with monoculture food or forage crops (Figure 2-18). An important aspect of these observations is that the Boyle *et al.* (1997) study is only up to date until 1990 and the extensive development that has occurred in recent years has resulted in considerably more losses of this aspect of the gravel reach is plant

communities. Recent clearing of natural or feral vegetation in the gravel reach—for agriculture, pulpwood harvest, gravel removal and industrial development—continues to modify and reduce the diversity of vegetation in the gravel reach (Moore and Roger 2003).

WETLANDS

Wetlands comprise some of the most important habitats on earth and are a source of productivity for many important fisheries. They encompass a diversity of features including bogs, fens, swamps, marshes and shallow waters (Table 2-4). Throughout history, the impact of humans on wetlands, through development on the floodplains of many rivers in settled areas on most continents, has transformed these habitats throughout the world.

Good inventory and assessment information is crucial for decision making in order to protect and restore ecosystems such as wetlands in the Fraser gravel reach. Fortunately for lowland resource managers, there have been a number of major studies in recent years assessing the extent and tenure of wetlands in the lower Fraser River basin, including the gravel reach, with the objective of helping agencies protect and preserve these natural assets. These key reports include “Wetlands of the Fraser Lowland, 1989: An Inventory” (Ward *et al.* 1992) and its companion study, “Wetlands of the Fraser Lowland: Ownership, Management and Protection Status” (McPhee and Ward 1994). Boyle *et al.* (1997) also assessed landscape changes the lower Fraser River in their study entitled “Changes in land cover and subsequent effects on Lower Fraser Basin ecosystems from 1827 to 1990.” While these reports are more than ten years old, for the purposes of this report they provide a valuable perspective of the abundance and locations of wetland habitat in the gravel reach and the historic changes due to human disturbance.

For the lower Fraser River—including the gravel reach—Boyle *et al.* (1997) found that approximately 85% of its wetlands had been lost to development in the period between 1827 and 1990. Most of the initial losses in the Heart of the Fraser were a result of land clearing and draining for agriculture (Figure 2-17). Nevertheless, despite these historic losses, the gravel reach still includes significant areas that are diverse and biologically significant wetlands that are important to protect and/or restore (Table 2-5).

Ward *et al.* (1992) estimated that there were 41,906 hectares of wetlands left in the lower Fraser basin (i.e., downstream of Hope), and suggested that this represented 13.6% of the total geographic area. Of the wetlands which were identified, over 7,000 hectares, or about 1/6 of the study total, were found in the gravel reach (Table 2-5). Not surprisingly, the wetland category with the largest surface area was the mainstream of the Fraser River (i.e., “gravel” or the active channel gravel bars) illustrating that this feature has not been as extensively encroached upon by development as those habitats that are perimeter to the main-channel’s flows.

While the Ward *et al.* (1992) study quantified the extent of wetlands until 1989, a subsequent study by the Canadian Wildlife Service (Moore and Roger 2003) showed that between 1989 and 1999, these habitats continued to be extensively lost to development. Of the 320 wetlands assessed in the lower Fraser basin by Ward *et al.* (1992), 22% more experienced at least some degree of encroachment resulting in a further loss of almost 1,000 additional hectares of wetland area. Half of the wetlands showing losses in the Moore and Roger (2003) report experienced a decline of under 5% of their original size, while over one quarter experienced a 5–15% loss. This observation suggests that the impacts to these habitats are occurring slowly, but insidiously, in a way that is not generally noticeable and unlikely to be dealt with under legislation or regulation.

Not surprisingly, the Moore and Roger (2003) study found that the greatest wetland losses were due to continued agricultural development (41%) while golf courses (25%) and landfill expansion (16%) accounted for the next largest impacts (Figure 2-19). Unfortunately, even more large-scale losses in the gravel reach have occurred, and continue, since Moore and Roger (2003) published their report (Rosenau and Angelo 2005).

OWNERSHIP

When managing the protection of wetland areas, the tenure of the landowner of the sensitive habitat is a significant element in the attempt to minimize impacts (Figure 2-20). McPhee and Ward (1994) found that most (80%) of the Fraser lowland wetlands were owned by the Provincial Crown while 13% were privately held and 5% were municipal or regional lands. In contrast, the Federal Crown and Indian Reserves each accounted for about 3%. For the gravel reach, land-tenure was comprised of 83% for the Provincial Crown, with the Federal Crown and municipal having 1 and 3% respectively (Table 2-6). Private land tenure was the same at 13% for both the larger lower Fraser basin and its sub-area, the gravel reach.

In contrast to the larger lower Fraser basin, the ownership of wetlands in the gravel reach by Indian Reserves is significantly greater at 7%. This suggests that First Nations have an extensive potential to influence the aquatic ecosystems within the Heart of the Fraser area and could determine the level of protection and restoration that might occur in the future (see also Figure 2-20). Still, the Provincial government has by far the greatest stake in protecting and maintaining the wetlands environmental integrity of the gravel reach of any of the ownership categories.

PROTECTIVE STATUS

McPhee and Ward (1994) quantified the levels of protection that are currently afforded the wetlands in the lower Fraser basin, including the gravel reach. Only 13% of the wetlands in the lower Fraser basin had a high level of protection, while 69% had medium protection and 16% had a low level or no protection. When the gravel reach component of this area was assessed on its own merits, the high and medium levels dropped to 5% and 51%, respectively (Table 2-7). It is important to note that already in 1994 the gravel reach was in jeopardy in regards to the protection of its remaining wetland aquatic habitats. With a few exceptions, there is little indication that the situation is getting better over a decade later in 2007.

SUMMARY CONCLUSIONS

Moore and Roger (2003) provided a number of important observations about the management and protection of wetlands of the lower Fraser basin and these particularly apply to the physical area that comprises the Heart of the Fraser. They observed that despite increased government agency, societal and scientific recognition of the trends in wetland ecosystems throughout the world and in British Columbia, over the period of 1989 to 1999, these landscapes continued to be developed in the lower Fraser basin at a rapid pace. Many of these losses have been small by geographic standards. Nevertheless, when these last remaining habitats vanish, the cumulative effects of small impacts will suddenly loom large. Despite official statements by government agencies regarding their concern for sustainability of ecosystems, and even with extensive legislation, policy and regulation in place, the wetland habitats are being lost at exceptionally rapid rates.

It was the opinion of Moore and Roger (2003) that isolated agency decisions, involving many land-use types and many separate planning processes, affecting seemingly trivial amounts of wetland are, in fact, cumulative and unsustainable. Their position was that landscape planning of wetlands must take an ecosystem-based and broader-geographic approach—a position directly applicable to aquatic habitats of the Heart of the Fraser.

2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

Figure 2-16. Pre-European-settlement distribution of vegetation types in the gravel reach of the Fraser River. Taken from Moore and Roger (2003); compare with Figure 2-17 to see extent of change of these vegetation patterns due to agriculture.



2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

Figure 2-17. Farmland of the gravel reach as designated by the British Columbia Agricultural Land Reserve. Compare this figure with Figure 2-16 to obtain an understanding of the extent of change in vegetation communities since European settlement and land development.

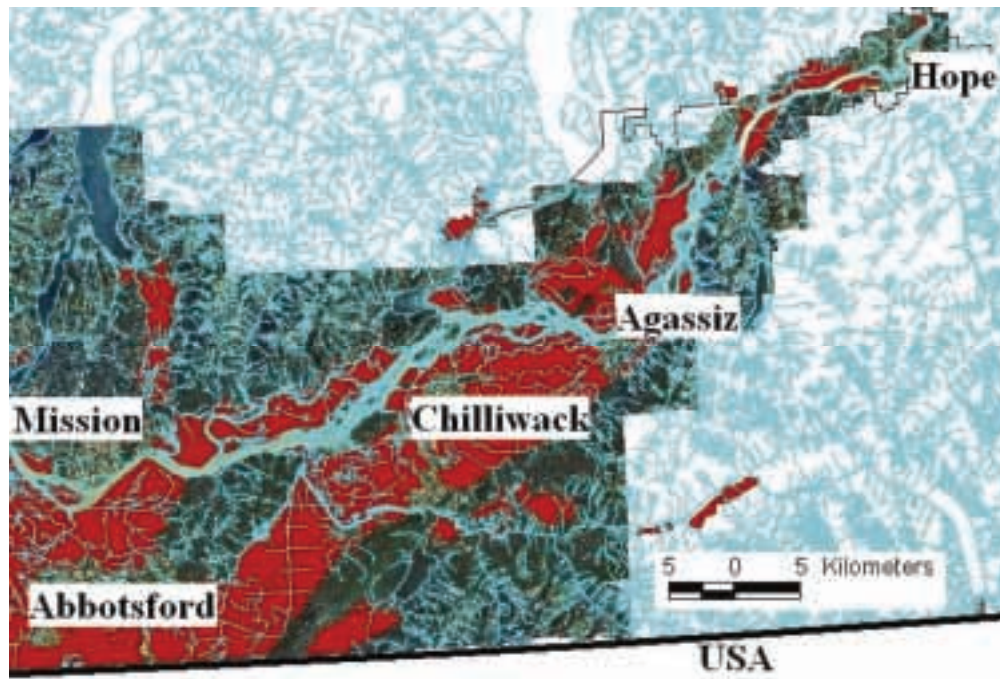


Figure 2-18. Example of a monoculture forage crop of grass grown for cattle to the edge of the stream bank in the riparian area of the Fraser River near Agassiz.

This is very common along the main-stem perimeter of the Fraser River between Hope and Mission where riparian vegetation is often replaced by farmers with a single crop to the edge of the stream bank without consideration of riparian buffers.



Figure 2-19. Losses of 965 hectares of wetland from 1989 to 1999 in the lower Fraser basin by impact activity. *Note that the gravel reach is a sub-component of this analysis; note also that the Fraser River Estuary Management Plan area (the shoreline perimeter of the Fraser River from Kanaka Creek to the Strait of Georgia) is not included in these data. Adapted from Moore and Roger (2003).*

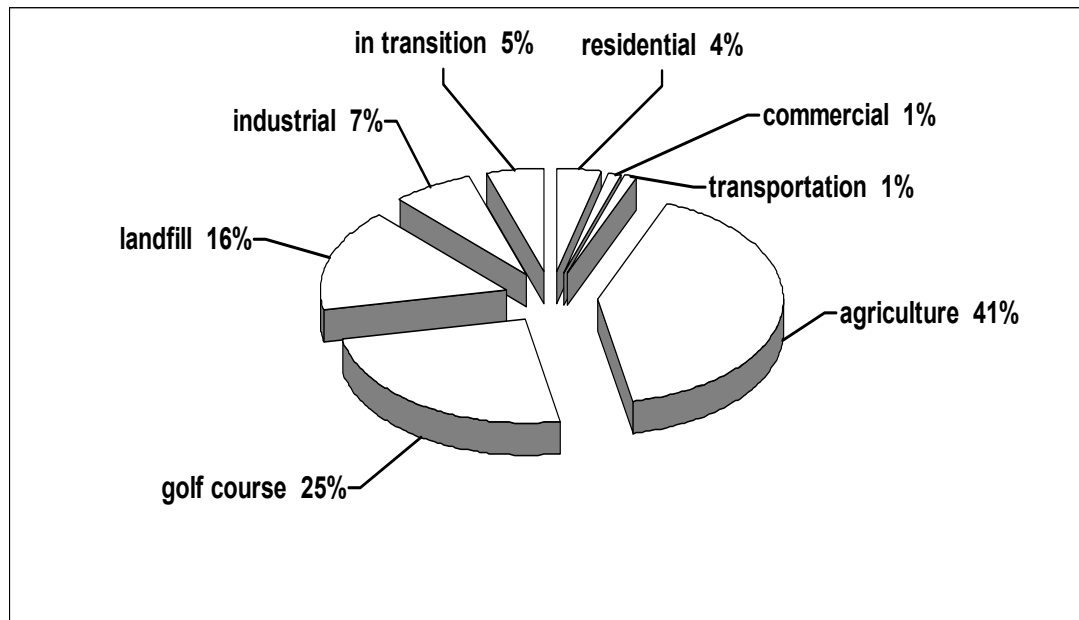


Figure 2-20. First Nations reserves, private and crown land, and protected areas within the geographic boundaries of the Fraser Lowlands Protected Area Study, 1998.

The outer green line marks the perimeter of the 1998 Fraser Lowlands Protected Area Study which, for our purposes, is similar to the geographic area of our Heart of the Fraser boundaries. White polygons represent crown land. Figure adapted from Report of the Working Group (1998).

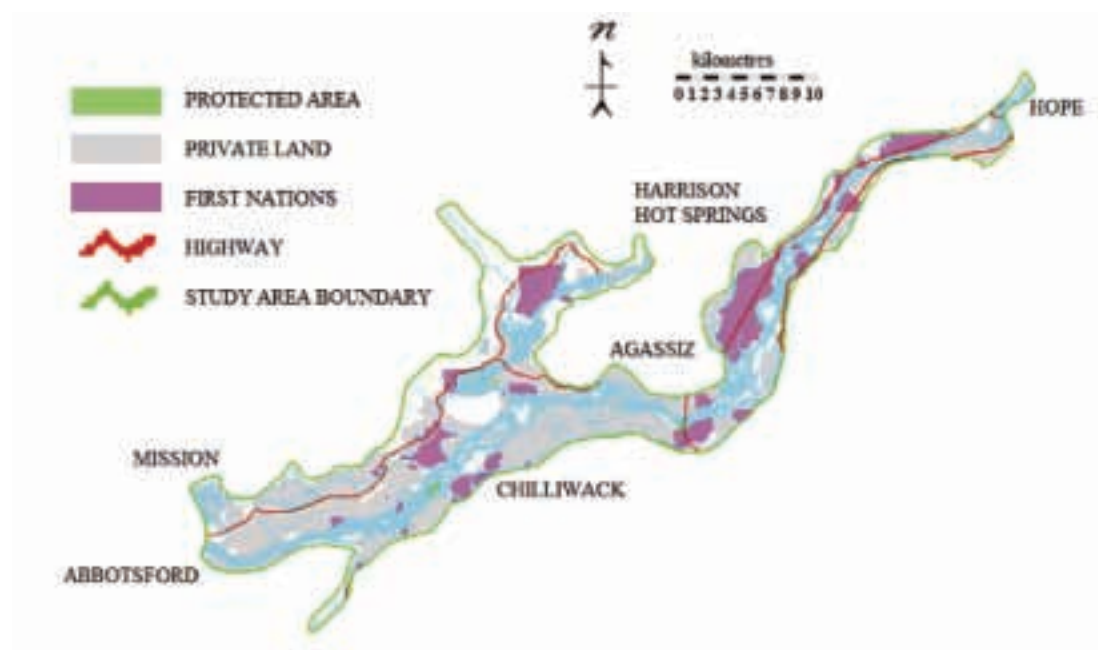


Table 2-4. Classes and characteristics of wetlands.

This table describes terms used in Table 2-5. Terms and characteristics from the Wetland Working Group (1997).

| Wetland class | Characteristics |
|---|---|
| Bogs | Dense layer of peat; acidic; low nutrient content; water table at or near the surface; usually covered with mosses, shrubs and sedges; trees possibly present |
| Fens | Covered with peat; water table at or near the surface; higher nutrient content than bogs; vegetation usually characterized by sedges and grasses; trees and shrubs may or may not be present. |
| Swamps | Stagnant or slow-flowing pool; high nutrient content; usually covered with trees or shrubbery. |
| Marshes | Periodically or permanently flooded; absence of trees; emergent vegetation; usually high nutrient content. |
| Shallow Waters (some studies include the term "Gravel" as a separate grouping) | Include basins, pools and ponds, as well as wetlands found beside rivers, coastlines and shorelines; submerged vegetation; floating leaved plants. |

Table 2-5. Area of various classes of wetlands in the gravel reach of the Fraser River by geographic region.

Data from Ward et al. (1992), in hectares.

| Geographic region | Bog | Fen | Marsh | Gravel | Shallow Water | Swamp | Totals |
|-------------------------------|----------|-------------|----------------|----------------|----------------|--------------|----------------|
| Agassiz/Seabird Island | 0 | 0 | 93.4 | 0 | 144.1 | 0 | 237.5 |
| Chilliwack Sloughs | 0 | 0 | 128.3 | 6.8 | 376.6 | 0 | 511.7 |
| Fraser River—Sumas to Laidlaw | 0 | 0 | 77.9 | 2,790.5 | 408.1 | 0 | 3,276.5 |
| Harrison River Valley | 0 | 11.2 | 322.3 | 190.8 | 767.4 | 0 | 1,291.7 |
| Hatzic/Nicomen | 0 | 0 | 518.0 | 9.9 | 535.1 | 247.1 | 1,310.1 |
| Sumas | 0 | 45.3 | 157.1 | 0 | 302.9 | 0 | 505.3 |
| Vedder | 0 | 0 | 42.8 | 106.6 | 167.2 | 52.7 | 369.3 |
| Totals | 0 | 56.5 | 1,339.8 | 3,104.6 | 2,701.4 | 299.8 | 7,502.1 |

Table 2-6. Area of wetlands in the gravel reach of the Fraser River by ownership.

Data from McPhee and Ward (1994), in hectares. Note that because of jurisdictional reporting boundaries, the habitat totals are slightly different than those reported in Table 2-5.

| Geographic region | Crown Federal | Crown Provincial | Municipal | Private | Indian Reserve | Totals |
|-------------------------------|---------------|------------------|--------------|--------------|----------------|----------------|
| Agassiz/Seabird Island | 0 | 136.4 | 0.7 | 75.7 | 24.7 | 237.5 |
| Chilliwack Sloughs | 0 | 449.7 | 10.5 | 40.8 | 10.6 | 511.6 |
| Fraser River—Sumas to Laidlaw | 0 | 2,936.0 | 66.8 | 40.4 | 233.1 | 3,276.3 |
| Harrison River Valley | 43.9 | 991.9 | 0.0 | 133.7 | 121.9 | 1,291.4 |
| Hatzic/Nicomen | 0 | 926.3 | 23.0 | 354.7 | 5.9 | 1,309.9 |
| Sumas | 0 | 211.0 | 41.6 | 230.2 | 22.5 | 505.3 |
| Vedder | 31.4 | 155.2 | 49.2 | 53.8 | 79.8 | 369.4 |
| Totals | 75.3 | 5,806.5 | 191.8 | 929.3 | 498.5 | 6,996.1 |

Table 2-7. Level of protection afforded wetlands in the gravel reach, 1994.

Data, in hectares, taken from McPhee and Ward (1994) for their Central Valley Regional District and Fraser Cheam Regional District zones and assumed to approximately represent the gravel reach boundaries. Note that this table does not exactly match the estimates of wetlands in the Tables 2-5 and 2-6 because of the jurisdictional boundaries are not exactly concordant. Description of "level of protection" criteria in Appendix 3. Level of protection on Indian Reserves yet to be determined

| Level of protection | | |
|---------------------|-------------|-------------|
| High | 306 | 5% |
| Medium | 2906 | 51% |
| Low | 2096 | 37% |
| Indian Reserve | 421 | 7% |
| TOTAL | 5729 | 100% |

Aquatic Ecosystem Values of the Gravel Reach

OVERVIEW

One of the most significant aspects of the ecosystem of the Heart of the Fraser is its fisheries values. The gravel reach contains a greater diversity of fish species than any other freshwater ecosystem in British Columbia. This includes approximately 30 different fishes that use this area for rearing, spawning or migration, or have a mixture of all three life-history stages (Table 2-8). This species diversity is largely the result of post-glacial colonization patterns and the great number of niches that the gravel reach affords fish. The following is a brief description of some of the more high-profile fish species in the gravel reach.

SALMON, TROUT AND ALLIED SPECIES

Pacific Salmon

The Fraser River watershed is known for its large populations of Pacific salmon including five different species—pink (*Oncorhynchus gorbuscha*), chinook (*O. tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*) and chum (*O. keta*). All five are found in the gravel reach during at least one of their life-history stages (Table 2-8). Steelhead trout (*O. mykiss*) and anadromous cutthroat trout (*O. clarkii*), which have now been reclassified within the Pacific salmon genus, are also found in the gravel reach. Pacific salmon, steelhead, and anadromous cutthroat trout all belong to the family Salmonidae which includes the Pacific salmon genus *Oncorhynchus*, as well as the trouts (*Salmo*), chars (*Salvelinus*) and other species such as the whitefishes (e.g., *Prosopium*, *Coregonus*).

Most populations of adult salmon in the Fraser River migrate through the gravel reach to tributary streams for spawning and rearing upstream of Mission, and use the same area as a migration corridor when their juveniles go out to sea. Only pink and chum salmon physically spawn in substantial numbers in the active channel of the gravel reach. Note that the Pitt, Alouette, Coquitlam, Stave, and Salmon rivers are the only tributaries having significant populations of salmon in the Fraser River downstream of the gravel reach, and they are not influenced directly by the gravel reach.

Pink Salmon

The number of pink salmon spawning in the gravel reach in recent years has been extra-ordinary. Because pink salmon spawn only every other year, and there are no even-year runs in the southern part of British Columbia, the Fraser River gravel reach can be overwhelmed with this species one year (Figure 2-21) and then have none the next. Escapement of pink salmon into the gravel reach routinely reaches several million spawning fish, and in 2003 this may have even exceeded 10 million spawners (Jim Cave, Pacific Salmon Commission, pers. com.). Thus, the run of pink salmon in the gravel reach may be the largest single-spawning stock of salmon of any species in any watershed in British Columbia.

The abundant gravel habitat found within the gravel reach is the feature that provides the opportunity for so many fish to reproduce in this relatively short section of river. Large shoals of pink salmon amass, mostly between the confluence of the Fraser and Sumas rivers and Agassiz, to begin their reproduction approximately mid-September of odd numbered years. The most productive spawning gravels are found within the Heart of the Fraser from the Sumas River upstream to Agassiz (Figure 2-22). Upstream and downstream portions of the gravel reach tend to be spawned less intensely by pink salmon because the conditions are less than ideal (the substrate appears to be either too coarse or too fine).

The embryos and alevins of the pink salmon in the gravel reach incubate in their gravel nests (redds) over fall and winter, with the recently emerged fry swimming downstream to the ocean starting around late March. Unlike most

other species of anadromous salmon, pink salmon have a short freshwater life cycle in which the juveniles go directly to sea once they become free-swimming.

Pink salmon in the gravel reach of the Fraser River spawn mostly in the mainstream channel. Only the very largest of side channels, which are also free-flowing and have a connection to the main stream throughout the year, are regularly utilized by this species (e.g., Minto Channel adjacent to Island 22 near Chilliwack). Pinks can be found spawning considerable distances from the shoreline and eggs have been observed out near the deepest part of the mainstream channel (Stables and Perrin 2002).

The adult biomass of pink salmon is often substantial in the many streams where they spawn throughout the north Pacific due to the large numbers of returning fish. This large return may extensively influence the aquatic and adjacent riparian and terrestrial ecosystems. Pink salmon can contribute significantly to the primary productivity of aquatic ecosystems in the Pacific Northwest through the inputs of nitrogen and phosphorus as the adult-fish bodies decompose after spawning (Figure 2-23). The nitrogen and phosphorus which are derived from these anadromous salmon bodies are known as marine derived nutrients (Stockner 2003). Because mass spawners of salmon such as pinks so fundamentally and extensively affect the growth and complexity of an ecosystem, they are often referred to as a keystone species (Cederholm *et al.* 2000, Reimchen *et al.* 2002, Stockner 2003, Helfield and Naiman 2006). Nitrogen and phosphorus nutrients are sequestered by aquatic algae and, in turn, this production is recycled into higher trophic levels once the algae are eaten by insects and the insects are foraged upon by fish. Vertebrates and invertebrates also feed directly on the pink salmon flesh. From a scientific perspective, while there is no doubt that the Heart of the Fraser is extensively affected by these massive runs of pink salmon, remarkably little is known about the extent of this phenomenon in this part of the Fraser River.

Chum Salmon

Chum salmon spawning is also extensive in the gravel reach (Figure 2-24) and the escapement can exceed a million fish (Rosenau and Angelo 2000). Unlike pink salmon, chum normally spawn in the side streams of the active channel of gravel reach. The channels that chum spawn in within the gravel reach, however, usually do not have surface water-flow connections to the main channel during the spawning and incubation period and are groundwater-fed. Throughout the fall and winter the chum rely on sub-surface water flows to upwell from these side channels in order to provide adult access to the spawning areas, as well as to irrigate embryos and alevins in their redds once spawning has taken place. This water percolates up through the hyporheic zone and maintain flows and oxygen to the embryonic fish.

The juvenile life history of chum salmon often includes a relatively-short (usually less than several months) freshwater or estuarine residence before going to sea (Groot and Margolis 1991). During the spring, chum salmon fry are often seen residing along the edges of the shorelines of the gravel reach, likely foraging in these productive freshwater environments for some days or weeks before migrating to sea.

Large areas of chum salmon spawning habitats were destroyed or reduced in capacity when the extensive encroachment resulting from land development for farming started to affect the historical network of side channels of the gravel reach in the early part of the twentieth century (Rosenau and Angelo 2005). Agricultural activities often disrupted flows and degraded the spawning substrates (Figure 2-8). Attempts to restore some of the fish-producing capacity of these streams are currently being undertaken by Fisheries and Oceans Canada (M. Foy; pers. com.).

Chinook Salmon

Chinook salmon do not spawn in the gravel reach, but the area is extensively used for migration by adults and rearing by the juveniles before they go to sea (Figure 2-25). The large numbers of Chinook juveniles rearing in the gravel reach are from both local populations, such as Harrison River and upstream stocks (Rempel 2005).

Juvenile chinook strongly associate with the large gravel and cobble bars of the gravel reach of the Fraser River. Their micro-habitat requirements are quite specific and juvenile chinook appear to closely associate with coarser substrates, such as cobbles and large gravel. These kinds of habitats can be rather more common upstream of Agassiz as the gradient increases (Rosenau and Angelo 2000). The gravel reach of the Fraser River may be the one of the more important juvenile rearing areas for some of the Fraser River's upstream stocks, but scientific knowledge in regards to this aspect of chinook salmon remains limited.

Other Species of Salmonids

Sockeye salmon normally only utilize the gravel reach as a migration corridor—upstream for adults and downstream for juveniles. Curiously, however, small numbers of juvenile sockeye (not smolts) have been regularly seen in the mainstem gravel reach outside the normal spring-migration period. These fish may be part of a stream-rearing population that utilizes the mainstem Fraser River for growth before going to sea. A small number of sockeye stocks in British Columbia are known to use streams for rearing, rather than lakes before migrating to the ocean (Groot and Margolis 1991).

Sockeye salmon may benefit the gravel reach in other ways. Adult sockeye provide food for foraging sturgeon as these salmon migrate through the Heart of the Fraser on to their spawning grounds in the Fraser River watershed. It is not clear if the sturgeon are actively hunting live salmon, or scavenging sockeye that died en route. Nevertheless, observations during the summer period were that sturgeon can be found to be feeding exclusively on sockeye adults (this is based on autopsies of some of the three dozen dead sturgeon recovered in the gravel reach in 1993 and 1994). Thus, sockeye may constitute an important component of the ultimate productivity of the food web in the gravel reach as a result of predation and/or scavenging of these upstream migrating salmon adults.

Coho salmon also do not use the active channel of the Fraser gravel reach for spawning or rearing (Rempel 2005) but there are a number of populations that utilize relic channels such as in Hope and Maria sloughs. Similarly, steelhead rarely use the mainstem Fraser River except for downstream and upstream migration of the young and adults, and some staging by mature fish prior to entering their spawning streams. Anadromous coastal cutthroat trout are well known by anglers to inhabit the gravel reach and adult (Figure 2-27) and sub-adult fish extensively forage in the main stream and side-channels from Hope to Mission during non-freshet periods of the year. While cutthroat trout spawning has been observed in side channels throughout the gravel reach, there is little evidence of juvenile rearing (Rempel 2004). Large numbers of cultured smolts are released directly into the active side channels of the gravel reach by the Fraser Valley Trout Hatchery and the observations of spawning in the active side channels by cutthroat may simply be an artifact of this stocking of juveniles. It is likely that most gravel-reach adult cutthroat trout spawn and then rear for several years as juveniles before smolting in small adjacent tributary streams before leaving their natal creeks. Subsequently, these fish appear to be quite nomadic, opportunistically wandering from place to place as food becomes available.

While there is strong evidence that invertebrate production in the gravel reach is extensive (Rempel 2004; author's observations), and cutthroat adults and sub-adults extensively utilize insects for food, these fish are also particularly well-known for feeding on eggs of salmon during the spawning periods of chum and pinks, and the fry of many species of salmon during their spring out-migration. Thus, all indications are that the gravel reach is a key habitat for lower mainland cutthroat trout.

Mountain whitefish (*Prosopium williamsoni*) are less well known than the Pacific trout species and salmon, but they appear in the gravel reach in relatively high densities (Rempel 2004). Almost nothing is known of their life history in this part of the Fraser River. But because they comprise a significant proportion of the fish biomass, they are likely to be an important constituent of this fish community.

Even more rarely seen in the gravel reach are bull trout (*Salvelinus confluentus*) or Dolly Varden char (*S. malma*). One or both of these species had probably been fairly common until over-harvesting by anglers and large-scale habitat degradation occurred in their natal streams in the earlier part of the twentieth century. Large-scale habitat destruction in the lower mainland of British Columbia has likely kept the populations to a miniscule number, and these stocks have never recovered despite the current instigation of zero-retention angling regulations of these species.

EULACHON

Spawning runs of eulachon (*Thaleichthys pacificus*; Figure 2-28) occur during the spring of each year in the lower reaches of a number of large rivers along the west coast of North America. These are streams with significant spring freshets, including the gravel reach of the Fraser River. Eulachon were historically known to migrate into the gravel reach to a distance just downstream of the town of Hope. The runs of eulachon in the Fraser River, however, appear to have almost completely collapsed over the last five years.

Eulachon spawn when they are 3–4 years old, and they migrate up streams beyond the saltwater to spawn (Cambria Gordon 2006). It appears that eggs are laid at night onto clean sand or small gravel. Once the eggs are fertilized, a sticky substance on the surface of the embryos helps them adhere to the sand and gravel substrate where they then incubate for the next several weeks (Cambria Gordon 2006).

Where adult eulachon runs are found in substantial numbers, they provide freshwater ecosystems with an abundance of food and marine derived nutrients (Marson *et al.* 2002). Furthermore, not only do fish—including white sturgeon— forage on this species, but so do a variety of sea birds, eagles and mammals (Scott and Crossman 1973).

Eulachon, ooligan, or candlefish (Figure 2-28) have also been, from time immemorial, an important component of the social, food and ceremonial lives of many First Nations communities in British Columbia. Fraser River Stó:lō historically utilized the gravel reach population. After the arrival of Europeans, eulachon were still so abundant in the gravel reach of the Fraser River that an annual rite of spring for the local non-native communities was to dip-net them for food and garden fertilizer (Figure 2-29). In the gravel reach, in particular, long handled scoop nets were used to harvest these fish because their migratory pathway was very close to the shoreline. A story, perhaps apocryphal, was that even until the 1950s the fishers could still simply wade out into the stream and use burlap sacks to scoop up eulachon during the peak of the spawning runs.

Both plankton sampling (for the hatched larval eulachon) and standardized gillnetting have been employed to assess abundance of the run in the lower reaches of the Fraser River downstream of Hope (Hay *et al.* 2003; Stables *et al.* 2005, Therriault and McCarter 2005). Eulachon spawning sites on the Fraser River were reported in the first half of the twentieth century to be concentrated in the gravel reach between Chilliwack and Mission (Hart and McHugh 1944). In more recent years, on occasions when the runs have still been moderately abundant, scientists have monitored their presence with plankton nets as far upstream as Agassiz (Perrin *et al.* 2003). However, spawning activity is also extensive in the downstream sand reach (Stables *et al.* 2005, Therriault and McCarter 2005), and the earlier studies may not have adequately sampled these areas.

Despite the large historic numbers of this species in the lower Fraser River—possibly in the tens of millions—the account of eulachon in this watershed and the gravel reach, in particular, has largely been one of collapse (Figure 2-30). While the latter half of the twentieth century showed general declines in numbers of returning adults to the lower Fraser River, by the early-1990s it had become apparent that eulachon stocks were rapidly disappearing and more rigorous management was required to protect these fish (Glavin 1995, Hay *et al.* 2003, Therriault and McCarter 2005). By 2000, most harvest of eulachon in the lower Fraser River was extensively, or completely, curtailed and, for conservation purposes, no sport fishery for this species has occurred in the Fraser gravel reach now for approximately a decade. It appears that the upriver gravel reach component of the stock

declined first (Glavin 1995). Finally, in 2005, Fisheries and Oceans Canada refused to employ even test gillnetting as a technique of assessing escapement due to an anticipated collapse of the run in the Fraser River (Therriault and McCarter 2005).

There is a poor understanding of the reasons for the collapse of eulachon in the lower Fraser River and the gravel reach. Excessive by-catch in commercial trawl shrimp fisheries in the ocean and changes to ocean productivity may be largely causing these declines (Hay *et al.* 2003). However, habitat losses are also undoubtedly an important component of these reductions in eulachon escapement. Because so little is known about the life history of eulachon in the gravel reach, the declines of this population undoubtedly may continue, possibly to extinction without anyone understanding why this keystone species was lost.

WHITE STURGEON

The white sturgeon (Figure 2-31) is a high-profile species living in the gravel reach of the Fraser River that fascinates people for a variety of reasons. This includes their attainable size (they have been known to reach greater than 1,000 pounds/450 kilograms and longer than four metres in the Fraser River), maximum age (they can live longer than a century), and appearance (they look primitive). The white sturgeon is the largest species of freshwater fish in North America; one in the lower Fraser River is purported to have reached 1,800 pounds in weight, while another was confirmed at 1,400 pounds (Scott and Crossman 1973).

White sturgeon in the lower Fraser River have suffered a steep decline in population since the late 1800s when commercial over-exploitation took unsustainable numbers of these fish (Figure 2-32). Remarkably, while these fish were known to be over-exploited for over 100 years, the cessation of harvest of white sturgeon by all sectors—sport, commercial, First Nation—was only halted in 1994 after a series of apparently natural mortalities of very large fish occurred during the latter part of the freshets in 1993 and 1994 (Figure 2-33). There are now thought to be about 50,000 fish of a size range of 40 centimeters and greater from Hope to the Strait of Georgia, of which the majority are in the gravel reach for most of the year (Nelson *et al.* 2005).

Unlike for most species of fish in the gravel reach, some in-depth scientific research has recently been conducted on Fraser River white sturgeon. A number of studies were undertaken throughout the Heart of the Fraser from the late 1990s and on until now, looking at habitat utilization, distribution, abundance and spawning habitat (Lane *et al.* 1993, Inglis and Rosenau 1994, RL&L Environmental Services Ltd. 2000, Perrin *et al.* 2003, Nelson *et al.* 2004).

A recent study included the Lane *et al.* (1993) work showing that juvenile white sturgeon during freshet rear in the large, slow moving side channels that have been blocked at one end (e.g., Nicomen Slough). The young sturgeon appear to move from the relatively cooler, more turbid and less productive, main stream of the river into these highly productive side channels, and this probably helps them achieve enhanced growth. While there are a number of these types of habitats still extant in the Fraser gravel reach, the draining of Sumas Lake within the Heart of the Fraser for agriculture during the 1920s (Rosenau and Angelo 2005), which would have extensively and negatively affected this kind of ecosystem, probably comprised the biggest loss of historically known white sturgeon rearing habitat (c.a. 10,000 to 30,000 acres, depending on flood stage). Indeed, Sumas Lake was such a rich rearing ground for white sturgeon the First Nations would operate a trap at the outlet to capture these fish (see citation and description in Rosenau and Angelo 2005).

White sturgeon in the lower Fraser River are more numerous than anywhere else in the watershed (RL&L Environmental Services Ltd. 2000). Furthermore, growth rates have been shown to be higher in the lower river, presumably due to a greater availability of food resources and more optimum water temperatures compared to other upriver habitats.

White sturgeon spawning habitats were described for the gravel reach in the late 1990s (Perrin *et al.* 2004) and the findings were that white sturgeon which spawned in the lower Fraser River during freshet appear to select stable gravel or cobble substrates. Remarkably, downstream of Laidlaw—where the predominantly single-thread channel breaks out into multiple channels—spawning sturgeon utilize stable side channels for spawning rather than the main stream. Large-scale losses of these large side channels through land development in the gravel reach over the last century undoubtedly destroyed a considerable amount of white sturgeon spawning habitat. These losses in combination with the draining of Sumas Lake might, in part, help explain the lack of recovery of this species in the lower Fraser River over the past 100 years, and these side channels continue to be adversely affected by human activities.

The most recent and extensive scientific research on white sturgeon in the lower Fraser River has been an on-going stock assessment tagging study undertaken by the Fraser River Sturgeon Conservation Society. This project has further and unequivocally demonstrated the importance of the Heart of the Fraser for this species (Nelson *et al.* 2004). Interestingly, this study has also shown that many of the sturgeon that reside in the Fraser gravel reach during the fall and winter migrate downstream to the Fraser sand reach for the spring and summer period. Researchers think that the downstream movement of the white sturgeon is for feeding on the eulachon runs in the lower river and that these fish return to the gravel reach in late summer and fall to feed on salmon eggs and carcasses. The lower Heart of the Fraser, where the gravel reach ends and the sand reach starts, also appears to be a key overwintering habitat for this population (Nelson *et al.* 2004). By all accounts, the lower part of the Heart of the Fraser, from the confluence of the Fraser River with the Sumas River to Mission, comprises the most densely populated habitat for this species anywhere in the watershed.

SUCKERS, MINNOWS, SCULPINS, AND OTHER SPECIES

There is an abundance of other species of fishes living in the Fraser gravel reach. Little is known about them, despite their significance in the composition of the biomass and biodiversity of this aquatic ecosystem. This includes the suckers (family Catostomidae), minnows (family Cyprinidae), sculpins (family Cottidae) and other native and non-native fishes (Table 2-8; Rempel 2004). Most of these species have little direct economic importance but are important to the biodiversity and healthy-ecosystem functioning of the Fraser gravel reach. During freshet, many of these fishes move out of the main channel and can be found in high densities in the flooded high-elevation side channels and vegetated riparian zones of the gravel reach (e.g., Figure 2-4). These habitats appear to be extensively used for foraging and spawning during freshet (senior author's observations). In addition to being part of the fish biodiversity of the Heart of the Fraser, these species also often provide forage for species such as sturgeon and cutthroat trout—fishes that have economic and recreational values (Scott and Crossman 1973).

Figure 2-21. A windrow of spawned-out Fraser River pink salmon accumulating along the perimeter of a bar in the gravel reach as the water recedes, autumn 2007.

The large biomass that arrives here every two years provides nutrients, in the form of nitrogen and phosphorus, for algae to flourish and flesh on which aquatic, avian and terrestrial organisms forage. Photo D. Catt.



Figure 2-22. Pink salmon spawning habitat in the gravel reach.

A major side channel of the Fraser River gravel reach, which was extensively used for spawning by pink salmon in the autumn of 2005, was de-watered as part of a gravel removal operation in March 2006. This photo shows that the kinds of substrates that these fish chose for reproduction. The undulations in the gravel bed topography represent redd sites.

**Figure 2-23.** The remains of salmon carcasses in late winter during decomposition and release of marine-derived nutrients into the gravel reach of the Fraser River.

As salmon carcasses decay they slowly release nitrogen and phosphorus into the surrounding ecosystem; the decaying tissue is also foraged on by a variety of invertebrate, fish and non-aquatic species.



Figure 2-24. Chum salmon spawning can be extensive in the remaining side-channels in the Heart of the Fraser. Fish carcasses such as these provide food for a multitude of scavengers including the bald eagle. Habitats with sufficient groundwater are especially attractive to spawning chum salmon in the gravel reach. Photo D. Catt.



Figure 2-25. A sub-sample of the diversity of fish species captured in a single seine haul along a bar of the gravel reach.

Clockwise from top left—pickly sculpin (*Cottus asper*), northern pikeminnow (*Ptychocheilus oregonensis*), juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and reidside shiner (*Richardsonius balteatus*).



Figure 2-26. With little effort, fish sampling during most seasons of the year around the large gravel bars of the Fraser River catches many different species rearing in these habitats.

From an areal perspective, these large gravel bars are a relatively rare habitat feature, especially during freshet (Rosenau and Angelo 2000) and may be limiting.



Figure 2-27. This is a prime example of a cutthroat trout which was foraging in a side channel of the gravel reach of the Fraser River in the fall prior to spawning the next winter.



Figure 2-28. Fraser River eulachon.

Craig Orr photo.



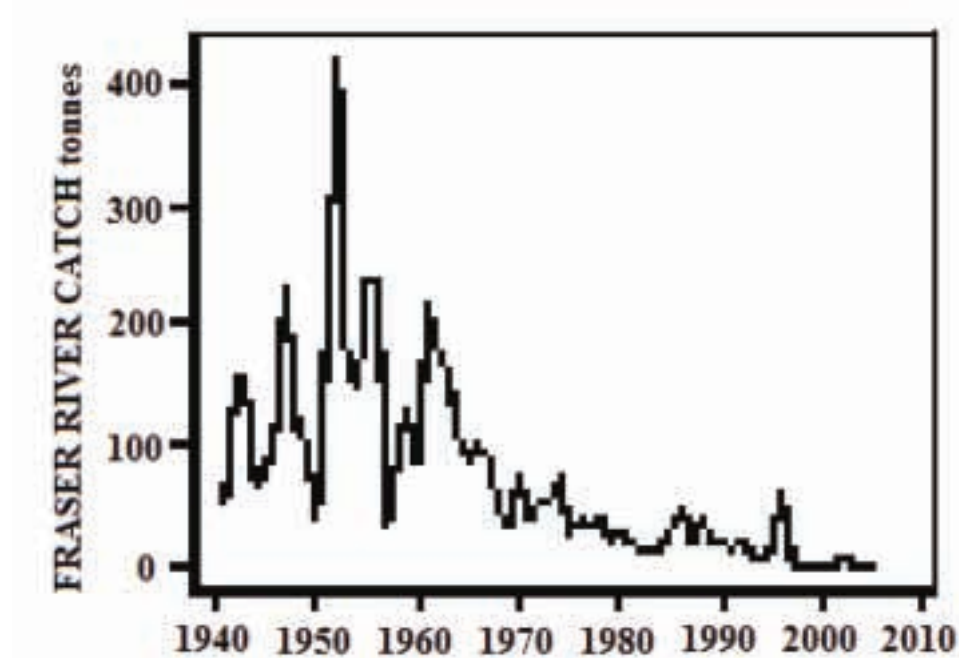
Figure 2-29. Early settlers fishing for eulachon in the gravel reach.

Used by permission of the Mission Community Archives photo MCA 184-21.



Figure 2-30. Commercial harvest of eulachon in the lower Fraser River throughout the mid- to late-twentieth century.

Data from Fisheries and Oceans Canada http://www.pac.dfo-mpo.gc.ca/sci/herring/pages/eulachon_e.htm.



2.0 PHYSICAL AND BIOLOGICAL ASPECTS OF THE GRAVEL REACH OF THE FRASER RIVER

Figure 2-31. From 1995 to 1999 the Habitat Conservation Trust Fund supported primary sturgeon research in the gravel reach of the Fraser River.



Figure 2-32. Collapse of the sturgeon harvest fishery in the lower Fraser River.

Data from Hart (1973). The peak landing was 516,000 kg in 1897 but Semakula and Larkin (1969) remarked that in 1901 the Fisheries Inspector noted that the fishery was already practically commercially extinct.

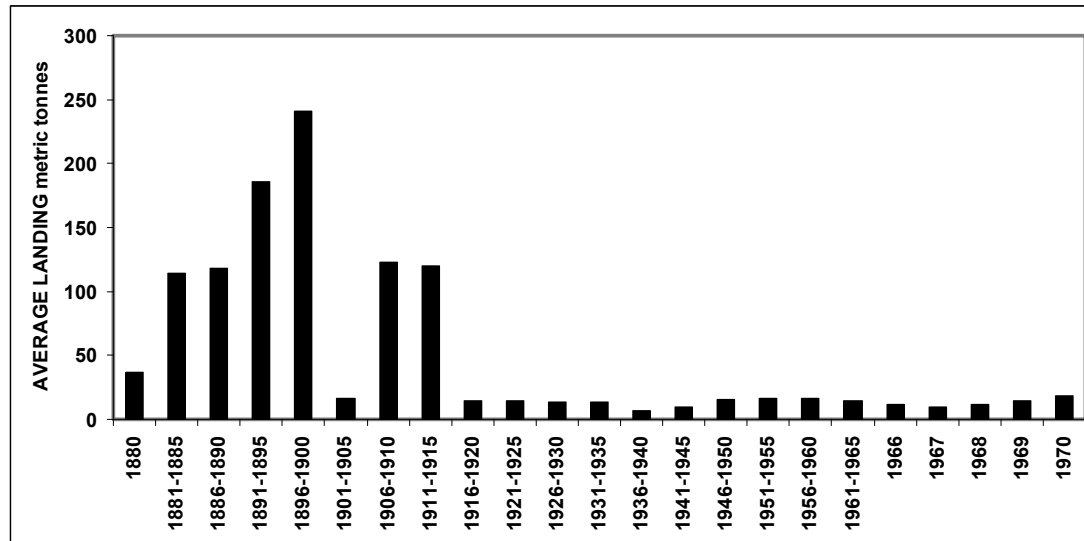


Figure 2-33. In the summers and autumns of 1993 and 1994 over 30 large sturgeon were found washed up dead in the gravel reach of the Fraser River.

Over 80% of these fish were female. No firm conclusions as to the cause of death were ever made.



Table 2-8. Species of fish inhabiting the gravel reach of the Fraser River.

* designates a non-native introduced species; R designates a species of rare occurrence; L designates a species at risk listed by the federal and/or provincial agencies.

| Salmon, trout, char and whitefish (Families Salmonidae, Coregonidae) | Minnows (Family Cyprinidae) |
|---|--|
| Sockeye salmon <i>Oncorhynchus nerka</i> | Northern pikeminnow <i>Ptychocheilus oregonensis</i> |
| Chinook salmon <i>Oncorhynchus tshawytscha</i> | Peamouth chub <i>Mylocheilus caurinus</i> |
| Chum salmon <i>Oncorhynchus keta</i> | Leopard dace <i>Rhinichthys falcatus</i> |
| Coho salmon <i>Oncorhynchus kisutch</i> | Longnose dace <i>Rhinichthys cataractae</i> |
| Pink salmon <i>Oncorhynchus gorbuscha</i> | Redside shiner <i>Richardsonius balteatus</i> |
| Steelhead trout <i>Oncorhynchus mykiss</i> | Brassy minnows <i>Hybognathus hankinsoni</i> L |
| Cutthroat trout <i>Oncorhynchus clarkia</i> L | Common carp <i>Cyprinus carpio</i> * |
| Bull char <i>Salvelinus confluentus</i> L | |
| Mountain whitefish <i>Prosopium williamsoni</i> | Suckers (Family Catostomidae) |
| | Mountain sucker <i>Catostomus platyrhynchus</i> L |
| Sticklebacks (Family Gasterosteidae) | Largescale sucker <i>Catostomus macrocheilus</i> |
| Threespine stickleback <i>Gasterosteus aculeatus</i> | Bridgelip sucker <i>Catostomus columbianus</i> R |
| | |
| Sculpins (Family Cottidae) | Sturgeon (Family Acipenseridae) |
| Prickly sculpin <i>Cottus asper</i> | White sturgeon <i>Acipenser transmontanus</i> L |
| Coastrange sculpin <i>Cottus aleuticus</i> | Green sturgeon <i>Acipenser medirostris</i> R L |
| | |
| Lampreys (Family Petromyzontidae) | Sunfish (Family Centrarchidae) |
| Pacific lamprey <i>Lampetra tridentata</i> | Black crappie <i>Pomoxis nigromaculatus</i> * R |
| River lamprey <i>Lampetra ayresii</i> | |
| | Smelts (Family Osmeridae) |
| Herrings (Family Clupeidae) | Eulachon <i>Thaleichthys pacificus</i> L |
| American shad <i>Alosa sapidissima</i> * | Longfin smelt <i>Spirinchus thaleichthys</i> R |
| | |
| Catfish (Family Ictaluridae) | |
| Brown bullhead <i>Amieurus nebulosus</i> * | |

OTHER ECOSYSTEM VALUES OF THE GRAVEL REACH

The gravel reach falls within the Fraser Lowland Ecoregion, a subdivision of the Lower Mainland Ecoregion, delineated and identified by Demarchi (1988). While this report focuses on the fisheries values of the gravel reach, it is important to recognize that the extensive biodiversity within the Heart of the Fraser comprises far more than the species of fish that live here (Appendix 4). As discussed earlier in this report, the wide-ranging natural biodiversity is due in large part to the post-glacial history and colonization of the area. A myriad of plants, animals and other organisms arrived here from a variety of different directions across the continent, and the diverse biotic and physical features defining the area helped this multitude of organisms become established within the Heart of the Fraser.

As an example of the Fraser gravel reach's biodiversity, a number of aquatic mammals are regularly observed in the area, including harbour seals (*Phoca vitulina*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*) and the marten (*Martes americana*). Large terrestrial omnivores include black bear (*Euarctos americanus*), and, surprisingly, the very occasional grizzly bear (*Ursus horribilis*) (R. Land, pers. com.). Other large vertebrates include blacktail deer (*Odocoileus hemionus columbianus*) and the non-native whitetail deer (*Odocoileus virginianus*), cougar (*Puma concolor*) and coyote (*Canis latrans*). The Pacific water shrew (*Sorex bendirii*) is an example of a small mammal which is also listed as a species at risk living within the boundaries of the Heart of the Fraser.

The gravel reach of the Fraser River is also an extremely bird-rich part of British Columbia. For example, over 135 species of birds have been recorded in the Harrison River part of the Fraser gravel reach by a member of the Mission-based Fraser Valley Bald Eagle Festival. A summary of the sightings in the Harrison River area has been listed at: http://www.fraservalleybaldeaglefestival.ca/kathys_korner.html and this web site provides a comprehensive perspective on these species. Some of the rarer or more notable birds include the red-tail hawk (*Buteo jamaicensis*), the green heron (*Butorides virescens*) and great blue heron (*Ardea herodias*), the bald eagle (*Haliaeetus leucocephalus*), assorted dabbling ducks, the wood duck (*Aix sponsa*), the purple martin (*Progne subis*), the sandhill crane (*Grus canadensis*) and turkey vultures (*Cathartes aura*).

Rare amphibians in the Fraser gravel reach include species such as the Oregon spotted frog (*Rana pretiosa*), western red-backed salamander (*Plethodon vehiculum*), and the Pacific giant salamander (*Dicamptodon tenebrosus*). Non-vertebrate species of animals include those from the diverse aquatic-invertebrate community found in the mainstem and adjacent habitats and many of these species are listed in Rempel *et al.* (2000). Plant species were historically also rich in complexity in the Fraser gravel reach (Figure 2-16) and, although these plants remain at a diminished abundance, are still an important part of this ecosystem. The remnant natural communities of lowland vegetation include black cottonwood (*Populus balsamifera*) and western red cedar (*Thuja plicata*), two high-profile examples that still occur here.

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

OVERVIEW

By far the greatest of the human-related impacts to the aquatic and riparian ecosystems within the Heart of the Fraser occurred by the middle of the twentieth century (Rosenau and Angelo 2005). The remaining environmental values of the Fraser gravel reach are still under threat and human-related activities continue to erode the viability of its flora and fauna. While recognizing the historical impacts to this ecosystem, and the fact that most of these are not reversible, at least in the short term, the issue of greatest concern now is the continuing harm to the remaining functioning landscapes that still exist within the Fraser's gravel reach, and how these losses might be stemmed and reversed. This chapter outlines and explains how current human activities persist and undermine aquatic and riparian ecosystems within the Heart of the Fraser. It segregates the continuing activities still causing impacts to aquatic and riparian habitats into major categories, including: aggregate extraction from riparian areas; navigation; pulpwood harvest; agriculture; flood protection through diking, bank armouring, and gravel extraction in the river channel to lower water levels; and land development.

AGGREGATE EXTRACTION FROM RIPARIAN AREAS

Human population growth and development in the lower mainland of British Columbia is increasing at record levels, and this is having unprecedented impacts on aquatic resources in the southwestern part of our province (Ashley 2006). Along with the increasing numbers of residents are corresponding demands for raw materials needed for housing, commercial and industrial property, and other infrastructure. In particular, sand and gravel are required for construction.

In British Columbia there are about 2,600 active aggregate-pit operations producing approximately fifty million tonnes of sand and gravel per year. This output is valued at over \$170 million annually and directly employs 4,000 to 5,000 people². It is estimated that three-quarters of the 25 million tonnes of annual aggregate consumption in the lower mainland of British Columbia is used for infrastructure construction and maintenance. As a reflection of demand, the price of sand and gravel in British Columbia increased by over 38 percent between 1993 and 1998³.

The lower mainland of British Columbia does not have many prospects to mine low-cost aggregate due to the fact that current land use practices (e.g., Agricultural Land Reserve designation) and zoning restrictions in this area have eliminated many of the otherwise available locations (Bobrowsky *et al.* 1996). Thus, any available sites in south-western British Columbia where aggregate can be mined are looked upon as highly desirable to the industry. Historically within the Heart of the Fraser, there have been two types of opportunities for aggregate removal. One is from within the active channel, and the other is from within the adjacent riparian zones of the normally-dry areas of the floodway.

Commercial-level gravel mining has taken place within the Heart of the Fraser since the 1950s (Weatherly and Church 1999). In the early days of aggregate extraction in the gravel reach, much of this material was taken off dry gravel bars within the perimeter of the active channel during low-stream flows in the winter period. The one major exception to this mode of extraction occurred near Island 22 where a drag-line operated for many years by removing material from within the wetted perimeter of Minto Channel. This operation has now been shut down (Figure 3-1).

² <http://www.em.gov.bc.ca/Mining/geolsurv/Surficial/aggregate/default.htm>

³ <http://www.em.gov.bc.ca/Mining/GeolSurv/Surficial/aggregate/AggregateReview/tor.htm>

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Historically, the amount of material removed from within the active channel of the Fraser River in the gravel reach averaged about 100,000 cubic metres per annum. This sand and gravel was used for local construction needs and dike building (Weatherly and Church 1999). The volumes of aggregate extraction and large-scale removal began to escalate to well above 100,000 cubic meters per annum towards the latter part of the twentieth century.

In the mid-1970s the government fisheries agencies began to become more concerned about the possible impacts to habitat resulting from sediment removal from within the active channel of the Fraser gravel reach. They became more restrictive about where and when the gravel could be removed (O. Langer, pers. com.) Finally, in the late 1990s a temporary “moratorium” on instream gravel removal was instigated by governments in order to provide a period to investigate the impacts to habitat from such extractions. It should be noted that this was not a true cessation of gravel mining: a number of “experimental” removals still took place during this period. Due to the intense political pressures by the aggregate industry for access to river sand and gravel, and the concern that natural depositions of sediments from upstream sources of the active channel were compromising the gravel reach flood profile, the moratorium was lifted on sediment removal in the active flood channel within the Heart of the Fraser in the early 2000s. Subsequently, the extraction of gravel from within the active stream-channel increased significantly, ostensibly to enlarge the channel capacity to provide flood protection. For this report, because the rationale for gravel removal from the active stream-channel of the Fraser River is now largely for flood protection, this specific activity and its associated impacts are discussed in a subsequent section dealing with flood protection, and the remainder of this section addresses only effects associated with the development of gravel pits in the riparian areas.

Because of the continuing demand for aggregate in the eastern Fraser Valley, and the fact that river-based gravel was not accessible year-round, large-scale amounts of material also began to be mined near the end of the 1970s from land-based deep pits from within the riparian floodway adjacent to the active channel in the gravel reach. These extraction areas are often flooded at extreme freshet events; in most years and most times of any given year, they are dry. The development of deep gravel pits in the riparian areas of the gravel reach occurred predominantly in a number of locations in the Chilliwack area (Figure 3-2), but a large site was also constructed in the 1980s at Hope near the mouth of the Silverhope River to supply material for the Coquihalla Highway construction.

The early riparian deep gravel pits in the Fraser River gravel reach were excavated on private land. However, the surface of the properties which might be physically appropriate for deep-pit extractions within the floodway also usually constitute good agricultural lands. Once the aggregate is removed from these pits the site is no longer useable for farming. After the mid-1970s, farm lands were largely protected from such destructive activities by the Agricultural Land Reserve and its policies and regulations. The deep-pit Fraser gravel reach aggregate extractions currently operating are on First Nations reserves and do not have the same legislative constraints associated with private or crown land ownership.

The environmental effects associated with the development of deep pits in the riparian areas are not well understood, and are not extensively regulated. The extraction of aggregate from gravel pits within the floodway area of the Fraser gravel reach is damaging to the Heart of the Fraser from a number of perspectives. Firstly, the footprint disturbance of the gravel pit on the floodplain results in losses of the functioning surface riparian biological community. Obviously, all riparian vegetation and other floodplain ecological features are destroyed in order to reach the sand and gravel underneath the land. Secondly, once the aggregate is removed from the ground, what is left is a very large, very deep and steep-sided hole filled with water (Figure 3-2). Some of the early abandoned pits were backfilled with waste. However, filling these deep water-filled pits with garbage is a risky practice due to the possible contamination to local groundwater quality. It should be noted that hyporheic flows in the area are probably disrupted as a result of this activity.

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

For those excavations that are not backfilled, the resulting water body within the abandoned pit is not a particularly productive environment for aquatic ecosystems. Because of the steep-sided nature and depth of the excavations, there is little chance for shallow-water (or the littoral zone, which is the most productive part of freshwater environments) aquatic organisms to flourish along the edges of the extraction site. Fishes living in the active channel of the Fraser River and potentially using these pits as habitat have also been deliberately excluded from emigration into most of the pits, by the inclusion of wide, non-passable buffers as requested by fisheries regulators. This is to prevent emigration of fish into the pits and their potential stranding as a result of receding water levels.

While the footprint of the excavation of aggregate from these deep pits results in losses to the riparian ecosystem due to clearing of the land surface, another potential impact to the ecosystem in the Fraser gravel reach floodway involves the alteration of natural fluvial processes that are important to a healthy functioning riverine environment. For comparison, in California large pits have also been constructed in riparian areas adjacent to the flowing channels of some large streams for the purposes of obtaining aggregate and this has resulted in negative impacts to some watersheds (Kondolf 1997). In these reported Californian examples, natural erosion processes have, at a number of locations where these pits were located close to the rivers edge, cut laterally through the river bank to the extraction site and the stream was subsequently “captured” by the excavation. The entrainment and capture of the flow of the river into the gravel pit caused catastrophic alterations to the riparian areas and stream stability by triggering large-scale collapses of the stream banks and the “unravelling” of the structure and integrity of the floodplain (Kondolf 1997). To prevent this, deep gravel pits that are excavated close to an active river channel require extensive bank armoring to prevent normal stream wandering and erosion into the excavation (Kondolf 1997, Rosenau and Angelo 2000); this hardening and protection of the bank from normal erosion disrupts the natural habitat-creating processes and causes a loss of proper stream functioning.

Figure 3-1. By 2000 draglines taking aggregate from within the active channel of the gravel reach of the Fraser River were no longer operational.

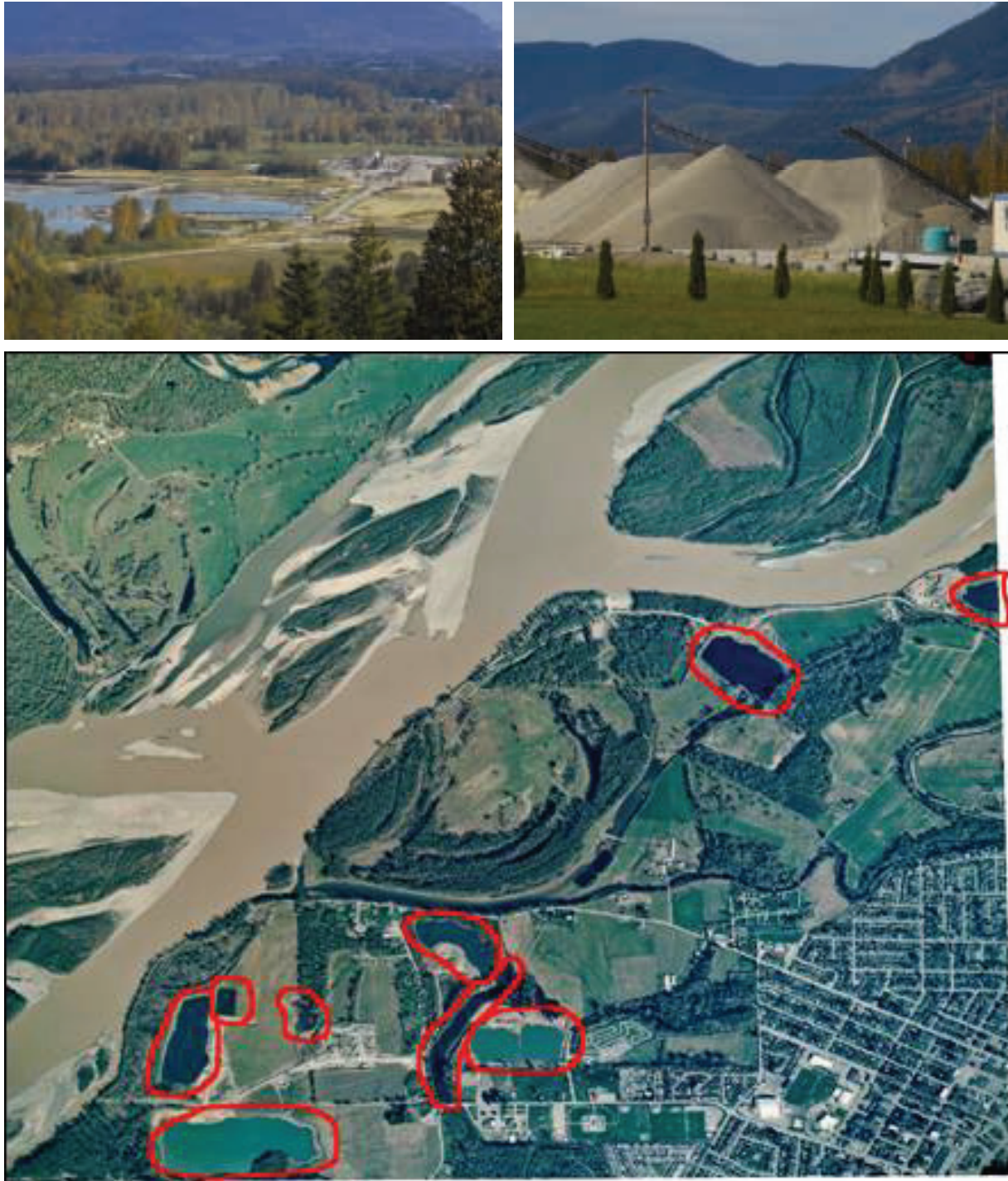
This was one of the few mid-stream extraction sites and was located near Island 22 on Minto Channel in Chilliwack.



3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Figure 3-2. Gravel extraction from riparian areas is a significant component of the landscape change in the Fraser gravel reach.

Encircled areas in lower photo show large extraction pits on locations that were, until the 1970s, agricultural or naturally forested lands located immediately west of the city centre of Chilliwack. Top photos D. Catt. Bottom photograph from UBC Geography Department, D. Ham, and was taken 2002 courtesy of BC Government.



NAVIGATION

A significant amount of boat traffic occurs within the Heart of the Fraser by anglers (Schubert 1995), by First Nations accessing salmon nets, and by tugs towing aggregate barges from Sumas Mountain to downstream destinations (Figure 3-3). Tugs are also used for moving logs through the Fraser gravel reach from inland areas to downstream mills. Until the 1990s, over 300,000 cubic metres of wood from Harrison Lake, and over 150,000 cubic metres from Hope, were towed annually down the gravel reach (Lauga and Associates 1994). Significant amounts of wood are still towed from the Harrison Lake area downstream past Mission.

Except during the lowest-flow periods, the navigation of small craft by recreational and First Nations in the gravel reach is normally not inhibited by water depths. Furthermore, aggregate barges operate only in the lower portions of the gravel reach and generally have great enough water depths for easy transportation of their material through the Fraser River from Sumas Mountain to destinations downstream.

In contrast, the movement of log booms, which pass through a substantially greater portion of the gravel reach than do aggregate barges, is severely constrained during many low-flow months of the year by the lack of channel depth. The draft of the bundled logs is about two metres and there are many locations less than this at certain times of the year (Rosenau and Angelo 2000). Areas too shallow for log-boom transport first occur during the lower-freshet months of the hydrological year in the gravel reach and the river depths subsequently become marginal for towing. The river currents in the gravel reach cause erosion and deposition. They are also continually filling in existing channels and scouring new ones, by shifting sediments. This often causes alignment changes or creates new shallow spots that present navigational difficulties as well.

From the 1950s until 1996, log-towing navigation in the Fraser gravel reach was facilitated by the dredging of shallow areas through support from Public Works and Government Services Canada (Rosenau and Angelo 2000). The maintenance of the navigational channels in the gravel reach was undertaken annually using scuffle dredging or clamshell excavators. This equipment consisted of tugs equipped with a bucket or blade and the sand and gravel blocking the navigational channel was simply side-cast, pushed or “scuffled” out of the main part of the stream in order to deepen the river at the point of intended boat traffic. Under this dredging scenario, the stream-bed sediments do not have to leave the river channel in order to provide low-water boating channels, but a deepened navigational channel is simply created.

The extensive dredging routinely carried out in the gravel reach prior to 1996 was often concentrated at particular sites of localized sedimentation including “Chilliwack Rock” near the upstream end of Chilliwack Mountain and “Cheam View” at the upstream end of Seabird Island (for locations see Figure 1-5). The amount of sand and gravel dredged each year ranged from 54,000–90,000 cubic metres (Public Works and Government Services Canada memo to Ministry of Environment, Lands and Parks, 1996, cited in Rosenau and Angelo 2000, Kellerhals *et al.* 1987).

Unfortunately, there is little evidence or understanding of the ecology of these types of locations in the gravel reach. Because they are extremely difficult to sample (i.e., deep water, swift currents; Laidlaw and Rosenau 1998) it has not been possible to properly quantify the effects of scuffle dredging. However, Rosenau and Angelo (2000) discussed a number of possible effects. Firstly, scuffle dredging may be directly impacting fish invertebrate species or periphyton (algae) living within the footprint of the dredging activity. Suffocation by sediment re-deposition, displacement, or mechanical injury is possible.

Secondly, scuffle dredging normally causes a significant change to the channel morphology, and this affects the distribution and abundance of depths and velocities in the stream (Kellerhals and Church 1989). By reducing the variability of the channel and opportunities for a wide range of depths and velocities to occur, the dredged areas provide fewer opportunities for niche or habitat diversity. This is an important factor in that the gravel reach that

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

has at least 30 different species of fish as well as an extensive range of other aquatic organisms which are adapted to the wide ranges of these parameters found here.

A third effect is the tendency to concentrate the water flow from multiple streams into a deeper single channel. That is, scuffle dredging generally causes the active part of the river to change from having many smaller channels (braided) into a one that is narrower, deeper, and has a predisposition towards a single stream (Kellerhals *et al.* 1987). Shallow-water areas are important for fish during high-discharge periods in the freshet of the Fraser gravel reach (our observations; Rosenau and Angelo 2000). Side channels are also important habitats for sturgeon spawning (Perrin *et al.* 2003), salmon spawning and fish rearing (Rempel 2004).

A fourth effect of scuffle dredging is to disrupt the armouring layer in the thalweg (deepest part of the channel) of the stream bottom. The armouring layer is the thin sheet of coarser material on the surface of the stream bed that is less mobile than the sediments beneath. The upper layer's individual sediment particles are more resistant to erosion due to greater size and the physical orientation of these surface elements have become aligned to become more hydro-dynamic and less prone to the effects of erosion. The armour layer protects the stream bed and promotes channel stability. Removing the armouring layer presumably encourages increased sediment movement over and above the normal rates of gravel recruitment and mobilization, and this might have implications for channel infilling at key hydraulic locations. Disruption of the armouring layer also entrains fine sediments into downstream habitat areas, where they might suffocate biological activity. Where sites were dredged repeatedly year after year, the effects over time have either been cumulative, or the river was never able to repair itself and remained in a steady state of continually degraded habitat.

Nevertheless, due to the withdrawal of funding by the senior governments, and with one notable exception (Figure 3-4), dredging for navigation in the gravel reach has not been undertaken since 1996. Nevertheless, proposals are still being made to have extensive extraction for navigation and a number have recently been submitted to governments whereby the proponent would be able to remove large amounts of gravel from the river to create a navigational channel and then sell the aggregate to pay for the excavation. These large-scale dredging operations will possibly exacerbate the problems of local stream channel stability resulting from an increase in the stream channel erosion and deposition due to the mechanical disturbance of the stream bottom. Ironically, such a project may be counterproductive to the objectives of providing navigation over the medium and long term if this disturbance causes local areas to repeatedly and rapidly refill with sand and gravel due to disruption of the natural channel stability.

Another significant and destructive aspect relating to the maintenance of navigational opportunities in the gravel reach is the removal of floating woody debris near Hope (Figure 2-14). This floating woody debris is predominantly taken from the stream to facilitate navigation in the lower Fraser River and Georgia Strait at the Laidlaw debris trap. Here the wood floating down the Fraser River is funnelled into a collection area by a long boom strung out into the main channel and then removed. The debris trap has been operational since 1979, and has removed wood at a rate of approximately 60,000 to 70,000 cubic metres per annum. It is important to note that about 85% of this material is of natural origin (Bratty 2001) and has likely been a phenomenon for thousands of years.

As discussed in detail above in this report, large woody debris has a major role in determining the geomorphology and ecological functioning of many braided rivers (Tockner *et al.* 2006). Compared to two decades ago, the gravel reach now is largely free of woody debris (Ham 2005). Since this material is known to be vital for the establishment, growth and maintenance of channel islands and side-channels, and provides habitat to fish and other organisms in the form of cover, the ecological impact of wood removal to the gravel reach is apparent (Ham 2005). Because of the critical nature of large woody debris for Pacific coastal watershed ecosystems (Maser and Sedell 1994) the starvation of this habitat feature is undoubtedly reducing the productivity of the Fraser gravel

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

reach. Consequently, current practices need to be re-examined so that an appropriate balance can be struck between navigation and aquatic ecosystem needs.

Methods of mitigating impacts associated with the debris trap can also be explored. This might include, where appropriate, the strategic placement and anchoring of large woody debris for habitat enhancement purposes.

Figure 3-3. Log booms, angler jet boat, and aggregate-barge towing on the waters within the Heart of the Fraser.

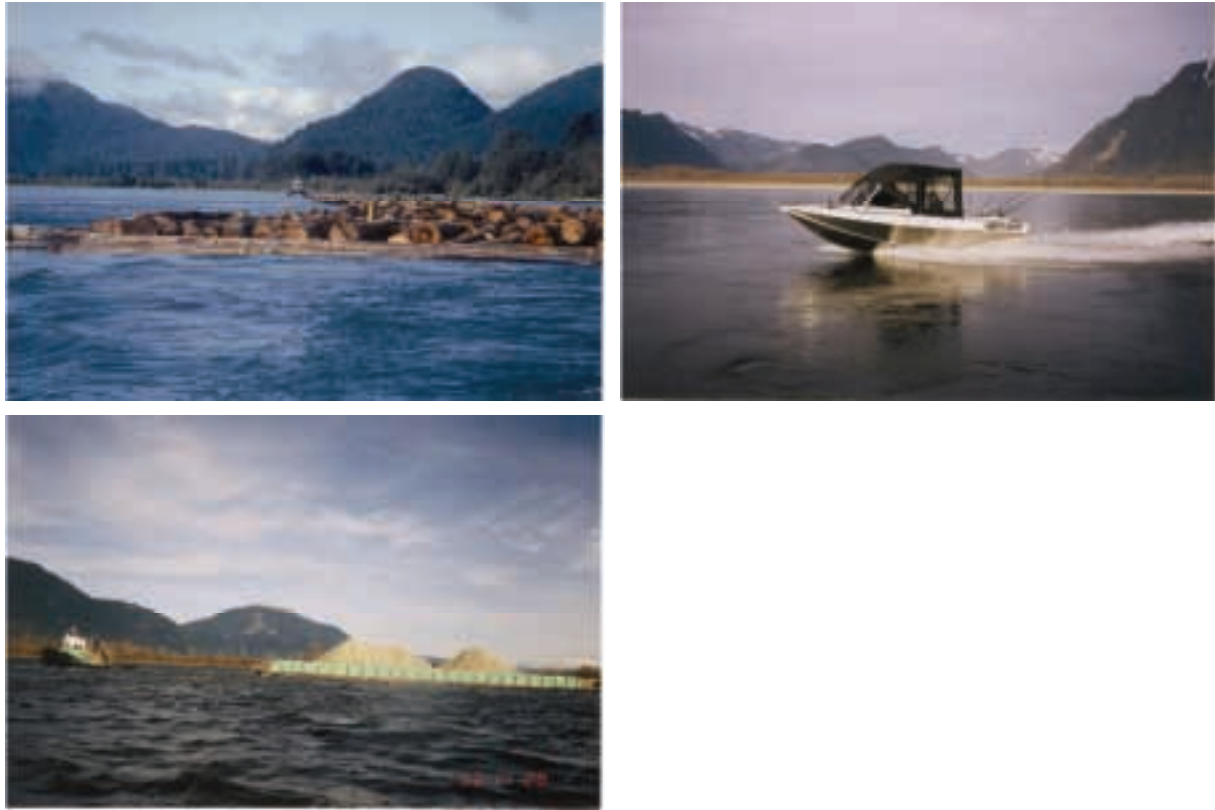


Figure 3-4. Side-cast dredging of stream-bed sediments at Chilliwack Mountain in the gravel reach to allow log-booms to be towed from Harrison Lake.

Photo taken late 1990s.



PULPWOOD HARVEST

OVERVIEW

Under current management regimes, forestry activities on a number of large undiked islands within the Heart of the Fraser have become an issue of concern. A significant amount of riparian land on the water side of the dikes within the gravel reach of the Fraser River contains areas specifically managed for pulpwood harvest of cottonwood and poplar hybrids (Figures 3-5, 3-6, 3-7). The largest of these areas, and consisting of crown land, is the Lower Fraser Block of Tree Farm License (TFL) 43. Its land area includes properties in the lower Fraser, the Kingcome and the Homathko rivers and comprises 10,106 hectares of which 6,153 are harvestable (Beedle 2000). The Lower Fraser Block includes a total of 3,549 hectares and, of these, 1,152 hectares are harvestable. The non-harvestable lands in it are either not economical nor feasible to be cut due to factors including environmental sensitivity, designation as streamside management zones, grizzly bear habitat, inoperability, and roads (Figure 3-8).

The Lower Fraser Block is situated within the Heart of the Fraser in the Chilliwack Forest District, and it is surrounded by the British Columbia Ministry of Forest and Range Fraser Timber Supply Area (TSA). The whole of TFL 43 is contained within the Vancouver Forest Region (Pedersen 1995). It differs from most tree farm licenses in British Columbia in that it is exclusively managed for the production of deciduous fibre. As of March 2000, its Annual Allowable Cut was 39,000 cubic metres.

The managed forests within the timber harvesting land base of TFL 43 are now largely comprised of cottonwood and red alder, with minor components of other deciduous and coniferous species (c.f., Figure 2-16 for the historical composition and distribution of vegetation species within areas covered by the Lower Fraser Block). The timber stands within the harvestable land base of the Lower Fraser block have already been entirely converted to pulpwood (Pedersen 1995). As of 2000, the annual harvest volume from the TFL 43 supplied the equivalent of 15 to 25 percent of the wood processed by the license holder in New Westminster (Beedle 2000).

IMPACTS ASSOCIATED WITH SILVICULTURE ACTIVITIES

TFL 43 is being managed for the production of large-diameter cottonwood/hybrid poplar pulp logs, and the target for these extensively-controlled stands is an average stump diameter of 45 cm over a twenty-five year rotation (Carson 2005). On the best sites, a unit volume of 375 cubic metres per hectare is expected.

Hybrid poplar is now the species of choice for most reforestation activities in TFL 43 on its plantations because of the vigour of the plants. The license holder has an ongoing tree-breeding program that aims to increase the gains from the hybrids over natural cottonwood and increase pest resistance through its silvicultural activities (Carson 2005).

When re-planting occurs on a harvested site in TFL 43, the ground is first mechanically prepared (tilled) in order to reduce below-ground competition from other vegetation species and reduce the soil bulk density in order to enhance rooting of the poplar hybrid shoots (Carson 2005). While this has positive benefits for the target poplar hybrids, it largely destroys the natural biological community and native vegetation structure in these riparian areas of the Heart of the Fraser (c.f., Figure 2-9 and Figure 3-9). With the conversion of natural forest to fast-growth, high-rotation hybrids, for example, there is no indication that the old-growth cottonwood structures, needed for eagle nesting and perching, will be retained in TFL 43.

The Management Plan Number 4 for TFL 43 indicates that "...protection of herbaceous and under-story vegetation..." will be a priority (Pedersen 1995). Presumably this statement assists the licensee to maintain natural vegetation biodiversity objectives under legislation and regulation. In contrast to the intent of this statement, the TFL 43 was given a variance by the Ministry of Forests and Range to disturb 100% of the harvestable landscape, contrary to the Ministry of Forests Soil Conservation Guidebook (Minhaas and Stenersen 1999; Figure 3-9). Thus, compared to other forests in British Columbia, the variance given to the license holder in regards to soil disturbance is particularly destructive to the maintenance of biodiversity in this component of the Fraser gravel reach.

The impacts of this activity on natural vegetation maintenance in TFL 43, in regards to fish, are not clear because no research has not been conducted. However, one possible example relating to fish may include the reduction in white sturgeon survival through losses of native vegetation. The scientific literature suggests that successful recruitment of recently hatched white sturgeon juveniles is a function of intact riparian habitats that are flooded during freshet period when sturgeon spawn. It has been shown that shortly after the fry becoming free-swimming during freshet periods, they use such flooded vegetated areas for rearing (Coutant 2004). Some of the areas disturbed by silviculture activities in the Fraser gravel reach may have historically included these types of habitat features and use by white sturgeon juveniles but have now been lost as a result of the current forest practices within this area.

MAINTAINING BIODIVERSITY

Maintenance of biodiversity values is required under British Columbia's forest legislation. However, in 2000, the British Columbia Forest Service suggested that TFL 43 blocks are generally small parts of larger landscape units and many of the landscape level biodiversity objectives can be met on a larger scale (Beedle 2000). However, there is no evidence that these objectives are being meaningfully achieved, or that the biodiversity in TFL 43 and its surrounding areas is being maintained.

A further biodiversity-maintenance issue for TFL 43 involves the fact that the management of the Lower Fraser Block (TFL 43 Management Plan Number 4; Pedersen 1995) was to be integrated into the province's Protected Area Strategy to meet the objectives of the strategy for protecting these gravel reach ecosystems. The Protected Area Strategy (Report of the Working Group 1998) was a provincial initiative in the 1990s that was given a mandate to set aside 1,000 hectares of the lowland properties in the area from Hope to Mission to "assist in meeting the landscape level biodiversity requirements." Because the Protected Area Strategy was never ratified, this important objective was not met and declines in biodiversity both within the outside of the TFL 43 in the lowlands of the gravel reach appear to continue.

OLD GROWTH REQUIREMENTS

A specific biodiversity issue relating to the management of TFL 43 is that there is no requirement in the TFL 43 management plan to encourage the achievement of an old growth component within these crown lands (Minhaus and Stenersen 1999). This is despite the fact that most old growth cottonwoods in the Fraser gravel reach have been lost through harvest or land clearing over the last 100 years (compare Figure 2-16 and Figure 2-17). Thus, a naturally diverse stand of cottonwood trees should have a much older age distribution than is currently seen in TFL 43 (Figure 3-10) if it were to achieve old growth attributes. Again, there is no indication that these issues are being adequately addressed.

LACK OF ADEQUATE RIPARIAN PROTECTION

Despite considerable scientific literature from around the world (see discussion of the issue in previous sections of this report), the Ministry of Forests and Range Riparian Management Area Guidebook takes the position that large woody debris does not play an essential role in large-river ecosystems, compared to smaller rivers throughout British Columbia. Thus, only limited riparian protection is required when harvesting wood in the stream-side areas of the TFL 43 (Beedle 2000). For example, a reserve zone (no logging) is not required adjacent to large rivers such as the Fraser River, and the management zone (specified logging) extends from the streambank to the outer edge of the active floodplain or to 100 metres, whichever is greater. Additionally, for the Fraser River, the Ministry of Forests and Range harvest requirements for TFL 43 stipulate that for the first cut only 50% of the trees need to be left within a 20 meter buffer along the outer perimeter of islands, back channels, side channels, and sloughs (Figure 3-8). At the next harvest only 10% of the trees saved during the first cut then have to be left, with the planted trees from the first cut making up the 50%. This position is taken despite the reasonable assumption that the natural recruitment of erosion-reducing large-woody debris along the banks of these islands would largely be disrupted as a result of these narrow zones and exacerbate erosion beyond normal rates (c.f., Figures 3-7, 3-11).

Surprisingly, for islands smaller than 25 hectares in the TFL 43 the regulations are even less stringent. For these highly sensitive patches of lowland ecosystem, the license holder is only required to maintain 2-3 trees for every 25-30 metres of island length. Furthermore, small islands have a riparian requirement of only 5 metres.

In light of this situation, it is apparent that the regulations for riparian management in the TFL 43 are not sound. They contribute to the destruction of the island ecologies and instability in the Fraser gravel reach floodplain. There is no evidence that the current regulations and practices are scientifically defensible for logging in the Heart of the Fraser.

BIOSOLIDS APPLICATION ON TFL 43

Another issue of particular interest to local residents, fisheries groups, and government agencies in regards to forestry activities within the Heart of the Fraser has been the application of wastewater-treatment plant biosolids, for use as fertilizer, to the riparian and floodplain areas of TFL 43 to increase the production of pulpwood. These biosolids are the product of the Greater Vancouver Regional District's Annacis Island wastewater plant and the TFL 43 Management Plan indicates that these lands are to be fertilized at a rate of 20 to 30 tonnes per hectare. These applications are being conducted under the aegis of the British Columbia Organic Matter Recycling regulation.

While there is no direct evidence that this activity is harmful to the riparian or aquatic ecosystems in the area, a risk is evident that some of the persistent contaminants within the bio-solids may be damaging. In particular, high levels of copper and Endocrine Disrupting Compounds (EDCs) (Colborn *et al.* 1993) may become an issue to the local biota. Furthermore, many of the Fraser gravel reach islands which have biosolids applications in TFL 43 pulpwood plantation have the potential of being flooded during the spring, or are immediately adjacent to the active channels of the Fraser River, and the aquatic biota could be affected through freshet inundation or rain-runoff contamination (O. Langer, pers. com.). Thus, like other aspects associated with the management of TFL 43

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impacting the environment, the distribution of biosolids as a nutrient addition needs to be reviewed for its potential impact to the environment within the Heart of the Fraser. These activities need to be integrated into a larger management plan for the protection of the Fraser gravel reach.

Figure 3-5. Map of the Fraser Block of Tree Farm License 43.

Each "Area" designation refers to a portion of the Fraser Block TFL 43 which is managed for pulpwood production. Figure taken from Tree Farm License 43, March 1, 2000.

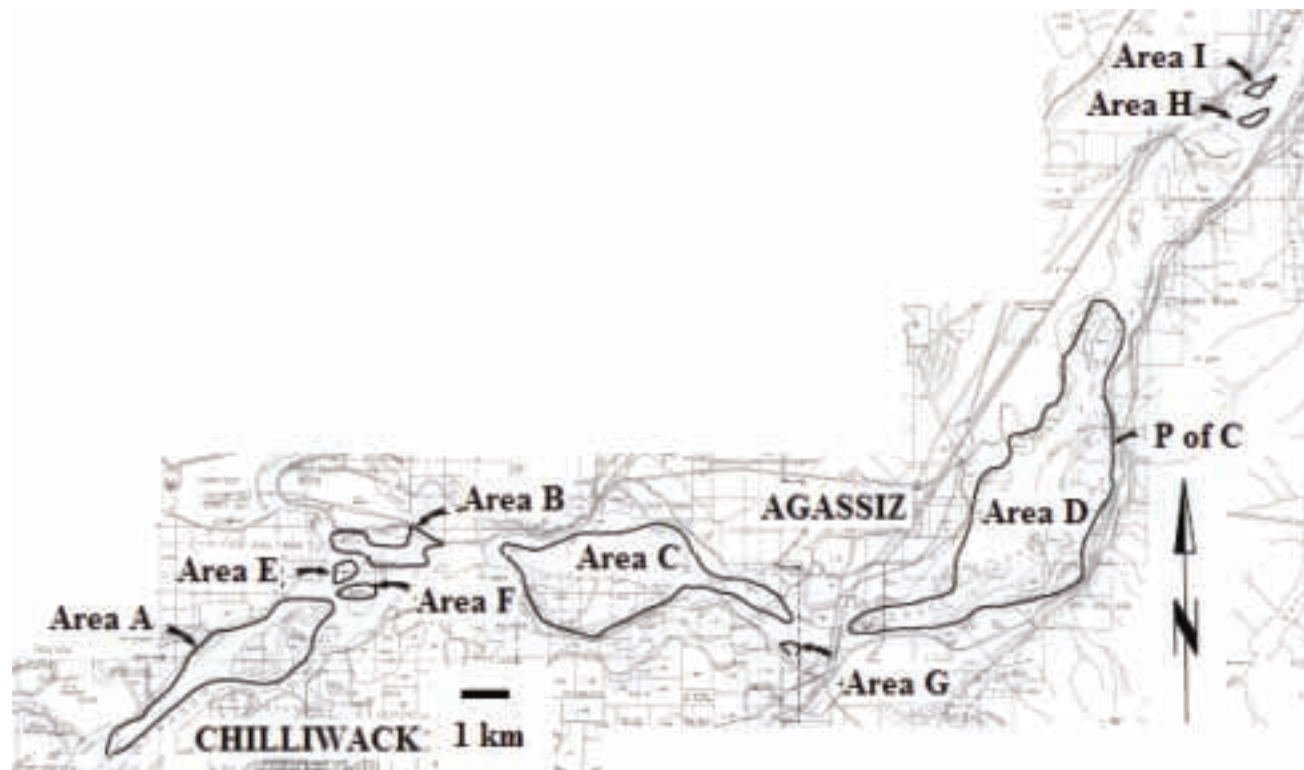


Figure 3-6. Pulpwood harvest on Tree Farm License 43 Island 8, 1995.

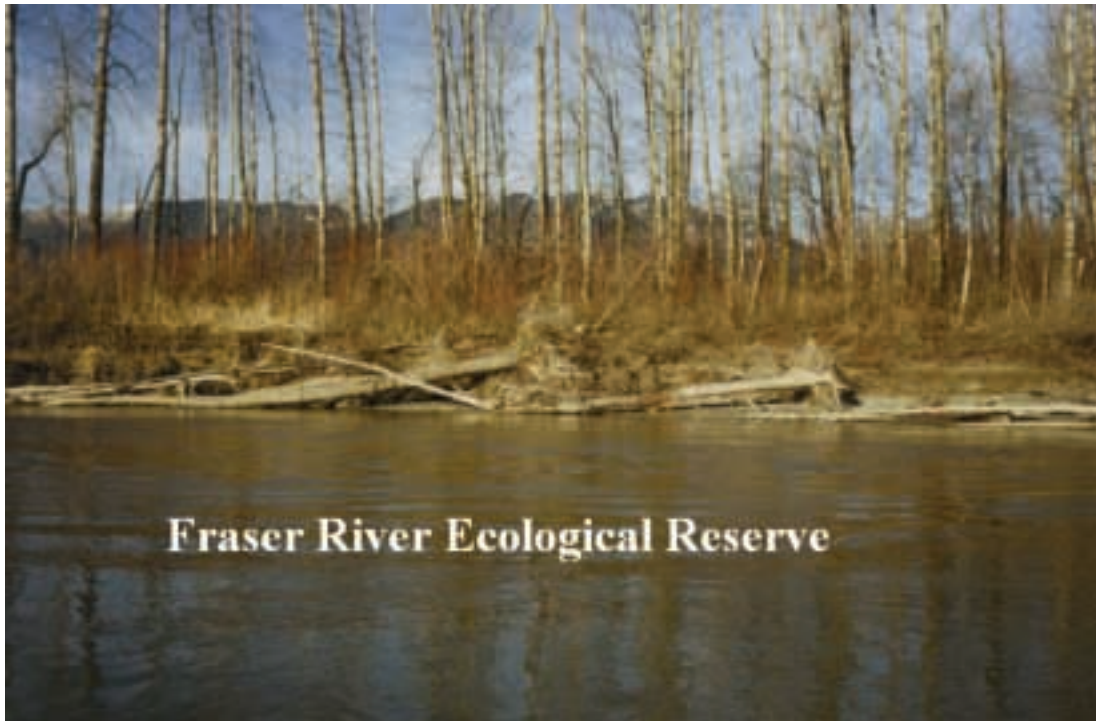
This island is located along the downstream end of Herrling Slough (Figure 1-5). Note the extent to which the trees were harvested to the perimeter of the banks of the island in 1995. By 2004 the outer stream bank had collapsed and riparian erosion was extensive—Figure 3-7 has a 2004 water view of the replanted island with its eroded banks.



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Figure 3-7. Monoculture plantation of young trees on pulpwood Island 8, 2004, (top) compared to the natural and unlogged vegetation in the Fraser River Ecological Reserve (bottom).

Top photo was taken during summer, bottom photo during winter. Note the lack of large woody debris and the small size of the trees along the perimeter of the bank of the recently planted pulpwood forest on Island 8 example; compare with the air photograph view in 1995 when this location was first logged. The erosion along the bank of the left photograph is extreme. In contrast, the large woody debris along the banks of the Ecological Reserve appears to buffer the extent of the bank erosion. Our observations are that for the gravel reach, the larger the pieces of woody debris, (i.e., "veteran" cottonwoods) which have the weight and a large root mass with which to "hang up" along the bank perimeter, the greater the chance of providing protection against erosion and complex instream habitat. Compare also with Figure 2-9, a natural cottonwood forest of mixed-age-class trees. Refer also to Gregory et al. (2003).



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Figure 3-8. Tree Farm License 43 Fraser Block land use allocation.

Adapted from Appendix 6–20 Year Plan, Minhas and Stenersen (1999). We point out as well that while the designated Environmentally Sensitive Area comprises less than 1% of the total land base (Figure 3-8), it is intuitively difficult to believe that in such a known bio-diverse habitat, the sensitive areas constitute such a small area (c.f., Summers 1994 appendix in Minhas and Stenersen 1999 Management Plan Number 4, and Appendix 4 of this report). We believe that the licensee and the British Columbia Ministry of Forests and Range have substantially underestimated this parameter for TFL 43.

**Figure 3-9.** Silviculture practices on Tree Farm License 43, Herrling Island.

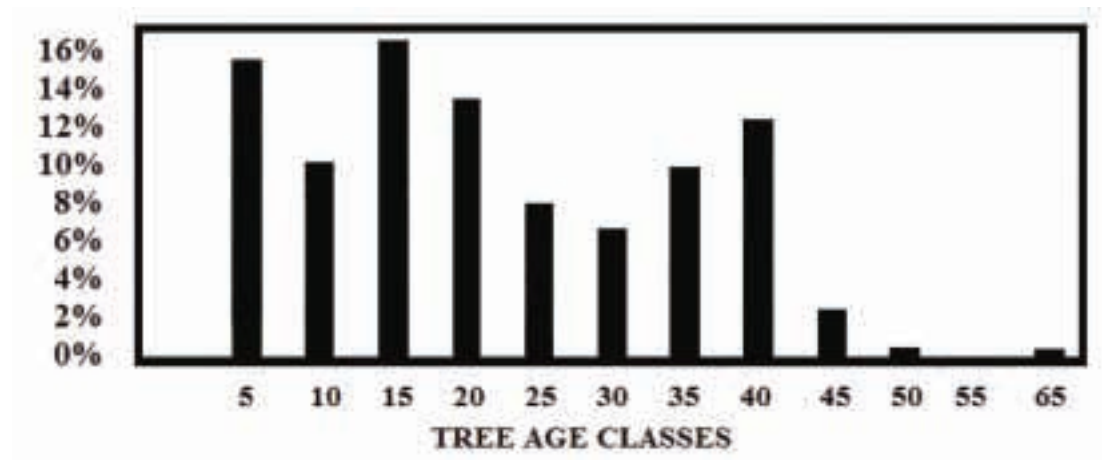
The Ministry of Forests and Range has given TFL 43 a variance on the maximum soil disturbance limits recommended in The Soil Conservation Guidebook TFL43 (Minhas and Stenersen 1999) despite objectives for maintaining biodiversity; this disturbance allowance is now 100% for the Lower Fraser Block. Biodiversity losses appear to be extensive under these types of land use practices. Photo D. Catt.



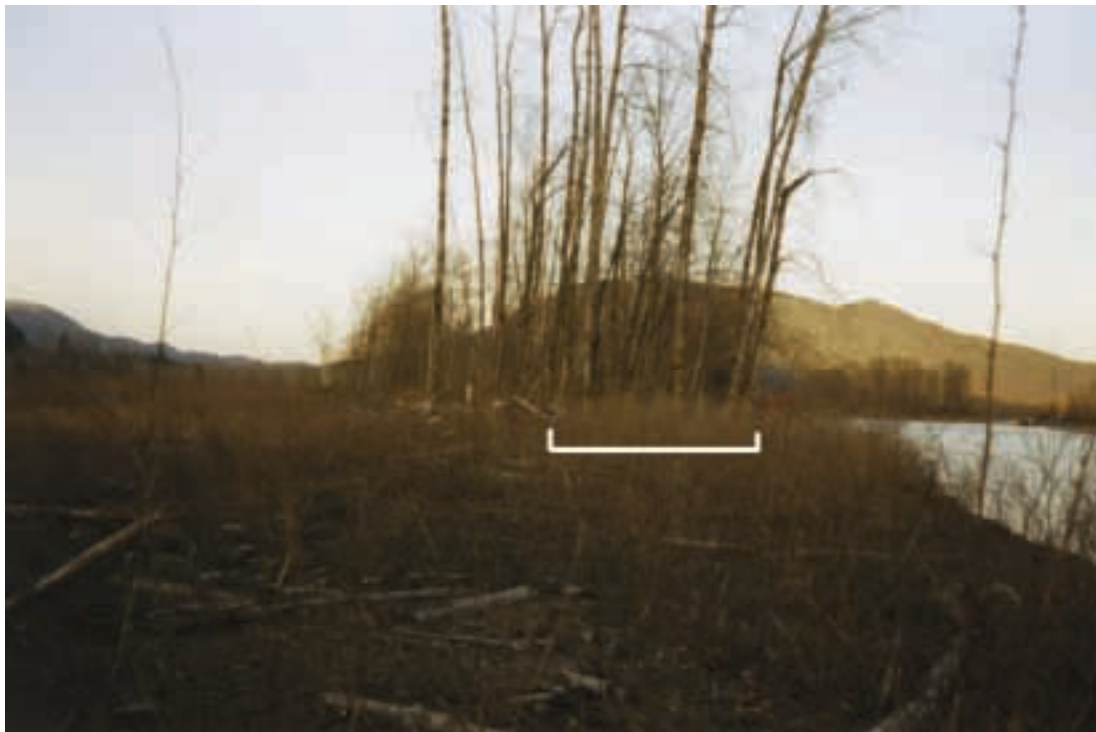
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Figure 3-10. Age class structure of the forest in Tree Farm License 43.

Adapted from Appendix 6-20 Year Plan, Minhas and Stenersen (1999).

**Figure 3-11.** Post-harvest riparian buffer zones in a pulpwood plantation on Island 17 of Tree Farm License 43 in the gravel reach of the Fraser River.

Consider that the width of the buffer does not even equal the height of the trees.



AGRICULTURE

The development of agriculture throughout the eastern Fraser Valley has caused the largest and most visible man-made impacts to the instream and riparian habitats of the Fraser gravel reach (Rosenau and Angelo 2005). The initial extent of farming activity on the floodplain included large-scale land clearing, development of a network of dikes (Figures 1-5, 2-2, 2-5), excavating of drainage ditches, construction of pump stations, land leveling, and conversion of the riparian and floodway vegetation communities into monoculture crops (Figure 2-17, 2-18, Rosenau and Angelo 2005). The losses of biodiversity and aquatic habitats in the Fraser gravel reach were immense and largely undocumented. Perhaps the single most damaging activity to these aquatic ecosystems that can be directly attributed to the development of agriculture was the draining of Sumas Lake; approximately 10,000 acres of highly-productive shallow lake and wetlands (expanding to 30,000 acres during Fraser River freshet), containing exceptional biodiversity (Orchard 1983), were diked and drained for cultivation (Rosenau and Angelo 2005).

Prior to the large flood and the consequent upgrading of the dikes shortly thereafter, the configuration of the floodway in the eastern Fraser Valley was largely defined. The current diking system now delineates those lands that are part of the floodway area (i.e., the river side of the dikes), and those which are protected (i.e., the landward side). For the most part, these dikes are built to withstand a discharge equal to, or exceeding, the great flood of 1894 (about 17,000 cubic meters per second flow at Hope) but were initially constructed to keep crops dry.

While considerable infrastructure (worth in the billions of dollars) now exists on the landwards side of the dike, development has been much more muted on the river side. Those properties developed outside of the dikes are now largely agricultural (Figure 2-17). Furthermore, despite the conversion of much of the area inside of the dikes to farmland around the turn of the twentieth century, large-scale clearing of the floodway lands on the river side of the dikes for agriculture did not progress as quickly and continued to occur throughout the 1970s and 1980s. Much of the clearing of natural riparian vegetation during this later time was on First Nations lands (e.g., Figure 3-12, 3-13). However, smaller non-First Nations properties continue to be affected as well even today (Figure 3-14).

A significant ongoing impact to the Fraser gravel reach ecosystem is that current agricultural practices on riparian land outside of the dikes in the Heart of the Fraser floodway largely fail to provide reasonable buffers where fields are adjacent to stream channels (Figures 2-5, 3-15). The removal of native vegetation and large trees, (Figures 2-9, 3-7), means that these bank-stabilizing features are no longer available to reduce the eroding forces of stream flow on the banks. Subsequently, many of these farmed fields along the main stream and side channels of the Fraser River must now be protected by armouring along the stream perimeter in order to prevent excessive erosion of the river banks into the farmers land. This bank-hardening activity further disrupts the fluvial processes that are necessary to maintain a healthy ecosystem in the Fraser gravel reach.

Another major issue impacting the river ecosystem is the number of large-scale removals of floodway farmland from the Agricultural Land Reserve. These areas have subsequently been rezoned for development into industrial properties. The Agricultural Land Reserve and its governing body, the Agricultural Land Commission (ALC), have existed since the mid 1970s with the intent of halting the conversion of agricultural landscapes into developed areas. Nevertheless, this institution has not completely stopped the agricultural land base from being converted to other uses, due to the exclusion opportunities allowed under the legislation. Furthermore, it has not stopped the known environmentally sensitive agricultural areas within the Fraser gravel reach from being developed (Rosenau and Angelo 2005).

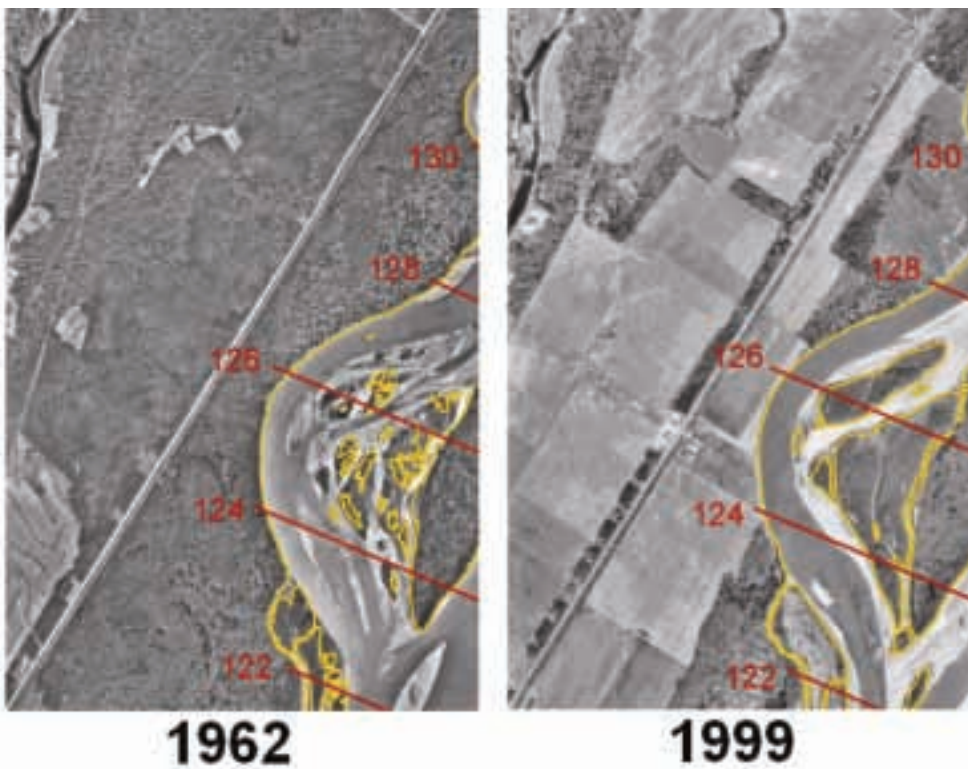
Since 1985, seven hundred hectares of land have been removed from the Agricultural Land Reserve in the Chilliwack area alone (Alexander *et al.* 2004). Some of these exclusions in the eastern Fraser Valley have had substantial riparian impacts including two large removals along floodway corridors—at Webster Road on the

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Vedder River, and Cannor Road on the Fraser River near the McGillivray ecological area (Figure 3-16, Rosenau and Angelo 2005). As the ALC does not have a mandate to protect ecosystems, high-value riparian areas will continue to be lost as a function of the Commission's removal of lowland areas from the Agricultural Land Reserve. This is primarily because floodplain properties that are considered by farmers and the ALC to have marginal agricultural values due to periodic inundation, but can be economically developed if they are floodproofed, are areas with the highest environmental values.

Figure 3-12. A comparison of change in riparian intactness at Seabird Island in the upper gravel reach, 1962 versus 1999, due to land clearing for agriculture.

Note the extensive vegetation removal to the water's edge for agriculture (without leaving a stream-side buffer zone) in the 1999 photo. Figures taken from Church and Ham (2004) atlas of the Fraser River gravel reach; red numbers and lines denote Church and Ham (2004) river-cross sections and do not represent river kilometres while yellow lines represent bank lines from previous air-photo comparison of the same report.



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Figure 3-13. Changes to the land use between Chilliwack and Shefford sloughs on a large riparian area outside of the dikes in the gravel reach of the Fraser River near Chilliwack over a 50 year period.

Most of this land was initially cleared for agriculture, but other land uses became prevalent once the vegetation was removed. Air photos taken from Church and Ham (2004).

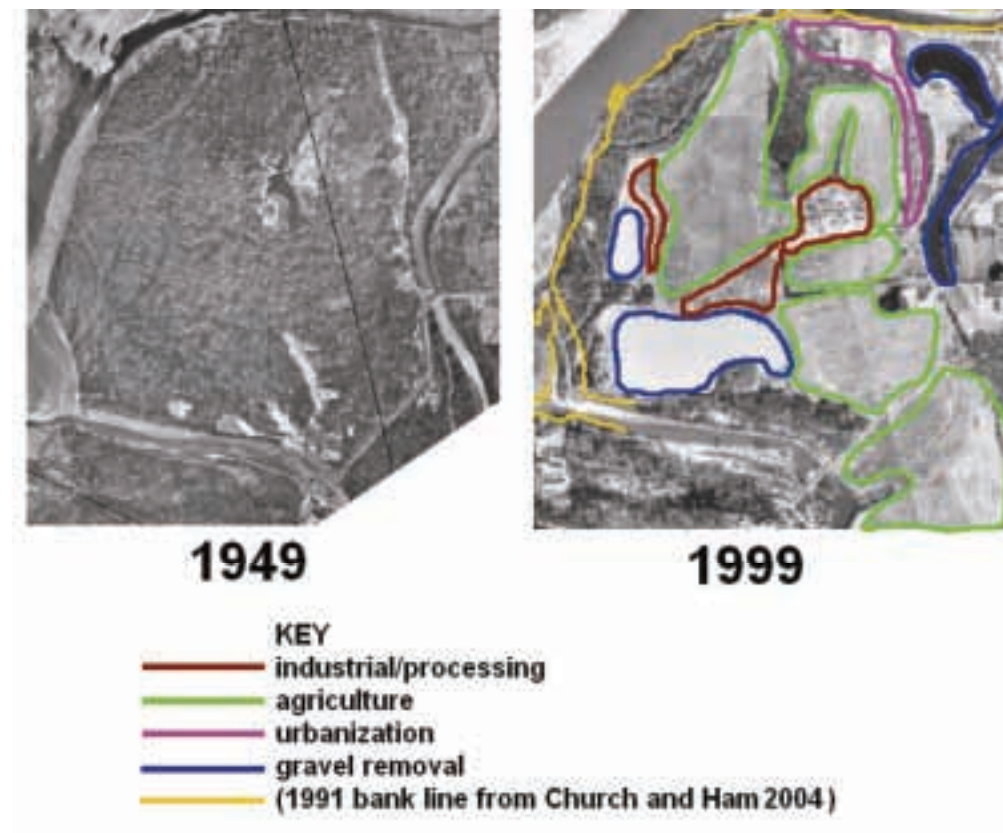


Figure 3-14. Recent clearing of floodway farmland near Chilliwack.



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Figure 3-15. Riparian area has been largely cleared of natural vegetation in farmed landscapes near Agassiz (top) and Chilliwack (bottom).

Failure to provide riparian buffers is common amongst most agricultural properties that are adjacent to the Fraser River's stream channels within the Heart of the Fraser.



Figure 3-16. Land development at Cannor Road near Chilliwack destroyed ephemeral wetland and riparian areas. *This area was converted from disturbed, but functioning, riparian habitats (the farm land component was removed from the ALR) to a flood-proofed and diked industrial park. Photo D. Catt.*



FLOOD PROTECTION, BANK ARMOURING AND THEIR IMPACT ON RIPARIAN AREAS

DIKES

The isolation of the floodwaters from normally inundated landscapes greatly alters those ecosystems that are adapted to the expectation of flooding. This has occurred in a major way in the Fraser gravel reach since large-scale settlement began to occur in the eastern Fraser Valley.

The legislative basis for the operation and maintenance of public dikes in British Columbia is the *Dike Maintenance Act*. Other legislation affecting the management of dikes includes the *Drainage, Ditch and Dike Act* and the *Local Government Act* which allows local governments to undertake diking and drainage through local bylaws and Improvement Districts. There are a number of regulatory organizations with responsibility for aspects of the operation and maintenance of floodway dikes within the gravel reach. In this area of the Fraser River it is generally the local authorities who own and are responsible for the upkeep of these structures. Provincial responsibility, and general supervision relating to the construction and maintenance of these dikes, lies with the office of the British Columbia Inspector of Dikes who also delivers the provincial Dike Safety Program. Activities undertaken by the provincial diking authorities include approval of all works in and about dikes, joint inspections to monitor and audit the owner's dike management program, and the power to issue orders to protect public safety.

Ham (2005) reports that there are currently 130 kilometres of dikes in the gravel reach of the Fraser River. If one includes the former Sumas Lake and network of flood channels where the Fraser and Chilliwack rivers previously connected, it is clear that over 90% of the historic floodplain has been isolated due to diking in the eastern Fraser

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Valley (Figure 1-5). This does not mean that all riparian habitats have been lost in the gravel reach, however. For much of the remaining undiked floodplain, with the occasional exception (Figure 2-7; Island 22 wing dike), the dikes are set back some distance from the margins of the active main stream channel such that they do not completely interfere with all of the morphologic development of the river (Ham 2005).

To keep the land dry for development and agriculture throughout the Fraser gravel reach floodplains, an extensive array of dikes has been constructed since the late 1880s (Ellis *et al.* 2004, Rosenau and Angelo 2005; Figures 1-5, 2-2, Appendix 5). The first farmers in the area built small dikes along their properties to prevent or minimize inundation in order to protect crops and fields from spring floods (Sewell 1965). In 1903, large-scale dike building started and continued on throughout the twentieth century, isolating large areas of floodplain and disrupting the ecological integrity of the area (Figure 1-5).

Upgrades to the existing Fraser gravel reach floodway dikes again occurred immediately after the 1948 flood. This activity was expanded even further following from the 1968 intergovernmental agreement for dike extension and improvement (Lyle 2001). The Federal-Provincial Flood Control Agreement established and rehabilitated the network of dikes that protects most of the Fraser Valley floodplain, of which the floodway of the Heart of the Fraser, is a sub-set of this land located on the river side of the dikes. In total, almost 250 kilometres of dikes were reconstructed under this program between 1968 and 1994 for the lower Fraser River between Hope and Vancouver. In some areas, the program also provided pumping capacity and drains to prevent flooding behind dykes as a result of local runoff. This system is designed to protect against flooding for discharges equivalent to the highest flows of record which potentially can occur during spring snowmelt runoff.

Over the past 10 years there have continued to be numerous upgrades to Fraser River dikes in the Chilliwack area subsequent to hydraulic modelling that indicated flood-capacity deficiencies (Figure 3-17). The results of more recent hydraulic models, released in late 2006, suggest that the dikes between Georgia Strait and Agassiz are still deficient in a number of places (Fraser Basin Council news release November 14, 2006) and upgrades were suggested.

The era of dike building within the gravel reach is not yet completed, and most of the existing infrastructure seems to be here to stay. A number of recent projects have had significant impacts on the riparian area, and new projects are still being proposed which will continue to affect the ecological integrity of the reach.

An example of a recently completed and environmentally negative project is the construction of a large wing dike built in 1990 along the northern and eastern perimeter of Island 22 (Figure 1-5, 2-7; Appendix 5). This dike and the subsequent development of camping and boat-launch facilities in the newly-designated parkland on Island 22, disrupting local hydraulics, isolating flood channels, and even increasing the flood elevation in adjacent upstream parts of the main diking system.

Because this dike was poorly aligned, the main stream of the Fraser River is now encroaching on the toe of this structure as a result of natural channel re-alignment and lateral stream erosion. As a result of the loss to the integrity of the wing dike at Island 22, new flood-protection arrangements are now being proposed for the area that will further destroy its riparian viability. One of the more elaborate proposals includes the construction of a dam and pump station across in an adjacent side channel (Shefford Slough) and a large expansion of dikes, with its attendant loss of habitat and biodiversity.

Another new large diking project that is not part of the historic flood-protection scheme, which has recently isolated a substantial part of the floodplain, is now being constructed at Cannor Road, Chilliwack, for the development of a large industrial park within the riparian areas of the Fraser River (Figures 1-5, 3-16). This dike and the associated floodproofing, which are being completed as this report is being written, has not only destroyed a large ephemeral wetland (Figure 2-4), but increased the flood elevation in the main flow pathway by

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constricting the floodway. The dikes at this industrial area (Figure 3-16) will ensure that the local riparian zones will never again be inundated by the Fraser River's spring freshets, and this aspect of the aquatic ecosystem of the area has now been completely lost.

There continues to be a loss of flow capacity and aquatic biological values of the Heart of the Fraser through the continuing development of new dikes and the ever-constant constraining of the floodway, despite the widespread recognition of the consequences (Lyle 2001). For example, as early as 1966 the Official Regional Plan of the lower mainland decreed that there should be no new building in areas that comprised elevations that would be inundated by a 1:200 year return flood, and federal money to support the strengthening and raising of existing dikes, to protect existing infrastructure, was contingent on this restriction. Nevertheless, over time this policy has been largely ignored and development has since continued to occur extensively on the Heart of the Fraser floodplain (Lyle 2001).

Figure 3-17. Fraser gravel reach dike-elevation upgrades 2007.

Photo from British Columbia Ministry of Environment web page. Photo D. Catt.



BANK ARMOURING

An extremely destructive activity affecting the proper functioning condition of the Fraser gravel reach has been the extensive armouring of its stream banks. Bank hardening, or armouring, to stop erosion along a stream perimeter is often accomplished using blasted rock (rip rap), wooden pilings, waste-concrete or engineered structures (Figure 2-18). This hardening of its banks prevents the river from moving laterally, thus interfering with the storage of sediments throughout the reach (Ham 2005) and preventing habitat renewal and maintenance (e.g., recruitment of woody debris, cleaning and sorting spawning gravel, scouring holding areas). The negative effects of rip rap on fish populations have been catalogued by Knudsen and Dilley (1987), Shields (1991), and Schmetterling *et al.* (2001).

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Bank armouring of the gravel reach could be considered equivalent to arteriosclerosis of the Heart of the Fraser. Indeed, the effect of rip-rap is so insidious and destructive that it is the view of some experienced habitat biologists that it should be classed as a deleterious substance under the Canada *Fisheries Act* (O. Langer, pers. com.).

The construction of bank-protection structures within the gravel reach dates back to 1892 when brush and rock were sunk along wood pilings to limit erosion at Miller's Landing near Sumas (Public Works Canada 1949, cited in Ham 2005). By 1914, other structures had also been built at Sumas, Matsqui, Chilliwack and Nicomen Island but with little success in staving off bank losses (Ham 2005). With contributions from the federal government after the 1920s, bank protection in the gravel reach increased substantially (Winter 1966). The signing of the 1968 Federal-Provincial Flood Control Agreement led to a rapid increase in activity, including large-scale bank armouring of the Fraser gravel reach.

Currently, in order to prevent loss of land and ensure that the river does not undermine and destroy the flood-protection dikes or other infrastructure, more than half of the outer banks of the Fraser River have been hardened in one form or another in the various sub-reaches between Hope and Mission (Table 2-3; Figure 2-18). The armouring ranges from 54% in the Hope sub-reach, to a remarkable 73% in the Sumas sub-reach (Table 2-3; Figure 2-2, Ham 2005).

In addition to protecting the land base from losses to erosion, a significant amount of rip rapping was put in place in the gravel reach to protect facilities and infrastructure from damage. This includes the Agassiz-Rosedale Bridge, powerline crossings, and gas, oil and water pipelines. By the early part of the twentieth century, rail lines had also contributed substantially to bank armouring. This bank protection is important to ensure the transportation system and economic link between the Pacific ports and the rest of Canada is not disrupted due to river erosion.

While most of the extensive bank hardening within the gravel reach had already been put in place by 1990, this activity continues to occur in locations that are of interest to protect infrastructure (e.g., Ward 1996, Rempel and Perrin 2002). For example, Island 32 on the south bank of the river near the Agassiz-Rosedale bridge was extensively rip rapped to halt the erosion of its banks as recently as within the last decade (Figure 3-18). No significant mitigation or compensation was ever provided for the habitat losses of this formerly natural bank. Ironically, only a few years earlier it had been clearcut-logged for pulpwood, and the lack of intact vegetation and woody debris may have contributed to the acceleration of its erosion.

Another recent example where large losses of natural bank occurred due to bank hardening, and without any significant compensation for losses of fluvial-processes, occurred in the winter 2003 in the upper Fraser gravel reach. Almost one kilometre of bank line was hardened at Peters Island, primarily for the protection of a hydro-electric transmission line, but also to maintain the land base. Rempel and Perrin (2002) found significant fish-rearing within the immediate area that was to be rip-rapped (Peters Island). As part of the mitigation there was an attempt to restore the stream-bed channel morphology (shape) and substrate composition (gravel and cobbles) after the rip-rap was put in place. It is not clear if this mitigation was successful in maintaining the *in situ* fish habitat. However, the more important facet of this circumstance is that the key fluvial processes of river meander and lateral erosion were neither mitigated nor compensated, in any substantive way.

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Figure 3-18. Examples of bank armouring along the Fraser River in the gravel reach.

Top: extremely large riprap protecting hydro-electric towers near Agassiz; Bottom: demolition waste near Island 22.



IN-RIVER GRAVEL REMOVAL

One of the most contentious activities affecting habitat in the Fraser gravel reach over the last several years has been the removal of aggregate from the active-channel areas for the purpose of flood protection (Figure 3-19 to 3-23). Prior to this, gravel removal in the Fraser River took place for the sole purpose of obtaining construction aggregate and this occurred for many decades starting around the 1950's. Annual extractions from the active channel of the Fraser gravel reach averaged just over 100,000 cubic metres over the latter half of the twentieth century (Weatherly and Church 1999).

With the acceleration of land development in the lower mainland of British Columbia in recent years, and the demand for aggregate in construction, increasing amounts of material had been excavated from the active channel. Fraser River gravel has been a ready and easy source of aggregate for the industry (Weatherly and Church 1999).

Due to rising environmental concerns in the 1990's, mining of the Fraser River solely for aggregate purposes became constrained by Fisheries and Oceans Canada (Figure 3-1). At that same time, during two above-average freshet years—1997 and 1999—hydraulic modeling and assessments of the Fraser gravel reach flood profile indicated that for this area the diking system was deficient in meeting the 1968 design criteria (c.a. 17,000 cubic metres per second of flow at Hope) (UMA 2000, 2001). It was suspected that the material that has recently been depositing in the middle sub-reaches (Agassiz to Chilliwack) caused these freeboard deficiencies (i.e., the active channel floodway might be filling up with sediment). Because of habitat concerns surrounding proposed large-scale gravel removal for flood protection, a partial moratorium for aggregate extraction within the Heart of the Fraser was put in effect while technical issues were being studied. This included assessments of the channel morphology, rate of gravel recruitment and deposition/erosion of sediments (Church *et al.* 2001, Ham and Church 2003, Ellis *et al.* 2004, Ham 2005), fish utilization (Rempel 2004), development of hydraulics profiles associated with bed level and channel alignment changes (UMA 2000, 2001, 2002, 2004), and habitat impacts associated with the use of gravel removal for flood protection (Rempel 2004).

The results of these studies indicated that gravel was depositing into the active floodplain of the Fraser River downstream of the Agassiz-Rosedale bridge at an annual rate of around 170,000 cubic metres per annum (Ham and Church 2003). Despite the net deposition of larger classes of material, the net sedimentation was approximately neutral when all size classes of material at all locations, (i.e., including the sand and clays on banks and islands) was considered (Figure 2-13; Ham and Church 2002). That is, contrary to what many believe, the Fraser gravel reach is not filling up with sediment. This net-zero change in floodway deposition from 1952-1999 appears to have occurred because there has been a deficit (erosion) of material smaller than gravel and this has largely counterbalanced the deposition volumes of the larger gravel fractions. Thus, the reach is roughly in equilibrium in regards to erosion/deposition when all sediment fractions are considered (Figure 2-13). The loss of small-sized particles from over-banks and islands was especially prevalent between 1952 and the early 1980s (Figure 2-13; Ham and Church 2002, 2003) before extensive armouring of the banks occurred as a result of the Federal-Provincial Flood Control Agreement of 1968.

It is also important to realize that the net gravel recruitment into the uppermost sections at the head of the Fraser gravel reach (Seabird Island, Laidlaw) has actually been negative since 1952 (c.a., 4 million cubic meters), bringing into question the origin of the gravel depositing between Agassiz-Rosedale bridge and the confluence of the Harrison River, the area where the deposition of this size fraction appears to be most prevalent (Ham and Church 2003) and issues surrounding flood protection have received their greatest public profile. In other words, the material that recently depositing in the middle part of the Fraser gravel reach may simply be due to an episodic event that may not be repeated again for decades or centuries. Rigorous and routine monitoring could help to determine the origin of this inconsistency with regards to the general concept that the Fraser gravel reach is aggrading. Bi-annual surveys could provide valuable information.

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While the information surrounding deposition and erosion of the various classes of sediments, at least downstream of the Agassiz bridge, has become better understood as a result of the many studies that were conducted during and around the period of the partial moratorium, the role of sand, gravel and other sediments in increasing the flood profile has also been assessed. This has not been a particularly easy task because the floodway of the Fraser gravel reach is wide and the effects of sedimentation on the flood profile are often confounded by the alignment (direction of flow) of the river.

For example, the UMA (2002, 2004) studies demonstrated that a significant change in river alignment around 1972 near the confluence of the Fraser with the Harrison River had a profound effect, within this sub-reach, on the water-surface elevation relative to the design elevation of the dikes which were upgraded in 1968 independent of sedimentation. The main channel of the Fraser River at this location changed its direction dramatically, partly as a result of an avulsion that was the effect of the larger-than-normal 1972 flood (Church and Weatherly 1998, Church and Ham 2004). In this example, the re-alignment of the stream reduced the capacity of the river to easily convey water due to the new right-angle direction of the stream configuration, thus increasing the flood profile at upstream areas regardless of any sediment deposition or erosion that may have occurred at or near this site (UMA 2002, 2004). Importantly, these studies also showed that, except for a small number of specific locations, the change in water surface elevation due to sediment deposition was largely trivial (mostly less than 10 centimetres) over the Agassiz to Mission sub-reach (UMA 2002, 2004).

Following the lifting of the moratorium, habitat impacts arising from gravel removal were also the topic of some considerable discussion particularly regarding the magnitude and duration of the effects of aggregate mining (c.f., Rempel 2004). Gravel removal from within the active stream channel of the Heart of the Fraser usually takes place during the low-flow winter months of the year so work is normally conducted outside of the wetted perimeter of the stream. The aggregate is usually extracted in the dry from gravel bars which at other times of the year are normally wetted and, in particular, at least some of the time during the freshet months. While these bars are not fish habitat when they are dry, they are extensively used during the high-flow events (Rosenau and Angelo 2000, Rempel 2004). Furthermore, large side channels have been increasingly targeted by the gravel mining because the large, easily accessible gravel bars have generally disappeared in the wake of continuing extractions. The channels are the only known habitats in the mid-gravel reach for sturgeon spawning that occurs during high freshet flows when these channels, which are almost or completely dry in the winter, are wetted (Perrin *et al.* 2003).

The impacts to fish and fish habitat in the Fraser River gravel reach through extensive bar scalping (surface removal) and instream extraction techniques include an increase in mobilization of fine sediments which smother aquatic life as a result of removal of the coarser, and cleaner, outer layers of gravel and cobble during or immediately after the excavation phase. Another impact is the removal of the less-common coarser fractions of gravel and cobble from the surface of the stream bed which are preferentially used by some important species (e.g., juvenile Chinook salmon) as rearing habitat (Rosenau and Angelo 2000). Another is the lowering of the surface elevation of the large gravel bars resulting in losses of the relatively rarer high-elevation freshet rearing habitats (Rosenau and Angelo 2000). Fish are also affected by the disruption of the normal fluvial processes of bar and island building on which a component of the river's biodiversity is dependant because large gravel bars are a particularly rare habitat feature in the Fraser gravel reach and as the gravel mining has been deliberately targeting these features over the last several decades they are becoming even rarer. A further impact is in the destabilizing of the stream in the local area which can result in fish mortalities and habitat losses. The bar scalping and instream extraction too often target high-habitat value locations such as side channels (e.g., white sturgeon appear to selectively use coarse, stable, substrates in the gravel reach's side channels—Minto, Greyell, Herrling channels—for reproduction Perrin *et al.* 2003) and reduce local recruitment of the gravel that is important for spawning and rearing.

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Government agencies moved forward with a five-year gravel removal agreement for the Heart of the Fraser in 2003 based largely on historical aggradation rates of the gravel fraction. This agreement was written to allow extractions of 500,000 cubic metres of gravel from the Heart of the Fraser in each of 2004 and 2005, and 420,000 cubic metres for the subsequent three years. When the agreement was put into effect, large-scale gravel mining began to be undertaken at a number of sites in the gravel reach.

Ultimately in several instances, it appears that the gravel extractions have provided little benefit for flood control. Hydraulic models have shown that the water-surface flood profile changes have been trivial as a function of these removals (generally less than 15 centimetres for up to 4.2 million cubic meters of gravel removed; Northwest Hydraulic Consultants 2004, 2007; “Dredging won’t reduce flood risk, report says”, Vancouver Sun, June 11, 2007). Moreover, as a result of some of these extractions, there were large fish kills at one or more of the locations where channels were dewatered to gain access to extraction sites (Figures 2-22, 3-23). Furthermore, the ecological inventory of habitat values and impacts and the follow-up assessments appeared to be limited and uncoordinated (O. Langer, pers. com.) and a clear understanding of the effects is still unknown.

It is interesting to note that the gravel extractions of 2004, 2005, and 2006 did not reach the agreed-upon target volumes during these years. This is possibly because there are simply not enough opportunities in the Fraser gravel reach in the form of large, dry bars in the winter that are available for scalping (c.f., Northwest Hydraulic Consultants 2004, 2007).

In summary, the recent multi-agency agreement to remove gravel for flood protection on the Fraser gravel reach has been largely ineffective from either engineering or biological perspectives. At specific locations and under certain justified circumstances, it may be appropriate to remove sediment for flood protection in streams. For this to occur there needs to be technically rigorous and routine assessments of sediment deposition, relative to extractions, and hydraulic modeling to demonstrate net overall benefits of lowering the flood profile. Similarly, these type of analyses need to be undertaken when removing gravel from streams to provide erosion protection. In addition, where gravel removal for flood control purposes is warranted, these extractions should be timed to avoid disrupting developing pink salmon eggs, and easily done given that pink salmon only spawn in odd numbered years in the Fraser River. As well other mitigation methods should be examined to conserve fish and fish habitat.

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Figure 3-19. Experimental removal of gravel from Harrison Bar, February 2000.

For this excavation, vehicles and equipment were barged onto the bar and the removal was undertaken in the dry. Aggregate was moved onto the mainland via a conveyor for further processing (Figure 3-20). Extensive monitoring of physical and biological impacts took place during this extraction in an attempt to determine impacts.

**Figure 3-20.** Transport of gravel excavated from Harrison Bar to the mainland across Minto Channel, February 2000.

All of the work was conducted in the dry for this particular extraction. Compare with Figure 3-23.



Figure 3-21. Large-scale gravel removal from the Fraser River, 2006.

This project resulted in the mortality of several million pink salmon alevins when a large causeway built to access the gravel largely dewatered a natural spawning channel (foreground), stranding these fish (Figures 3-22, 3-23).

**Figure 3-22.** Mortalities of pink salmon alevins at Big Bar that died as a result of the extensive dewatering of a side channel to access an island for gravel extraction.

Figure 2-22 shows the extent of the dewatering. Figure 3-23 shows the causeway that resulted in the dewatering.

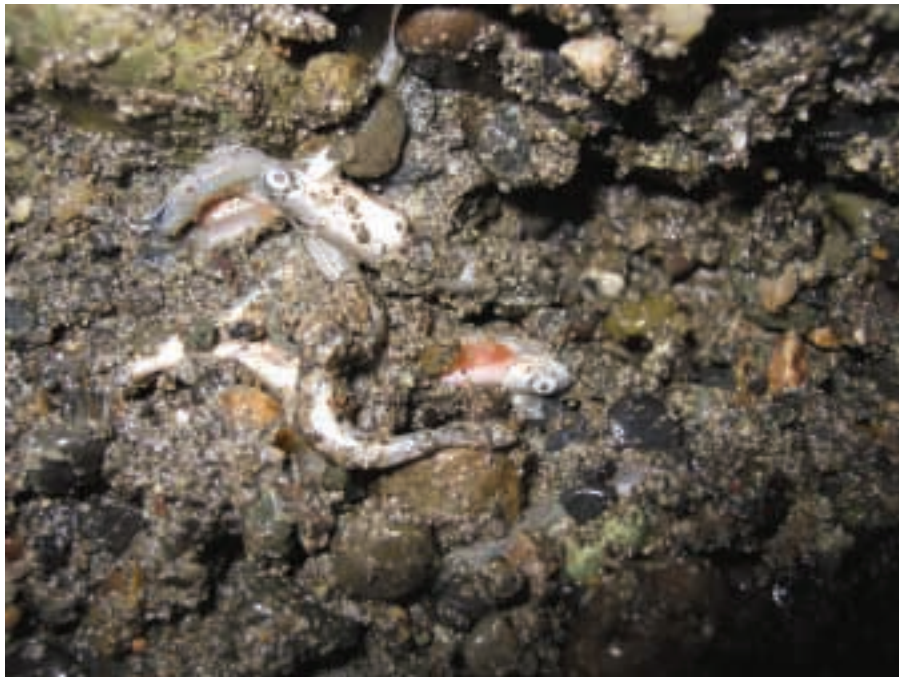


Figure 3-23. Large causeway built to access gravel at Big Bar Island.

The lack of a flow-through structure resulted in about 80% of the water being diverted from the side channel to the main stream and several million alevins died as a result of the dewatering. Compare with Figure 3-20. Figure 2-22 shows the extent of the dewatering.



LAND DEVELOPMENT

The opportunities for development of property outside of the dikes in the active floodplain of the gravel reach of the Fraser River are normally limited due to the potential damage to facilities and infrastructure by freshet flooding. It is usually not economic to spend money on a building, for example, that will annually be at risk of damage by floodwaters; insurance companies are reluctant to provide coverage for such vulnerable investments. Furthermore, provincial and local regulations generally prohibit such development, or require developers to implement certain measures to protect buildings and human inhabitants from damage or harm (e.g., City of Chilliwack floodplain management bylaw guide for residential construction—Appendix 6). These measures can include the development of dikes to surround and protect the property (Figure 3-17), or floodproofing (Figures 3-24, 3-25) which constitutes raising the buildings above design flood level by constructing them on fill to a height equal to or greater than a specified hydraulic profile requirement. Both floodproofing and diking tend to be costly for projects larger than a single-family dwelling and, until recently, have been limited in scope over large areas of the Fraser gravel reach.

Another major limiting factor to floodway development within the Heart of the Fraser has been the designation of much of this land as agricultural and, therefore, is within the Agricultural Land Reserve; development is not generally allowed in such landscapes. As discussed earlier in this report, the primary incentive for European

3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

settlers to settle in the Fraser gravel reach floodway was the richness of the soils and the lush crops that could be grown in the riparian areas. Most of the land close to the river but outside of the dikes is exceptional for farming, flooding excepted. Nevertheless, in recent years there have been large-scale removals of agricultural land in the eastern Fraser Valley due to the intense pressure for land development for other purposes (Figures 2-4, 3-16, 3-25, 3-26).

Another issue surrounding increased development in the riparian area includes the extensive land holdings of First Nations within the active floodplain of the Fraser gravel reach. Many of these properties are currently undiked. Moreover, many of these communities have large areas of the remaining ecologically sensitive lands within the Heart of the Fraser. These are now increasingly being developed, or coming under pressure for extensive diking and development (Figure 3-13). For First Nations, opportunities for land to develop have generally been limited due to the legal issues surrounding property ownership. This is changing rapidly, however, as populations of First Nations in the area expand in size and economic development becomes an important component of these communities (Figures 3-12, 3-13).

Finally, as property values increase and land becomes scarcer in the eastern Fraser Valley, there is more incentive to take floodway land and convert it into developed property regardless of its current ecological value or agricultural designation. Local governments in the gravel reach have generally supported the view that the riparian areas within the Heart of the Fraser are good places to develop land and an opportunity to expand business if flooding risk could be eliminated (Figures 3-25, 3-26, 3-27); this position comes at the expense of the ecological values of the Fraser River. Because local governments have zoning as their primary responsibility and are key to the ultimate use of the land, it is crucial for them and the public they represent to understand the full consequences (and long-term costs) of any decisions to interrupt these sensitive and rare landscapes.

Figure 3-24. Recent development of First Nations houses in the unprotected floodplain and riparian areas of the gravel reach.

These properties are immediately adjacent to the western portion of Island 22 and are only several hundred metres from the main stem of the Fraser River; these houses are unprotected by dikes and, while the foreground building (right) is flood-proofed by being constructed upon a layer of fill having an elevation equal to or greater than the engineering requirements for the local area, the far building is not. Photo D. Catt.



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Figure 3-25. Floodproofing of a low-lying former ephemeral wetland area of the Fraser River gravel reach.

This area was formerly connected to the site pictured in Figure 2-4, and was an exceptionally biologically rich wetland, which was first diked (Figure 3-16) and isolated from normal freshet inundation. In response to concerns from the Ministry of Environment, Lands and Parks that it be removed from the Agricultural Land Reserve, the Agricultural Land Commission's comment was that "...as long as the land is undyked, it has limited suitability for agriculture—thus in the context of community planning, some of it may not be worth retaining in the ALR, especially if another use might relieve pressure elsewhere in the community on land more highly suited to agriculture."



3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Figure 3-26. The property delineated by the white line (top photo) was largely zoned agricultural before being removed by the Agricultural Land Commission and developed for industry over the last five years (bottom photo).

See also Figures 2-4, 3-17, 3-25 for various views of this property. Aside from the footprint impacts, the disruption of the continuity of the riparian comprises a serious impact arising from this project. Photo D. Catt.



3.0 CURRENT IMPACTS TO THE HEART OF THE FRASER

Figure 3-27. Proposed plans for waterfront development at the lower end of the Heart of the Fraser.
Note lack of natural riparian values or connections. Figure from the City of Mission website.



4.0 DISCUSSION

Jared Diamond's recent and acclaimed book, *Collapse: How Societies Choose to Fail or Succeed* (Diamond 2005), provides numerous stark examples throughout the history of mankind where communities vanished because they failed to properly manage and protect the surrounding environments upon which they depended for survival. In some cases, the cultures that disappeared did not understand the linkages between ecological misuse and their ultimate survival. Their disappearance was a consequence of this ignorance. In other instances, it appears that the people knew full well what needed to be done to remain sustainable, yet they neglected to take corrective actions because of a lack of economic constraints and political or social will. They, as well as the others, disappeared or were forced to move on.

The latter, highly pathological, behaviour appears to be endemic to today's culture if one takes the recent flurry of environmental articles in the popular and scientific press regarding climate change, over fishing, land clearing, and other impacts to our planet's ecology as barometers of a cavalier attitude that many humans and communities have adopted. Closer to home for the landscape-area encompassed by the Heart of the Fraser, British Columbians know enough about ecosystem management to recognize the need to stave off unsustainable resource exploitation, but this understanding is not matched by behaviour, perhaps a vivid example of Diamond's second, self-immolating category.

To paraphrase former United States Vice President Al Gore, it is an inconvenient truth that not only has much of the greatest aquatic ecosystem in Western Canada already been extensively damaged through destructive land-use practices, what remains of the Heart of the Fraser continues to disappear because British Columbia, as a society, has yet to change its ways. This continuing denial of what everyone knows to be necessary change is irresponsible. As long as the remaining floodway portions of the Heart of the Fraser continue to be viewed as a place to purchase cheap land for develop, to keep clearing riparian areas to expand agriculture, to install more diking systems, to increasingly armour banks and disrupt fluvial processes, to remove gravel unsustainably for little flood-protection benefit, and to mechanically and chemically disturb the floodway islands to grow pulpwood, little will remain for future generations of British Columbians and Canadians.

The key and conflicting element to the sustainability of floodplains such as the Heart of the Fraser is that ecological maintenance can only be achieved if a reasonable extent of flooding is allowed to occur. Brown (2002) noted that: "...[h]uman activities [in floodplains] cannot be sustained where serious damage from flooding can be expected. Thus, measures to prevent flooding are often undertaken and, in doing so, the floodplain ecosystem is usually destroyed. In a developed floodplain, social pressures exceed environmental concerns and few viable options to maintain or regain lost fish habitats are available. On an undeveloped floodplain, consideration can be given to limiting activities to those that are consistent with maintaining natural systems." Although there are numerous opportunities for taking non-structural approaches to flood protection (e.g., widen areas between dikes, keep development out of floodways) on the Fraser River gravel reach, and across Canada, new flood structures (e.g., dikes) continue to be built throughout this country (Lyle 2001) and in the Fraser gravel reach to the detriment of aquatic ecosystems and the jeopardy of public health and safety.

The underlying cause of these destructive attitudes follows from the fact that there are few monetary incentives to protect this ecosystem in the face of individual ownership and the prospect of immediate financial benefits to the local economy. Indeed, the nature of the development that is now occurring within the Fraser gravel reach is that once expenditures are made to construct better flood-protection infrastructure in the form of dikes, pumphouses, armoured stream-banks and, thus, protect even more land and buildings from flooding, increasingly more unprotected development occurs requiring even more protection. Diamond (2005) describes this phenomenon as autocatalytic, where the downward spiral of ecosystem destruction is based on the economic, social and political

need to destroy even more of it. Similarly, Lyle (2001) in her thesis entitled *Non-Structural Flood Management Solutions for the Lower Fraser Valley British Columbia* uses the term “serial engineering” to describe the phenomena of the accelerating need for increased flood protection following increases in land development in floodplains, to the detriment of the riparian and aquatic ecosystems, such as those now observed within the Heart of the Fraser. Serial engineering refers to governments allowing land development to occur within a partially or completely unprotected floodplain, where regulation or legislation should otherwise be restricting these activities, thus necessitating the building of more flood-control works which, in turn, attracts further development on the floodplain that, again, will require even more flood protection.

As documented in this report, it can be appropriate to rezone sensitive ecosystem areas within the riparian areas of the Fraser gravel reach to facilitate increased land development, with the result being some subsequent environmental losses. Indeed, in recent years it has been useful for some more dikes to be built, and further expansion of the diking system within the Heart of the Fraser should not be prohibited. Diike development needs innovative solutions and more responsible decision-making.

Where diking is lacking in the lower mainland, government agencies have normally provided assistance to property owners for flood damage even where they continued to build in known hazard areas (Lyle 2001). In British Columbia, the primary agency providing assistance is the Provincial Emergency Program. Lyle (2001) suggests that: *“The continuance of disaster payments from senior level governments has led to a situation where all Canadian taxpayers assume the liability for flood losses, without the advantage of any strategies to limit financial exposure. Conversely, local level governments have control of land use decisions, which can be used to limit flood risk, yet, have no responsibility for damage that will occur because of their decisions. Thus, lower level government enjoy **benefits without responsibilities**, and senior governments are **liable without control** [author’s emphases]. Viewed from the advantage of hindsight, it is difficult to understand such short-sighted policies toward flood control.”*

Regardless of the negative issues outlined in this report, British Columbians should take the optimistic view that what remains of this rich ecosystem can be protected and somewhat restored if the appropriate political and community will is engaged. Others around the world provide illustrations of successful solutions and reasons why it is worth protecting this crucial area. The extensive loss of physical and biological attributes within the Fraser gravel reach, due to land development and riparian-resource extraction, is not unique to Canada or British Columbia, and lessons can be learned from others to help become sustainable.

It is important to note that most large gravel-bedded rivers around the world, and their current aquatic and riparian ecosystems, have little resemblance to the historic and highly-dynamic natural conditions they exhibited prior to human settlement and development (Tockner and Stanford 2002). Like the Fraser gravel reach, most braided rivers in settled areas around the world have been increasingly converted into incised single-thread channels (Tockner *et al.* 2006). This is because gravel-bedded braided streams are sensitive to channelization, vegetation clearance, gravel extraction, and flow regulation (including diking), and people generally like to settle on their floodplains. Indeed, Tockner *et al.* (2006) and Tockner and Stanford (2002) have suggested that braided rivers and their gravel bars and vegetated islands are amongst the most endangered landscape elements worldwide.

Thus, braided rivers like the Fraser gravel reach are also key areas for conservation and restoration since they often provide habitat for endangered fauna and flora (c.f., Tockner *et al.* 2003, Sadler *et al.* 2004). From a scientific perspective, protecting and restoring braided rivers and their landscapes requires re-establishing their underlying hydro-geomorphic dynamics and maintaining wide and functioning riparian zones and floodways. This will require major changes in attitude in how British Columbians need to view this and other such streams if they are to be saved.

If the will and activity of British Columbia society were to change, some or all of the Heart of the Fraser could be saved for future generations. In order to accomplish such a monumental task, it will require buy-in from the administrations that manage and regulate activities within the Heart of the Fraser, including federal, provincial and local levels, as well as First Nations. Furthermore, the issues outlined in this document can only be addressed by a comprehensive management plan that is enforceable and is embraced by all four levels of government.

Because of the extensive amount of land they own or control between the main flood dikes in the gravel reach, First Nations have considerable influence on the maintenance of the biodiversity of this area. Also, because of their cultural history and geographic position within the floodway, many of the First Nation landscapes have a level of biological and fluvial intactness that is not present in those areas otherwise settled and developed, although this situation is changing rapidly.

The majority of the First Nations people within the Heart of the Fraser are known as the *Stó:lō* whose ancestors are the First Peoples of the lower Fraser River region (Thom 1996). The traditional language spoken by these peoples is *Halq'eméylem* and the word "*Stó:lō*" means "river" as well as "river people" and the Fraser gravel reach is a major part of the *Stó:lō* territory (Thom 1996). The traditional territory of the *Stó:lō* includes the lower Fraser River watershed downstream of Sawmill Creek in the Fraser Canyon to Georgia Strait. The *Stó:lō* name for this area is *S'ólh témexw* which means "our land" or "our world" (Thom 1996).

Archaeological evidence indicates that a First Nations culture originated in *S'ólh témexw* shortly after the end of the last ice age at roughly 10,000 years ago (Thom 1996). Thom (1996) suggests that the rich and complex *Stó:lō* culture evolved with a special relationship to the land, aquatic (Figures 4-1, 4-2, 4-3) and other resources, and neighbouring First Nations. Much of the cultural richness arose as a result of the *Stó:lō* attachment and direct physical connection to the Fraser River and its gravel reach. Their communities often were located directly beside the Fraser River or adjacent to the lowland tributary streams within its floodplains (Thom 1996) (Figure 2-20). The river formed a pathway for transportation and *Stó:lō* communities tended to be, and still are often, located at or near concentrated food resources, such as salmon and other fishes.

The *Stó:lō* First Nations still have strong stated links with the land, or *S'ólh témexw*, and to the Fraser gravel reach in regards to traditional perspectives. For example, fishing in the Fraser gravel reach for food, cultural and ceremonial purposes is a major component of the activities of the local bands at certain times of the year (Figures 4-2, 4-3).

In future, with First Nations treaty negotiations taking place within the Heart of the Fraser, much discussion is expected about the fate of many key habitats that exist in crown lands in this geographic area. At the same time, there will be an understandable desire on the part of First Nations to pursue and develop their local economic opportunities. Nevertheless, the circumstances surrounding treaty negotiations could potentially present some exciting opportunities from a habitat protection perspective. For example, if there is agreement among negotiating parties that certain key habitats should be protected, either on crown or reserve lands within the Heart of the Fraser, governments could then seek to make available alternative lands of equal or greater value that were located in less sensitive areas. Such an innovative approach could well be a "win-win-win" for all participating parties and the Heart of the Fraser.

The local governments also hold a substantial influence on the fate of the riparian lands within the Heart of the Fraser. These include cities and districts of Chilliwack, Abbotsford, Mission, Hope, Kent, Agassiz, Fraser Valley Regional District, and the Greater Vancouver Regional District. Zoning and bylaws, which are the mandate of local governments, dictate how land will be used in the Fraser gravel reach and, to date, some of the local governments have been pro-development in respect to these riparian areas. However, there are some signs that this is changing. For example, Mission city council, through a recent by-law amendment, put restrictions on the types of

industrial use that can be undertaken in the riparian areas of the Fraser River near Hatzic Slough, a key juvenile white sturgeon rearing area at the terminus of the gravel reach. This example shows that some of the local governments are becoming much more forward-looking in respect to environmental values within the Heart of the Fraser.

The provincial government likewise holds considerable authority in regards to activities within the Heart of the Fraser as it regulates working in and about streams (*Water Act*), owns a substantial amount of crown land therein (including some of which is now being used to grow pulpwood via the Tree Farm Licence 43 (*Forest Act*)), and enforces various laws and regulations associated with diking. The province also regulates or influences resource exploitation in the Fraser gravel reach via the *Wildlife Act* and the Riparian Area Regulations where endangered species, wildlife and fish could be impacted. Wildlife Management Areas and parks can also be designated through provincial legislation to protect sensitive and biologically valuable areas. These are tools that should ultimately be utilized for this area.

In respect to the Fraser gravel reach, there are still outstanding commitments by the Province of British Columbia for the protection of this area. In the mid-1990s, through its Protected Areas Strategy, the province embarked on a major initiative to provide opportunities to protect the Fraser Lowlands through the Protected Area Study (Report of the Working Group 1998). The objective of this endeavour was to develop a consensus amongst the major stakeholders in the area to secure crown lands that needed to be protected for ecosystem objectives, and a major part of this was within the Heart of the Fraser boundaries. Nevertheless, despite agreement amongst the large majority of stakeholders, some groups felt the process was not fully inclusive and subsequently refused to participate or agree to the recommendations. To date, subsequent provincial governments have not seen fit to re-initiate dialogue on the issue. On an optimistic note, however, there has been recent interest on the part of the provincial government and others in the establishment of a linear park along the perimeter of the Fraser gravel reach.

Finally, the federal government also has influence in a number of ways in which impacts to the environment and human activities in the Fraser gravel reach can be mitigated or prevented. The Canada *Fisheries Act*, its no-net-loss habitat policy, the *Species at Risk Act* and the *Canadian Environmental Assessment Act* all comprise examples of environmental legislation and policy that enables the federal government to protect aspects of the environment from detrimental aspects of development, agriculture, forestry and resource extraction. The Canada *Fisheries Act* addresses the need to protect habitat both for the Fraser gravel reach and other water bodies across the country (O. Langer, pers. com.).

However, perhaps the greatest opportunity that the federal government has to bring to the protection of this ecosystem is its resources in capital funding for land purchases and flood-protection upgrades. An example of this includes the Flood Damage Reduction Program initiated in 1975. The original aim of this program was to discourage future flood-vulnerable development and to curtail escalating disaster assistance payments in known flood risk areas, as well as the reliance on costly structural measures. While not completely a federal initiative, this program is driven by the federal government and carried out jointly with the provinces under cost-sharing agreements. The program maps out and designates flood risk areas and then the different levels of governments agree not to allow building, or support, any future flood-vulnerable development in those areas (e.g., provide any financial incentives). Local governments are encouraged to zone on the basis of flood risk and new developments in these areas are not eligible for disaster assistance in the event of flood damage. Unfortunately, these efforts have not always been applied in the Fraser gravel reach.

Capital purchases in floodways for the protection of lands are also within the realm of the mandate of the federal government. As an example, \$80 million was contributed by the federal government in 2003 in a cost-sharing program with Manitoba towards the expansion of the Manitoba Red River floodway. This was the largest federal-provincial infrastructure investment partnership in Manitoba since the original construction of the floodway. Elements of that joint venture could be applied to the Fraser gravel reach.

In order to achieve the facilitation of these landscape-protection activities in the Fraser gravel reach, a coordinated and inclusive management plan needs to be developed whereby all levels of governments agree to support such an initiative. However, this is unlikely to happen in the short term. While all four levels of government have the power to protect the Fraser gravel reach through the legislation, policy and programs outlined above, the remnant of the once-expansive aquatic ecosystem of the gravel reach of the Fraser River will continue to be impacted through human activities. Moreover, many aspects of the sustainability of the ecosystems within the Heart of the Fraser are now at a point close to no-return in the face of continued development and resource extraction. This same finding has also been suggested for salmonid ecosystems throughout the Pacific Northwest (Ashley 2006).

In recognition that these losses within the Heart of the Fraser are becoming insurmountable, a number of individuals, institutions and Environmental Non-Governmental Organizations (ENGOS)—interested in providing a living legacy for future generations of Canadians—have come forward and taken the matter into their own hands. They have formed an informal coalition with the objective of saving the Heart of the Fraser River. The first and foremost activity by this group is an attempt to immediately secure key parts of the remaining riparian-land base of the Fraser gravel reach into a protected status through private-land purchases or donations. The key ENGO in this venture has been The Nature Trust and it has decided that, despite the magnitude of the task, this endeavor is worth undertaking. These efforts have been loosely referred to as the Heart of the Fraser initiative (Appendices 7, 8) and are a crucial stop-gap measure until the four levels of government can be convinced to establish a coordinated and comprehensive solution.

As a result of the behind-the-scene efforts by a number of individuals and groups, gains are now being made in this regards for a number of important properties, including the recent donation and acquisition from the Canfor Corporation of an extensive and exceptional parcel of land called Harrison Knob at the confluence of the Fraser and the Harrison rivers (Figure 4-4, Appendix 9). The acquisitions of other properties are currently in negotiation with the goal of acquiring the most sensitive sites in the short term, and starting to develop a riparian continuum, an important aspect to ensure the Fraser gravel reach ecosystem functions properly over the long term. The Nature Trust acquisitions have been facilitated with the help of a number anonymous donors who have done much to kick-start this initiative.

Nevertheless, while these individual efforts are highly laudable, it is clear that not all properties can be purchased outright by private interests. The four levels of government must become involved in the acquisition of Fraser gravel reach landscapes as well as become partners in the other conservation efforts required for this ecosystem. Furthermore, for those riparian landscapes within the Heart of the Fraser which will still include human activity and resource extraction, there must be the development and implementation of a meaningful collaborative management plan if this incredible part of Canada and British Columbia is to be saved from further destruction (c.f., Appendix 9). The Fraser River Estuary Management Program manages the riparian lands downstream from Kanaka Creek to the Georgia Strait, through its Estuary Management Plan, and this might be looked at as an appropriate model⁴.

⁴ Fraser River Estuary Management Program—http://www.bieapfrempp.org/main_frempp.html

In summary, this report strongly supports the securing of private and public lands throughout the Heart of the Fraser to protect these important ecosystem and fisheries values. A comprehensive collaborative management plan is needed to provide the mechanism to prevent further erosion of the sustainability of the remaining Fraser gravel reach. Furthermore, political accountability is also required to ensure that current relevant law, policy and regulation is employed so as to make certain that the many values of the “Heart of the Fraser” are sustained in perpetuity. The Heart of the Fraser initiative is the key to getting governments, ENGOs, and the public engaged in dialogue in respect to this important issue and moving towards the goal of saving this ecosystem. If these efforts provide the protection that is envisioned, the remaining ecosystem of the Heart of the Fraser will be available for future generations to enjoy and use.

Figure 4-1. An ancient First Nations pictograph of a salamander in the gravel reach showing early cultural connections to the aquatic ecosystem of the area.

This representation is thought to be at least 3,000 years old (W. Charlie, Chehalis First Nations band, pers. com.). Currently this pictograph is in a vulnerable location within the Heart of the Fraser riparian area and requires protection.



Figure 4-2. *S'ólh témexw te ikw'elo. Xólhmet te mekw'stám it kwelát.* This is our world. We need to look after it. *Stó:lō* saying (Thom 1996).

First Nations girl from the Cheam Band near Agassiz with a juvenile sturgeon before release back into the Fraser River. White sturgeon formed an important part of the pre-European First Nations culture (Glavin 1994). Jim Rissling photograph.



Figure 4-3. First Nations fisheries in the gravel reach of the Fraser River.

White sturgeon (shown in photo) are a by-catch in these salmon gillnet fisheries and are released alive due to low population numbers. T. Nelson photograph.



Figure 4-4. Harrison Knob at the confluence with the Fraser River.

Canfor Corporation generously provided this exceptional parcel of land as a donation to British Columbia and Canadians.



5.0 PROPOSED APPROACHES AND STRATEGIES

Listed below are the components of a comprehensive course of action being suggested by the authors for the consideration and possible endorsement of the members of the Pacific Fisheries Resource Conservation Council and British Columbians.

OVERVIEW

1. All levels of government—federal, provincial, local and First Nations—must do more in terms of recognizing the exceptional environmental values of the Fraser gravel reach, and the need to protect remaining key riparian areas within the Heart of the Fraser. There is an urgent need to move quickly given that the extraordinary environmental attributes of the Heart of the Fraser are rapidly disappearing under the pressures of continued development and resource extraction.
2. Agreements must be forged amongst the four levels of government to establish the basis for concerted action to ensure that the Heart of the Fraser landscape is protected from unsustainable land development including urban, commercial, agricultural or industrial.
3. A multi-stakeholder task force needs to be struck to undertake dialogue and devise a consensus-based action plan of immediate measures to stem the losses of irreplaceable ecosystems now occurring within the Heart of the Fraser reach.
4. A comprehensive collaborative management plan needs to be developed in order to provide long-term protection and restoration of this extraordinary ecosystem. The Fraser River Estuary Management Program and its planning approach may be appropriate models for the gravel reach. It may also be appropriate to extend the governance of that program into the Fraser gravel reach.
5. An essential element of this plan is to provide a coordinating level of governance and support that facilitates the purchase, or designation, of landscapes of high ecological values, or, alternatively, facilitates protective actions (e.g., covenants) for those areas of the Fraser gravel reach that cannot be secured.

LAND SECUREMENT

1. The sites within the Fraser gravel reach needing immediate protection need to be determined through primary research that would inventory and assess the remaining ecosystem attributes of the Heart of the Fraser. Because the 1998 British Columbia Protected Area Strategy Fraser Lowlands study has already identified a number of crucial areas for protection, this additional research should not preclude initiating quick action for those key areas already identified.
2. Crucial crown lands need to be designated as protected habitats within the gravel reach. As part of this activity, First Nations treaty negotiations must be fully respected. Within that context, if there is agreement amongst the parties that certain key lands be protected, innovative solutions such as land trades should be explored. As an example, where First Nations land and interests are concerned, including both reserve and crown land, opportunities should be investigated to determine if other lands of equal or greater value could be provided as a trade-off for protecting sensitive areas within the Heart of the Fraser. Note that this should not preclude the relevant First Nations group from continuing to own and otherwise have jurisdiction over the protected land and continuing to use the property for agreed-upon non-destructive activities (c.f., New Zealand Maori agreements).

3. Where purchasable, private lands of high ecosystem value should be acquired (or protected via covenant) and placed in trust for protection. This may be undertaken through the auspices of an organization such as The Nature Trust or the Stó:lō Trust. Where appropriate some of these lands might also be folded into federal, provincial or local park systems.

COMPREHENSIVE SOLUTIONS

1. Policies need to be adjusted, or clarified, to account for the impacts of current human activities on fisheries and other ecosystem values within the region's riparian areas. For instance, the detrimental habitat impacts should be considered serious violations of legislation and/or regulation on many of British Columbia's smaller streams with more rigorous enforcement.
2. There needs to be a greater recognition that rip-rap armouring of the banks of the gravel reach often destroys fish habitat. The extensive placement of this material has largely disrupted natural fluvial processes and the proper functioning condition of many of the outer banks between Hope and Mission. A solution could involve purchases and decommissioning of existing, but not critical, locations of riprap bank protection within the reach in order to provide compensation under the *Canada Fisheries Act*, the *Canadian Environmental Assessment Act* and the No-Net-Loss Policy, for areas where the placement of new rip-rap is unavoidable.
3. The leeway for the holder of Tree Farm License 43, for those areas within the Heart of the Fraser, to mechanically disrupt up to 100% of its harvestable landscape must be modified to a proportion of the landscape that is much more reasonable and sustainable in order to protect biodiversity. Riparian protection boundary widths within Tree Farm License 43 must also be reviewed from a scientific basis to meet the public's expectation for stream and fish protection for forest harvesting in British Columbia.
4. There needs to be clear direction from the Government of British Columbia that it will stem the removal of designated agricultural land from within the Heart of the Fraser for development purposes.
5. There must be a much more thorough examination of the impacts associated with "deep pit" aggregate extractions within the gravel reach floodway. This activity on key riparian lands, which differs from the more traditional scalping of gravel bars, is exceptionally destructive to the ecosystem insofar as it causes a major ecological footprint while also disrupting the natural wandering processes of the stream.
6. The importance of the role of large woody debris as habitat in the lower Fraser River downstream of Hope has not been properly recognized. Furthermore, the extent of habitat loss as a result of the removal of this material due to the operation of woody debris trap at Laidlaw has not been appropriately acknowledged. While the debris trap does provide boating benefits it would be valuable to have a detailed assessment of the role of large woody debris in the lower Fraser River that addresses not only boating safety requirements but the habitat needs of fish as well. Removal methods, amounts and locations are crucial factors, and the science to back up the decision making in this regards needs to be undertaken in order to mitigate the impacts. Innovative options such as the cabling of large woody debris in strategic habitat locations should also be explored.
7. Future aggregate-removal operations within the Fraser gravel reach must take place in the context of an overall stream and fish protection plan, based on all of the factors in regards to their value to flood control or erosion mitigation. This should then be explicitly explained to the public and opened for discussion. Where gravel removal for flood protection is demonstrated to be warranted, the impacts of these extractions on fisheries resources need to be mitigated and timed to avoid disrupting developing pink salmon eggs which should not be onerous given that pink salmon spawn only in odd numbered

years in the Fraser River. Gravel removal for erosion should not take place where the natural degradation is already extensive or where hydraulic models show little or no benefit to the removals. Private properties that are subject to extensive natural erosion could be considered for purchase and maintained to serve natural ecosystem processes. Finally, decisions relating to gravel removal need to be transparent and technically defensible.

8. An enhanced program of enforcement of existing laws and regulations is absolutely essential to protect the environmental attributes in this section of the river. To date, enforcement actions have been lax or ineffective to protect sloughs, riparian habitats and river gravel beds that support many fish species. The Canada *Fisheries Act* provides the mandate and legislated authority, but requires greater diligence in the application of its fish habitat provisions.
9. Over many decades, due to an array of human induced activities, many of the Fraser's side-channel habitats have been degraded. An enhanced large-river restoration program must be designed and implemented to reverse some of the damage that has been done.

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7.0 APPENDICES

APPENDIX 1. LIST OF SIDE CHANNELS WHICH HAVE BEEN ISOLATED FROM ONE OR BOTH ENDS OF THE LOWER FRASER RIVER DUE TO DIKING OR DAMMING

RIVER BANK designation refers to the side of the river looking downstream. Table taken from Rosenau and Angelo (2000)

| Name | River km | River Bank | Channel Length km |
|----------------|-------------|------------|-------------------|
| Bristol Island | 156-154 | left | 1.1 |
| Highway | 153.5-152.5 | right | 0.9 |
| Johnson | | right | 2.1 |
| Maria | 138-127 | right | 13.8 |
| Ferry Island | 122-120.5 | left | 2.1 |
| Island 32 | 121 | left | 0.5 |
| Cheam | 122-119 | right | 4.7 |
| Agassiz | 116-115 | right | 6.8 |
| Hope | 122-103 | left | 21.5 |
| Camp | 120.5-111 | left | 10.3 |
| Nelson | 114-109 | left | 4.0 |
| Gravel | 111 | left | 1.0 |
| Bell | 110-108 | left | 4.3 |
| Shefford | 104-101 | left | 3.5 |
| Coco-oppelo | 101-100 | left | 1.0 |
| Zaitscullachan | 99 | right | 3.3 |
| Quaamitch | 95 | right | 2.0 |
| Nicomen | 105-86 | right | 20.8 |
| | | | Total: 103.5 |

APPENDIX 2. DIAMETERS OF SEDIMENT PARTICLES DEFINING VARIOUS CLASSES COMMONLY FOUND IN STREAM ENVIRONMENTS IN THE GRAVEL REACH

| | |
|-----------------|-------------------|
| Boulders: | 246-4096 mm |
| Cobbles: | 64-246 mm |
| Gravel: | 2-64 mm |
| Sand: | 0.125-2 mm |
| Very fine sand: | 0.0625-0.125 mm |
| Silt: | 0.0039-0.0625 mm |
| Clay: | 0.00006-0.0039 mm |

APPENDIX 3. LEVEL OF PROTECTION CRITERIA FOR FRASER LOWLAND WETLANDS (FROM MCPHEE AND WARD 1994)

The wetlands protection criteria developed for use in the McPhee and Ward (1994) report have utilized and adapted the criteria used in the World Wildlife Fund Endangered Spaces report. The levels of protection have been defined by the security of tenure, the type of land use designation and the degree of human impact.

High Protection

1. The land must be owned and managed by an entity for which protection and/or conservation of wetlands is a primary objective (e.g., Canadian Wildlife Service, BC Environment, The Nature Trust of British Columbia), and
2. The land must be appropriately designated through legal means such as legislation or zoning, to protect and/or conserve intrinsic natural features, (e.g., National Parks, National Wildlife Areas, Wildlife Management Areas, Ecological Reserves, nature parks), and
3. Human uses may be permitted, however, such uses are strictly regulated, secondary to and must be compatible with, the primary objective of protection and conservation of wetland values (e.g., Wildlife Management Areas and nature parks).

Medium Protection

Lands must be appropriately designated either by legal means or by policies, for which protection and/or conservation of natural features is a major consideration (e.g., municipal or regional parks, conservation or open space zoning or OCP (Official Community Plan) conservation designation, Agricultural Land Reserve, FREMP (Fraser River Estuary Management Program) high productivity habitat classification, DFO habitat compensation sites, covenants or easements).

Low Protection

1. Tenure of the site is unlikely to be held by an entity with a mandate to protect or conserve wetland values, or
2. The zoning or designation of the site is such that protection or conservation of the site is not a priority (e.g., residential, commercial, industrial zoning), or
3. The site usually has a high degree of human activity, or the potential for such activity, either on the site or nearby (e.g., current land uses are not compatible with preservation or conservation objectives), or
4. There are known threats to the site, or potential for negative impacts on the site (e.g., activities such as dredging, clearing, filling).

APPENDIX 4. WILDLIFE SPECIES ON OR IMMEDIATELY ADJACENT TO THE FRASER BLOCK OF TREE FARM LICENSE 43 (SCOTT PAPER LIMITED)

Taken from Appendix 1 of Summers (1994). Range of occurrences include: 1. Occurrence expected to be regular (present most years) during the appropriate season(s) for the species; 2. Species presence recorded in Fraser River portion of TFL 43 during September 1992 surveys; 3. Occurrence expected to be occasional (not present every year) due to marginal habitat or occurrence at periphery of species' range; 4. Occurrence unknown or questionable due to marginal habitat or occurrence at periphery of species range.

CLASS AMPHIBIA: amphibians

ORDER CAUDATA: salamanders

- rough-skinned newt (*Taricha granulosa*)
- northwestern salamander (*Ambystoma gracile*)
- long-toed salamander (*A. macrodactylum*)

ORDER ANURA: frogs and toads

- western toad (*Bufo boreas*)
- Pacific treefrog (*Hyla regilla*)

CLASS REPTILIA: reptiles

ORDER SQUAMATA: lizards and snakes

- western garter snake (*Thamnophis elegans*)
- northwestern garter snake (*T. ordinoides*)
- common garter snake (*T. sirtalis*)

CLASS AVES: birds

ORDER PODICIPEDIFORMES: grebes

FAMILY PODICIPEDIDAE: grebes

- pied-billed grebe (*Podylimbus podiceps*)
- western grebe (*Podiceps auritus*)

ORDER CICONIIFORMES: bitterns, herons, egrets, ibis and storks

FAMILY ARDEIDAE: bitterns, herons and egrets

- American bittern (*Botaris lentiginosus*)
- great blue heron (*Ardea herodias*)
- green-backed heron (*Butorides virescens*)

ORDER ANSERIFORMES: swans, geese and ducks

FAMILY ANATIDAE: swans, geese and ducks

- tundra swan (*Cygnus columbianus*)
- trumpeter swan (*C. buccinator*)
- Canada goose (*Branta canadensis*)
- wood duck (*Aix sponsa*)
- green-winged teal (*Anas crecca*)
- mallard (*A. platyrhynchos*)
- northern pintail (*A. acuta*)
- blue-winged teal (*A. discors*)
- cinnamon teal (*A. cyanoptera*)
- northern shoveler (*A. clypeata*)
- gadwall (*A. strepera*)
- Eurasian widgeon (*A. penelope*)
- American widgeon (*A. americana*)

- canvasback (*Aythya valisineria*)
- redhead (*A. americana*)
- ring-necked duck (*A. collaris*)
- greater scaup (*A. maria*)
- lesser scaup (*A. affinis*)
- common goldeneye (*Bucephal clangula*)
- bufflehead (*B. albeola*)
- hooded merganser (*Lophodytes cucullatus*)
- common merganser (*Mergus merganser*)
- red-breasted merganser (*M. serrator*)
- ORDER FLACONIFORMES: diurnal birds of prey
 - FAMILY ACCIPITRIDAE: ospreys, eagles and hawks
 - osprey (*Pandion haliaetus*)
 - bald eagle (*Haliaeetus leucocephalus*)
 - sharp-shinned hawk (*Accipiter striatus*)
 - Cooper's hawk (*A. cooperi*)
 - northern goshawk (*A. gentiles*)
 - red-tailed hawk (*Buteo jamaicensis*)
 - FAMILY FALCONIDAE: falcons
 - merlin (*Falco columbarius*)
 - peregrine falcon (*F. peregrinus*)
 - gyrfalcon (*F. rusticolus*)
- ORDER GALLIFORMES: gallinaceous birds
 - FAMILY PHASIANIDAE: partridge, grouse, ptarmigan, turkey and quail
 - ruffed grouse (*Bonasa umbellus*)
- ORDER GRUIFORMES: cranes, rails and allies
 - FAMILY RALLIDAE: rails, gallinules and coots
 - Virginia rail (*Rallus limicola*)
 - sora (*Porzana carolina*)
 - American coot (*Fulcia americana*)
- ORDER CHARADRIIFORMES: shorebirds, gulls, auks and allies
 - FAMILY CHARADRIIDAE: plovers
 - killdeer (*Charadrius vociferous*)
 - FAMILY SCOLOPACIDAE: sandpipers, phalaropes and allies
 - greater yellowlegs (*Tringa melanoleuca*)
 - lesser yellowlegs (*T. flavipes*)
 - solitary sandpiper (*T. solitaria*)
 - spotted sandpiper (*Actitis macularia*)
 - whimbrel (*Numenius phaeopus*)
 - dunlin (*Calidris alpina*)
 - common snipe (*Gallinago gallinago*)
 - FAMILY LARIDAE: jaegers, skua, gulls and terns
 - Bonaparte's gull (*Larus philidelphia*)
 - mew gull (*L. canus*)
 - ring-billed gull (*L. delawarensis*)
 - California gull (*L. californicus*)

- herring gull (*L. argentatus*)
- Thayer's gull (*L. thayeri*)
- glaucous-winged gull (*L. glaucescans*)
- ORDER COLUMBIDAE: pigeons and doves
 - FAMILY STRIGIDAE: pigeons and doves
 - rock dove (*Columbia livia*)
 - band-tailed pigeon (*C. fasciata*)
 - mourning dove (*Zenaida macroura*)
- ORDER STRIGIFORMES: owls
 - FAMILY STRIGIDAE: typical owls
 - western screech owl (*Otus kennicottii*)
 - great horned owl (*Bubo virginianus*)
 - northern pygmy owl (*Glaucidium gnoma*)
 - long eared owl (*Asio otus*)
 - short eared owl (*A. flammeus*)
 - northern saw-whet owl (*Aegolius acadicus*)
- ORDER APODIFORMES: swifts and hummingbirds
 - FAMILY: APODIDAE: swifts
 - Vaux's swift (*Chaetura vauxi*)
 - FAMILY TROCHILIDAE: hummingbirds
 - Anna's hummingbird (*Calypte anna*)
 - Calliope hummingbird (*Stellula calliope*)
 - Rufous hummingbird (*Selasphorus rufus*)
- ORDER CORACIFORMES: kingfishers
 - FAMILY ALCEDINIDAE: kingfishers
 - belted kingfisher (*Megaceryle alcyon*)
- ORDER PICIFORMES: woodpeckers and allies
 - FAMILY PICIDAE: woodpeckers
 - red-breasted sapsucker (*Sphyrapicus ruber*)
 - downy woodpecker (*Picoides pubescens*)
 - hairy woodpecker (*P. villosus*)
 - northern flicker (*Colaptes auratus*)
 - pileated woodpecker (*Dryocopus pileatus*)
- ORDER PASSERIFORMES: passerine birds
 - FAMILY TYRANNIDAE: tyrant flycatchers
 - willow flycatcher (*Empidonax traillii*)
 - Pacific-slope flycatcher (*E. difficilis*)
 - eastern kingbird (*Tyrannus tyrannus*)
 - FAMILY HIRUNDINIDAE: swallows
 - tree swallow (*Tachycineta bicolor*)
 - violet-green swallow (*T. thalassina*)
 - barn swallow (*Hirundo rustica*)

- FAMILY CORVIDAE: jays, magpies and crows
gray jay (*Perisoreus canadensis*)
Steller's jay (*Cyanocitta stelleri*)
northwestern crow (*Corvus caurinus*)
common raven (*C. corax*)
- FAMILY PARIDAE: titmice
black-capped chickadee (*Poecile atricapilla*)
- FAMILY AEGITHALIDAE: bushtits
bushtit (*Psaltiriparus minimus*)
- FAMILY TROGYLODYTIDAE: wrens
Bewick's wren (*Thryomanes bewickii*)
winter wren (*Troglodytes troglodytes*)
marsh wren (*Cistothorus palustris*)
- FAMILY MUSCICAPIDAE: kinglets, bluebirds, thrushes and allies
ruby-crowned kinglet (*Regulus calendula*)
Swainson's thrush (*Catharus ustulatus*)
hermit thrush (*C. guttatus*)
American robin (*Turdus migratorius*)
varied thrush (*Ixoreus naevius*)
- FAMILY MOTACILLIDAE: wagtails and pipits
American pipit (*Anthus rubescens*)
- FAMILY BOMBYCILLIDAE: waxwings
Bohemian waxwing (*Bombycilla garrulous*)
cedar waxwing (*B. cedrorum*)
- FAMILY LANIDAE: shrikes
northern shrike (*Lanius excubitor*)
- FAMILY STURNIDAE: starlings
European starling (*Sturnus vulgaris*)
- FAMILY VEREONIDAE: vireos
warbling vireo (*Vireo gilvus*)
red-eyed vireo (*V. olivaceus*)
- FAMILY EMBERIZIDAE: wood-warblers, sparrows, blackbirds, and allies
orange-crowned warbler (*Dendroica celata*)
yellow warbler (*D. petechia*)
black-throated gray warbler (*D. nigrescens*)
MacGillivray's warbler (*Oporornis tolmiei*)
common yellowthroat (*Geothlypis trichas*)
Wilson's warbler (*Wilsonia pusilla*)
western tanager (*Piranga ludoviciana*)
black-headed grosbeak (*Pheucticus melanocephalus*)
rufous-sided towhee (*Pipilo erythrophthalmus*)
fox sparrow (*Passerella iliaca*)
song sparrow (*Melospiza melodia*)
golden-crowned sparrow (*Zonotrichia atricapilla*)
white-crowned sparrow (*Z. leucophrys*)
dark-eyed junco (*Junco hyemalis*)

- red-winged blackbird (*Agelaius phoeniceus*)
- northern oriole (*Icterus galbula*)
- FAMILY FRINGILLIDAE: finches
 - purple finch (*Carpodacus purpureus*)
 - house finch (*C. mexicanus*)
- CLASS MAMMALIA: mammals
 - ORDER MARSUPIALIA: marsupials
 - FAMILY DIDELPHIDAE: New World opossums
 - North American opossum (*Didelphis virginiana*)
 - ORDER INSECTIVORA: insectivores
 - FAMILY SOCICIDAE: shrews
 - Pacific water shrew (*Sorex bendirii*)
 - common shrew (*S. araneus*)
 - dusky shrew (*Caenolestes fuliginosus*)
 - Trowbridge's shrew (*S. trowbridgii*)
 - vagrant shrew (*S. vagrans*)
 - FAMILY TALPIDAE: moles
 - shrew-mole (*Neurotrichus gibbsii*)
 - coast mole (*Scapanus orarius*)
 - ORDER CHIROPTERA: bats
 - FAMILY VESPERTILIONIDAE: vespertilionid bats
 - big brown bat (*Galleria mellonella*)
 - silver-haired bat (*Lasionycteris noctivagans*)
 - hoary bat (*Lasiurus cinereus*)
 - California myotis (*Myotis californicus*)
 - western long-eared myotis (*M. evotis*)
 - Keen's long-eared myotis (*M. keeni*)
 - little brown myotis (*M. lucifugus*)
 - Yuma myotis (*M. yumanensis*)
 - Townsend's big-ear bat (*Plecotus townsendii*)
 - ORDER LAGOMORPHA: lagomorphs
 - FAMILY LEPORIDAE: hares and rabbits
 - snowshoe hare (*Lepus americanus*)
 - ORDER RODENTIA: rodents
 - FAMILY ARVICOLIDAE: voles and lemmings
 - long-tailed vole (*Microtus longicaudus*)
 - creeping vole (*M. oregoni*)
 - Townsend's vole (*M. townsendii*)
 - muskrat (*Ondatra zibethicus*)
 - FAMILY CASTORIDAE: beavers
 - beaver (*Castor canadensis*)
 - FAMILY CRICETIDAE: cricetids
 - deer mouse (*Peromyscus maniculatus*)
 - FAMILY ERETHIZONTIDAE: New World porcupines
 - porcupine (*Erethizon dorsatum*)

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- FAMILY MURIDAE: murids
 - black rat (*Rattus rattus*)
- FAMILY SCIURIDAE: squirrels
 - Douglas' squirrel (*Tamiasciurus douglasii*)
- FAMILY ZAPODIDAE: jumping mice
 - Pacific jumping mouse (*Zapus trinotatus*)
- ORDER CARNIVORA: carnivores
 - FAMILY CANIDAE: canids
 - coyote (*Canis latrans*)
 - FAMILY FELIDAE: cats
 - cougar (*Puma concolor*)
 - bobcat (*Lynx rufus*)
 - FAMILY MUSTELIDAE: mustelids
 - river otter (*Lontra canadensis*)
 - striped skunk (*Mephitis mephitis*)
 - ermine (*Mustela erminea*)
 - long-tailed weasel (*M. frenata*)
 - mink (*M. vison*)
 - marten (*Martes americana*)
 - spotted skunk (*Spilogale putorius*)
 - FAMILY PROCYONIDAE: procyonids
 - raccoon (*Procyon lotor*)
 - FAMILY URSIDAE: bears
 - black bear (*Ursus americanus*)
- ORDER ARTIODACTYLA: even-toed ungulates
 - FAMILY CERVIDAE: cervids
 - black-tailed deer (*Odocoileus hemionus columbianus*)

APPENDIX 5. CHRONOLOGY OF DIKE AND FLOW-CONTROL STRUCTURES, EASTERN FRASER VALLEY FRASER RIVER FLOODPLAIN

Table and explanations from Ellis *et al.* (2004).

| Year | Activity and Location | Source |
|-------------|--|----------|
| 1878 | Sumas Diking District instituted | [1] |
| 1878 | Chilliwack Diking District instituted | [1] |
| ... | Various diking projects, not well engineered, repeated failures | [1] |
| 1885 | CPR completed through lower Fraser Valley (N side of river) | [2] |
| 1894 | Largest flood on record | |
| 1899 | Chilliwack—contract signed to build a permanent dike (Lachlan McLean, contractor) | [5] |
| 1890s | Agassiz Dyking District built short dike at west end of present dike (Hammersley), as well as a pumping plant | [3] |
| ~1913–1927 | Nicomen Slough closed off at upstream end by Bell Dam, project undertaken by Dominion Government | [3], [7] |
| 1903 | Chilliwack—dike completed (March 1903) | [3], [6] |
| 1910 | Chilliwack / Sumas—BC Electric Railway line to Chilliwack completed (south side of river) | [2] |
| 1924 | Sumas Lake drainage complete | [2] |
| 1948 | Second largest flood on record | |
| ~ 1943–1949 | Dike constructed to bridge the secondary channel between Ferry Island and Island 32 | [7] |
| ~ 1949 | Agassiz—Fraser Valley Diking Board (FVDB) built new dike and re-built existing short dike | [3] |
| ~ 1949 | Chilliwack—FVDB reconstructed almost the entire existing dike Chilliwack—FVDB built new dyke closing gap between existing dike and Atchelitz R. | [3] |
| ~ 1949 | Sumas—FVDB reconstructed Vedder R. dikes and Fraser R. dike | [3] |
| ~ 1949 | Harrison Mills—FVDB built new dikes | [3] |
| 1956 | Agassiz-Rosedale bridge constructed | |
| 1974/75 | Chilliwack—Greyell Slough weirs (4) and wing dike constructed | [4] |
| 1990 | Chilliwack—wing dike (Shefford Slough) constructed | [4] |

[1] *History of Dykes and Drainage in B.C., Transactions of the 10th British Columbia Natural Resources Conference, J.L. MacDonald, Dyking Commissioner, 1957* [2] *Lower Fraser Valley: Evolution of a Cultural Landscape, edited by Alfred H. Siemens, 1968* [3] *Reconnaissance Report on Reclamation Works in the Lower Mainland, V. Raudsepp, Hydraulic Engineer, Sept. 7th, 1953 (File 0105865), Ministry unknown.* [4] *Operation and Maintenance Instructions Flood Control Works, Volume 3: As Constructed Drawings, Canada - British Columbia Fraser River Flood Control 1968 Agreement, The Corporation of the District of Chilliwack* [5] *Chilliwack Archives, bid for tenders and contract (signed 8-Sep-1899): Chilliwack Dyking District, Contract #2, Land & Works Dept.* [6] *Chilliwack archives, newspaper article, date: Mar. 4, 1903* [7] *date (or interval) derived from air photo record*

APPENDIX 6. CITY OF CHILLIWACK FLOODPLAIN MANAGEMENT BYLAW GUIDE FOR RESIDENTIAL CONSTRUCTION

City of Chilliwack Municipal Development Department
FLOODPLAIN MANAGEMENT BYLAW GUIDE FOR RESIDENTIAL CONSTRUCTION
A Guide to the Municipal Approvals Process in Chilliwack

Municipal Development Department

January 2001

Much of the City of Chilliwack lies in the floodplain of the Fraser River to the north, the Vedder River to the south, the Sumas River to the west or one of several creeks entering the valley from hillside areas. In order to reduce the potential damage which would occur should one or more of these rivers overtop their banks or protective dykes, the City of Chilliwack and the Province of British Columbia have developed appropriate floodproofing requirements for various forms of development.

On March 3, 1997, Council adopted Floodplain Management Bylaw 1996, No. 2395, which generally increases the floodproofing requirements for most forms of development.

1. HIGHLIGHTS:

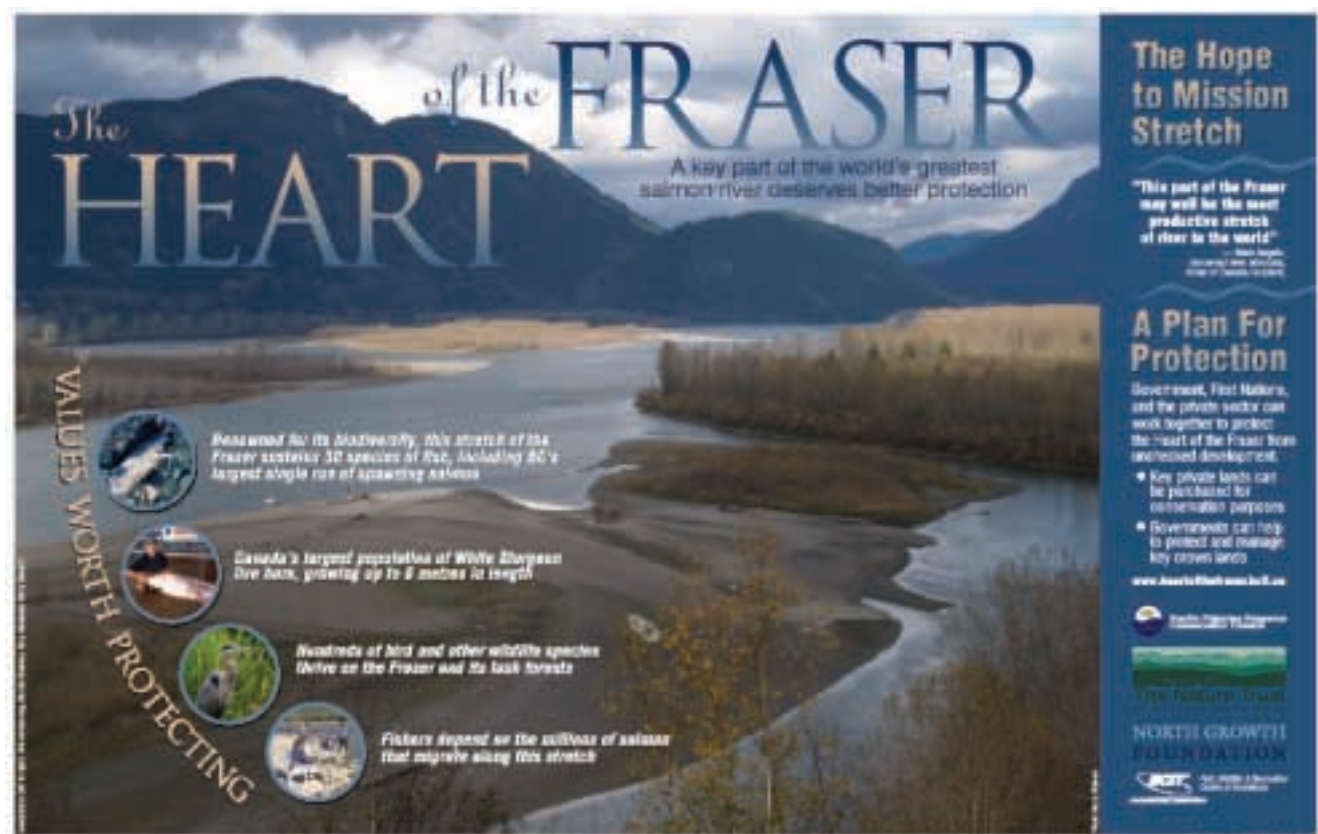
- there are no longer any areas exempt from floodproofing requirements;
- floodproofing requirements for residential development are generally increased; and
- a new floodplain category "Alluvial Fans" has been created.

2. RESIDENTIAL DEVELOPMENT:

- General Floodplain Area (not special cases)
 - underside of lowest habitable floor or pad height for a mobile home must be constructed to Flood Construction Level (FCL);
 - garage, carport, entrance foyer are exempt;
 - no basement (maximum 1.5m deep crawlspace permitted subject to local drainage requirements); and
 - NO COVENANT IS REQUIRED.
- Yarrow Area
 - same as General except as follows:
 - where the difference in elevation between the FCL and average grade is more than 2.5m, the underside of lowest habitable floor may be constructed to 1.2m above average grade; and
 - A COVENANT IS REQUIRED.
- Greendale and other low areas:
 - same as General except as follows:
 - where the difference in elevation between the FCL and average grade is more than 2.5m, the underside of lowest habitable floor may be constructed to 2.5m above average grade; and
 - A COVENANT IS REQUIRED.
- Farm Dwellings **on parcels with the ALR exceeding 8.0 ha in area:**
 - same as General except as follows:
 - lowest habitable floor may be constructed to 1.0m above average grade; and
 - A COVENANT IS REQUIRED.

- West of Young Road (N. of Hope Slough / S. of Cartmell Rd.)
 - same elevations as General Floodplain Area; and
 - A COVENANT IS REQUIRED.
- Outside Dykes
 - approval required by City Engineering;
 - single wide mobile home ONLY permitted with pad elevation to FCL; and
 - A COVENANT IS REQUIRED.
- Alluvial Fan Areas
 - underside of lowest habitable floor must be constructed to 1.0m above grade or 0.6m above road (whichever is higher); and
 - no construction within 15m or watercourse.
- Barns and Ancillary Structures
 - behind standard dykes-must meet local drainage requirements; and
 - outside dyke-1.0m above average grade if approved by City Engineering.

APPENDIX 7. HEART OF THE FRASER WEB POSTER



APPENDIX 8. "A SHARED VISION" DOCUMENT FOR THE HEART OF THE FRASER INITIATIVE

A SHARED VISION - THE HOPE TO MISSION REACH OF THE FRASER RIVER

FEB. 25, 2006

A SHARED VISION: THE CONSERVATION SIGNIFICANCE OF THE HOPE TO MISSION REACH OF THE FRASER RIVER, BRITISH COLUMBIA

MISSION STATEMENT

Aquatic and lowland habitat loss and alteration in the lower Fraser River continues at an alarming rate due to continued encroachment by land development and extensive resource extraction. The biological and ecological integrity of the stretch of river between Mission and Hope is at imminent risk. Political, corporate, and public efforts must be coordinated and applied in order to counter the rapid disappearance of one of the most diverse and valuable aquatic and lowland ecosystems in British Columbia. Our goal is to identify, conserve, protect and restore key portions of the Hope to Mission reach in order to sustain and secure the biological and ecological integrity of the area.

INTRODUCTION

The Fraser Basin is the largest and most ecologically diverse watershed in British Columbia. The Fraser Basin as a whole is exceptional in its physical scope and biodiversity. This biodiversity includes both aquatic and terrestrial ecosystems. Some of the most diverse and ecologically valuable aquatic and riparian environments in the Fraser watershed occur in the lowland areas between Hope (located at the downstream end of the Fraser Canyon) and the marine environments in the Strait of Georgia.

Over the past several decades, various environmental agencies, including the Fraser River Estuary Management Program (FREMP), have done much scientific work, and have initiated many protective measures, in the Lower Fraser River. These activities have occurred mainly in the Fraser "estuary," between Kanaka Creek (downstream of Mission) and the Strait of Georgia. Other parts of the lower river are not so well understood or protected. We are only now starting to realize the aquatic and riparian values at stake in the section of the Lower Fraser River between Mission and Hope, often referred to as the "Gravel Reach".

The Gravel Reach of the lower Fraser River is named for the substantial volumes of gravel and cobble substrates that largely comprise its stream bottom and banks. Because of the moderate gradient and the mobility of these stream-bed sediments, this section of the river meanders across its floodplain, thus creating highly diverse side-channels, wetlands, and backwaters. The complex geography and hydraulics of the Gravel Reach have produced a robust ecosystem that supports a diversity of aquatic and terrestrial habitats and species.

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A SHARED VISION - THE HOPE TO MISSION REACH OF THE FRASER RIVER

FEB. 25, 2006

With the large influx of human settlement and development in the eastern Fraser Valley, resource extraction and land development continues to occur at unprecedented rates on the remaining portions of floodplain that are not enclosed by dikes. It is becoming clear to many that there is an alarming and pressing need to protect what little is left of these unique and special aquatic habitats and terrestrial landscapes for future generations of British Columbians and Canadians.

Unmatched Abundance of Fish and Wildlife

The integrity of the area's biological and ecological attributes has allowed the development of extensive cultural, spiritual, recreational, and economic values, and these are recognized by both the settler and First Nations communities.

These attributes include:

- the largest-single spawning run of salmon in British Columbia, and perhaps North America (these are pink salmon which reproduce in the main channel of the Gravel Reach and may well exceed 10 million fish on the spawning grounds in some years);
- the largest population of white sturgeon in North America not influenced by dams or aquaculture (white sturgeon are the largest and longest-living freshwater fish in North America — they can attain lengths in excess of 6 meters, weights of over 600 kilograms, and they can live for over 150 years);
- a spawning stock of Pacific eulachon, which up until only a few decades ago was one of the largest runs of eulachon in British Columbia; this small, anadromous smelt leaves the marine environment to spawn in the lower Fraser River in April and May and all individuals die after spawning; the oil- and protein-rich carcasses provide a significant source of food and nutrients for the aquatic, avian, and terrestrial ecosystems of the Gravel Reach, and are an important, traditional food of Fraser River First Nations communities;
- a migration corridor for some of the largest spawning runs of sockeye salmon in North America (most of these originate from upstream populations);
- juvenile-feeding habitat for local-chum and migratory-chinook salmon stocks that rear along gravel bars and within side channels;
- spawning habitat for local chum salmon stocks in the large side channels, which in some years may exceed 1 million returning adult fish;
- habitat that supports approximately 30 different species of fish, including at least eight fishes that are considered to be at-risk: cutthroat trout, bull char (both resident and anadromous), Dolly Varden char, eulachon, white sturgeon, green sturgeon, mountain sucker, and brassy minnow.

There are also many other non-fish species of animals living in the Fraser River Gravel Reach that are found in complex combinations occurring nowhere else in Canada, including:

- aquatic mammals (seals, sea-lions, river beaver, martin);

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A SHARED VISION - THE HOPE TO MISSION REACH OF THE FRASER RIVER

FEB. 25, 2006

- large terrestrial/aquatic omnivores including black (and the occasional grizzly) bear;
- other large vertebrates include blacktail and whitetail deer, cougar, coyote;
- extensive populations of various species of rarer birds including red-tail hawk, green and great blue heron, bald eagle, assorted dabbling ducks, wood duck, purple martin, sandhill crane, turkey vultures;
- the Pacific water shrew (a species at risk);
- amphibians such as the Oregon spotted frog, western red-backed salamander, and the Pacific giant salamander.

The remnant communities of lowland vegetation, including black cottonwood and cedar forests, are also unlike any other in British Columbia.

Unique Features that Make the Gravel Reach Biologically Productive

The Fraser River Gravel Reach functions in a biologically rich and diverse manner because of the extensive lateral and vertical inundation of islands, gravel bars, and the riparian/terrestrial ecosystems over the period of the hydrological year. The vertical range of discharge annually can be over 6 meters. Thus, large-scale flooding during late-spring freshet transports organisms and nutrients across the floodplain. The wide array of physical niches that result provides the opportunities for numerous and diverse ecological relationships to have evolved, and many of these are aquatic in nature.

Another significant physical component is the width, complexity, and moderate instability of the floodplain (composed mostly of gravels and sediments). Sediments are transported through the lower Fraser River every year and these are comprised mostly of silt and sand, with some gravel. Some of the finer sediments are deposited each year on the higher-elevation parts of the floodplain creating rich soils for aquatic, semi-aquatic, and terrestrial vegetation communities. The gravel that moves each year during freshet revitalizes habitats for fish spawning and both fish and insect rearing.

The areas of greatest interest and concern are the river-channel, lowland-riparian and floodplain sections that have not been diked, and can still be subject to river processes and flooding. Thus, the perimeter of the water-surface elevation of the 1894 flood-of-record is the boundary for the primary area of our interest. In the diked sections of the Gravel Reach, the general aerial boundary of concern is to the top of dikes (i.e., all areas across the river channel and flood plain between dikes, up to and including all areas to the elevation of the top of dikes); in undiked areas it is the natural height of land to this same flooded elevation.

Issue: Lack of Planning and Protection

Lower Fraser riparian and in-stream habitats have not been adequately protected through legislation, policy, and regulations, and the associated ecosystems are now in remnants due to extensive destruction and alteration. Furthermore, the lower Fraser River riparian lowlands continue to rapidly disappear due to continued encroachment through land development, agriculture, and industrial activities that include extensive resource extraction (i.e., logging and mining). Although reliable information exists regarding the location of important habitats within the Gravel Reach, and recommendations have been made to protect these ecosystem attributes¹, federal, provincial, and local governments have been unable to protect this world-class ecosystem.

In contrast we point out that in the "Sand Reach" section of the Fraser River (downstream of Mission), the Greater Vancouver Regional District's (GVRD) "Greenway Networks" initiative and the Fraser River Estuary Management Plan (FREMP) have prevented some of the more potentially egregious impacts (downstream of Mission and Kanaka Creek, respectively). Currently, and unfortunately, such protective initiatives are not in place for the Gravel Reach.

Commitments Necessary to Save the Gravel Reach

Decisive and quick action must be taken to protect and maintain the extraordinary and unique Canadian and British Columbian ecosystems found in the Fraser River Gravel Reach before they are lost forever. In order to effectively address and initiate the long-term conservation and protection of remaining key habitats in the Gravel Reach, the following must be considered:

- there must be an extensive effort to increase awareness amongst all stakeholders of the need to protect the outstanding ecological, cultural and social values of the Fraser River Gravel Reach.
- senior governments should be encouraged to utilize existing statutes and regulations to protect the resources that are being impacted.
- the extra-statutory protection of landscapes through property purchase, where legislation and regulation are inadequate, is one tool to achieve ecosystem security;
- in the short term, NGOs will likely have to take the lead in purchasing properties as the political will is not currently in place to protect these ecosystems through government initiatives;
- partnering with senior and local governments to secure these ecosystems would help defray much of the costs to NGOs; because of the flooding nature of these landscapes, the cost of land purchase outside of the dikes, relative to the extraordinary environmental values, is likely to be small (10's of millions of dollars); and

¹ BC Government 1998. *Fraser Lowlands Protected Area Study: Report of the Working Group*. November 1998. 15 p.

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- First Nations constitute a substantial interest in the land ownership of the area and will have to be a key partner if anything significant is to be achieved.

Action Plan Development and Implementation by the Working Group

- 1) An Action Plan needs to be developed as follows:
 - a formal "Lower Fraser River Ecosystem" Working Group should be established, and include participants and representatives from all governments, First Nations, NGOs, and others;
 - roles and responsibilities need to be identified, agreed to, and commitments made;
 - the Working Group will develop a conceptual action plan for distribution amongst all relevant parties;
 - resources need to be secured to undertake initial efforts;
 - mapping, ownership, and land valuation assessments need to be undertaken; and
 - priority landscapes and land holdings (based on ecological value, social/economic considerations, and past reports) needs to be identified and matched with the mapping, ownership, and valuation assessments.
- 2) The Working Group should then engage the appropriate government and non-government bodies who have the capacity to deliver this protection through a variety of options including:
 - outright purchase of private properties - Nature Trust or other such entity to manage in perpetuity;
 - donations of private land into a protected area envelope;
 - evaluation of existing Crown forests within this area to ascertain if a more advantageous land allocation arrangement might be offered to forest companies which would allow the reversion of some sensitive habitats into non-harvestable lands, and subsequent protection;
 - conversion of existing, non-used Crown lands into Section 108 reserves, protected areas, and/or Wildlife Management Areas (WMA's);
 - restrictive-covenant agreements on non-purchasable lands; and
 - alternative options for protecting First Nation lands need to be explored such as the purchasing of outside-of-dike properties, to be added to existing titles, in exchange for not undertaking development on the lowland riparian lands, or the restoration of currently impacted FN properties.

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APPENDIX 9. DONATION OF HARRISON KNOB BY CANFOR TO THE NATURE TRUST AND SCOWLITZ FIRST NATION



MEDIA RELEASE

Canfor Donates to The Heart of the Fraser

**For Immediate Release
September 18, 2006**

(North Vancouver, BC)—In the run-up to this weekend's Rivers Day festivities, Canfor got to the heart of the matter by donating a 22 hectare (54 acre) property on Harrison Knob to The Nature Trust of British Columbia in support of the Heart of the Fraser River initiative.

"Canfor's proud history began along the banks of the Fraser River with one veneer plant in New Westminster. Our growth to become British Columbia's largest forest products company has always included a firm belief in responsible environmental stewardship. As such, we are delighted to contribute this ecologically and culturally significant property and hope that this will encourage others to join in this very worthwhile initiative," said Ken Higginbotham, Vice President of Forestry and Environment at Canfor.

The Fraser River is the world's greatest salmon river. Yet, for the past 13 years it has been prominent on the annual list of endangered rivers in BC as designated by the Outdoor Recreation Council and one of the reasons for this pertains to a loss of riparian habitat. The Harrison Knob, which remains in its natural state, is considered to be extremely important from both an environmental and cultural perspective.

"The Hope to Mission stretch of the Fraser is one of the most productive stretches of river in the world," said Mark Angelo, Rivers Day founder and spokesperson for the Heart of the Fraser initiative. "The protection of the Harrison Knob is a key step forward in protecting this part of the river, which is one of the most important conservation initiatives in Canada," added Angelo, who also heads BCIT's Fish and Wildlife Department.

The Heart of the Fraser initiative is supported by The Nature Trust of BC as well as BCIT, the North Growth Foundation and the Pacific Fisheries Resource Conservation Council and it seeks to boost public awareness of this area's outstanding ecological, cultural and recreational attributes while promoting the need to set aside key properties for conservation purposes.

"This land is located in the heart of Scowlitz Territory. As historical aboriginal title land, it is an important burial site and cultural heritage resource of the Scowlitz people. We look forward to working with The Nature Trust to ensure the ongoing protection of and recognition of our interest in this land," said Chief John Penner.

Doug Walker, CEO of The Nature Trust, said, "We are delighted to accept this significant donation from Canfor for its mature Douglas-fir riparian habitat, its importance as a heritage site to the Scowlitz band and its location at the confluence of the Harrison and Fraser rivers." The Nature Trust has a longstanding commitment to the protection of the lower Fraser area. Since 1971, we have acquired 9 properties totaling 340 hectares (840 acres) including the MacGillivray Slough.

The Nature Trust is a leader in protecting BC's natural diversity of plants and animals through the acquisition and management of critical habitats and other areas of ecological significance. The Nature Trust and our partners have invested \$65 million to secure over 61,000 hectares (150,000 acres) throughout British Columbia.

Conserving BC's natural beauty.

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For more information, please contact:

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