10.3 CUMULATIVE ENVIRONMENTAL EFFECTS

10.3.1 Introduction

Cumulative environmental effects are changes to the environment that are caused by an action in combination with other past, present and future human actions. According to the CEAA guide (Hegmann *et al.* 1999), cumulative environmental effects occur when:

- impacts on the natural and social environments are so frequent, or close, that the combined individual effects cannot be assimilated into the environment; or when
- the impacts of one activity combine with those of another in a synergistic manner creating a cumulative effect that is at least equal, or often greater, in intensity than the total of the individual effects.

This cumulative environmental effects assessment (often called a cumulative effects assessment, or CEA) of the proposed SFPR project has been undertaken to determine the combined effects of the project with other projects and activities in the study area[1]. It determines the incremental contribution of residual effects of the SFPR project, with the impacts caused by all past, present, and where possible future, human activities.

A cumulative environmental effects assessment is a requirement of every screening study under section 16(1) (a) of CEAA. This CEA has been completed using the CEAA practitioners guide as a framework (Hegmann *et al*. 1999), and uses their definition of cumulative effects:

> *"An assessment of the incremental effects of an action on the environment when the effects are combined with those from other past, existing and future actions."*

This CEA has been specifically completed as part of the SFPR project Application for EA Certification. To be considered cumulative, an impact from the project must interact with those from other historical, existing and future projects. Potential interactions with impacts from the SFPR project are the focus of the assessment, and this CEA does not attempt to be a regional resource or land use study that assesses the effects of many developments.

10.3.2 Methodology

The methodology and approach for this CEA is adapted from the five-step approach recommended by Hegmann *et al*. (1999), i.e., scoping, analysis of impacts, significance evaluation, mitigation and monitoring, and follow-up.

10.3.2.1 Scoping

The key component to undertaking this CEA was scoping the issues, identifying:

- SFPR-related potential residual impacts (from the Application) and their spatial and temporal extent;

[1] Different impacts are assessed over a variety of spatial extents; for example impacts on fish are considered at a catchment scale, but air quality impacts are assessed over the much larger airshed of the Fraser Valley.

- residual impacts from historical projects (as requested by reviewers) that define existing conditions in the study area; and
- activities from other projects that may interact with the potential residual impacts of the SFPR project, and the likely impacts.

10.3.2.2 Analysis of Impacts

A matrix was compiled with the issues (SFPR residual impacts) and projects / activities identified in the scoping (**Table 10.3-3**). Where there was an interaction between an issue and a project or activity, there is regarded to be potential for cumulative environmental effect that needed to be considered in the CEA.

To investigate the potential cumulative effects, background data about the issues and activities were collected. These data were quantitatively or qualitatively analysed to assess the potential cumulative effects of the SFPR project with other past, present and future projects. The residual impacts of the SFPR were taken from sections 7 and 8 of the Application. Reference to the appropriate sections of the Application will assist with details of sampling methodology and other impact assessment information used in this CEA.

10.3.2.3 Significance Evaluation

The significance (level) of the cumulative effects, including the contribution of the residual impact of the proposed SFPR project to the total cumulative effect was assessed. A range of characteristics (e.g., magnitude, extent, ecological context, duration and frequency, probability, contribution of the project and reversibility) of the potential effects was considered (section 10.3.5). 'Low' and 'Moderate' residual impacts are not considered significant to populations, but 'High' impacts are considered significant. This significance evaluation is the MOT's assessment, but final determination of significance remains the responsibility of the regulatory agencies.

10.3.2.4 Mitigation and Monitoring Recommendations

Where possible, mitigation measures and monitoring for the identified cumulative effects have been identified. Follow-up mechanism(s) to ensure the effective application of mitigation are also identified. MoT will be responsible, either directly or in its role of overseeing the work of contractors, for ensuring mitigation measures are applied, in accordance with the requirements of the EA documentation for SFPR. In addition, MoT will oversee the implementation of a mitigation monitoring program to ensure that proposed mitigation is implemented effectively to address potential effects.

10.3.3 Scoping

The scoping of the CEA identified projects (**Tables 10.3-1 and 10.3-2**) and associated impacts (**Table 10.3-3**) that collectively could interact with the SFPR. Scoping ensures that the CEA is focussed on the interaction of residual impacts from the SFPR and other projects, and the analysis manageable and practical. It assists in determining if the projects and activities reviewed have the potential to contribute to any cumulative impacts.

10.3.3.1 Scoping Historical, Existing and Future Projects and Activities

Residual impacts, associated with construction and operation of the SFPR Project may act in a synergistic manner with residual impacts from other past, present and future projects in the study area, and result in cumulative environmental impacts. This section describes the criteria that were used in determining which other projects were appropriate for inclusion in the CEA (**Table 10.3-1 and 10.3-2**), summarizes the projects that have been considered and provides a rationale for why some projects have not been considered.

Table 10.3-1 Historical and existing activities and projects, and associated issues, that may interact with the SFPR and are considered in the CEA.

Project / Activity	Impacts	Activity location
Development in Burns Bog - peat mining - farming	Impacts to bog and riparian forest and wetland habitat.	Southwest Delta
Dyking of Fraser foreshore	Impacts to, riparian habitat and wetlands. Aquatic impacts.	Fraser foreshore, Mission to Delta.
Development of railway - BNSF railway - CN railway - SkyTrain	Impact to, riparian, wetland, and cultivated field habitat. Aquatic impacts.	Throughout study corridor including upland areas and areas adjacent to Fraser River.
Municipal development - Farming - Fraser River ports - Housing development - Industrial parks	Loss of all habitat types, habitat fragmentation & wildlife movement change. Aquatic, air quality and noise impacts.	Listed projects located 500 – 1,000 m either side of SFPR corridor.
Transportation infrastructure - Highways (1, 17 & 99) - Major roads (River Rd) - Minor (municipal roads) - Bridges	Loss of all habitat types, habitat fragmentation & wildlife movement change. Aquatic, air quality and noise impacts.	Listed projects located up to 500 m either side of SFPR corridor.
Highway 91 between 64th Ave and the Alex Fraser Bridge	Air quality impacts. Bog and riparian forest and wetland habitat loss. Change to wildlife movement and habitat fragmentation.	North Delta / Nordel area.

Table 10.3-2 Future activities and projects, and associated issues, that interact with the SFPR and are considered in the CEA.

Project / Activity	Impacts	Activity location
Border Infrastructure Project	Air quality impacts.	Canadian Lower Fraser Valley airshed
North Fraser Perimeter Road Project (including Pitt River Bridge Project)	Air quality impacts	Canadian Lower Fraser Valley airshed
Port Mann Hwy. 1 Project	Air quality impacts Habitat loss impacts	Canadian Lower Fraser Valley airshed. Upland areas adjacent to the SFPR
Golden Ears Bridge	Air quality impacts Habitat loss impacts.	Canadian Lower Fraser Valley airshed. Upland areas adjacent to the SFPR
BCTC transmission line	Habitat loss to cultivated fields.	Southwest Delta
Deltaport Third Berth	Air quality impacts	Canadian Lower Fraser Valley airshed
Terminal 2	Air quality impacts	Canadian Lower Fraser Valley airshed

The study areas assessed in this CEA have been intensively developed over many years, but there are also many values (e.g., Burns Bog). An examination of the impact of residential, industrial and infrastructure development in the study areas over the long-term (past 100+ years) in the context of considering the cumulative impacts associated with the SFPR shows that any SFPR-related residual impacts are proportionally smaller than those of other more extensive residential, industrial, commercial and agricultural developments. Such historical development in the study area includes:

- approximately 3,950 ha of residential development for around 110,000 people (Table 8.3-3);
- industrial and commercial activity utilising 1,600 ha (Figures 8.3-1a and b);
- transportation infrastructure dominating the south bank of the Fraser River and;
- agricultural activity that encompasses 7,500 ha (Table 7.1-3).

These activities have dramatically altered the pre-contact conditions. The Fraser River would have once been more mobile (i.e., moving across the floodplains of Delta and Bridgeview), the slopes of the south bank escarpment would have been fully forested, and wetlands and watercourses surrounding Burns Bog would have held habitat for a different suite of species and been more connected to the Fraser River. Despite this there are many values still remaining, e.g., the raised peat dome of Burns Bog, riparian forests in the Delta escarpment ravines, habitat for waterfowl in agricultural fields.

The magnitude of residual impacts and proportion attributable to the SFPR (250 ha area of impact = footprint + 5m on both sides of the alignment) is only one of the factors that will be assessed in this CEA. Other factors related to the impacts of the projects and activities include the resilience of the ecosystem (ecological context), and the extent, duration and reversibility of the impact. Understanding how the projects and activities assessed (including the SFPR) relate to these factors is difficult, especially for projects and activities that have been in place or ongoing for many years. There is a lack of baseline information and control locations (comparison against unaffected areas) in the literature with which such assessments can be undertaken. The approach adopted in this CEA largely considers the footprint impacts of the existing level of development for past and present projects and activities (as these are easier to obtain), and layers the impacts of the SFPR and other projected projects on these. As such the temporal scope of this CEA primarily considers the impacts of projects and activities in the past 30 years, for which there are comparative data on which to make reasonable assessments of impacts due to all the factors under consideration (e.g., magnitude, extent, duration, ecological context, contribution). For the older projects, that have been particularly defining for their potential to contribute to any cumulative impacts in the study areas (i.e., railway development on the south bank of the Fraser River, channelisation of Cougar Canyon Creek and Burns Bog peat mining) best professional judgement has been used to undertake assessments that include factors other than magnitude / contribution of the project.

Each of the projects considered in this CEA (**Tables 10.3-1 and 10.3-2**), the potential for impacts from them to interact with those of the SFPR, and the rationale for exclusion from the analysis (where applicable) is presented below. Analysis of the potential for cumulative impacts is presented in section 10.3.4.

- **Development in Burns Bog**

  The historic extent of Burns Bog is estimated to be 4,800 ha (Rigg and Richardson 1938, cited in Hebda *et al*. 2000). Farming, peat mining, industry, infrastructure development (landfill, utilities, roads and railways) and residential housing have reduced the area of the bog to approximately 2,800 ha. Drainage and land clearance for farming since the 1870s have contributed to habitat loss and impacts to hydrology conditions as a result of their activities in and around the bog. Peat mining from the 1940s to the mid 1980s has resulted in alterations to habitat and hydrology and habitat loss, but much of the land disturbed by mining (other than that occupied by the City of Vancouver landfill) remains part of the bog. Railway (BNSF), road (Highway 91, see below), utility (gas, transmission line and sewer), industry (River Road industrial sites) and residential housing (Panorama Heights) have also reduced the area of the bog. Impacts to Burns Bog associated with all these activities are considered in this CEA.

- **Dyking of Fraser River foreshore**

  Containing the movement of the Fraser River has contributed to loss of fisheries habitat, as the movement of water and fish into tributary reaches has been constrained by the dykes and other foreshore developments (e.g., ports). While there are no residual effects on Fraser River fisheries habitat (or other fish habitat) predicted as a result of the SFPR, impacts to fish habitat as a result of changes to water quality and quantity from the SFPR and other activities are considered in this CEA.

- **Development of railway**

  Development of the Burlington Northern Santa Fe (BNSF) Railway (adjacent to Highway 91 and the Fraser River), the Canadian National (CN) and Canadian Pacific (CP) Railway (adjacent to Fraser River) and the SkyTrain (parallel to the Pattullo Bridge) was considered in the CEA. The Development and operation of the CN/CP and BNSF railways contribute to habitat loss, air and noise emissions in the study area and have been considered in this CEA, but the SkyTrain does not and it has not been assessed.

- **Municipal development (residential, rural and industrial development)**

  Development within municipalities consistent with the respective Official Community Plans (OCP) that is considered in this CEA includes farming (berry, crop and livestock), ports (Fraser Surrey Docks, Gunderson Slough and other port facilities on the south bank of the Fraser River), industrial developments (Tilbury Island, River Road, Nordel area, South Westminster and Bridgeview), the CN Intermodal yard and housing development (North Delta, Annieville, South Westminster, Bridgeview, Bolivar Heights and Fraser Heights). Such development has contributed to habitat loss in the study area, and allows for other activities that contribute to air and noise emissions. Habitat loss and fragmentation, wildlife mortality, stormwater runoff and air and noise emissions from all these activities have been considered in this CEA. The exceptions to this are habitat loss due to port activities, as there is no impact on the Fraser River foreshore as a result of the SFPR.

- **Transportation infrastructure**

  Transportation infrastructure in the study area, including highways 1, 10, 17, 91 (see below) and 99, major roads (Deltaport Way, River Road, South Fraser Way, King George Highway, 176th Street and Scott Road), bridges (Pattullo and Alex Fraser bridges) and all minor municipal roads (including 72nd Street) are considered in this CEA for their contribution to regional air emissions and habitat loss. The noise created by traffic on these roads is also assessed, as is their contribution to stormwater impacts.

- **Highway 91**

  Highway 91 between 64th Ave and the Alex Fraser Bridge was constructed in the mid 1980s through an area adjacent to Burns Bog. The habitat loss, fragmentation and hydrology alteration issues associated with this road are assessed in this CEA. The impacts of vehicles on this road on air quality and noise in the study area are also considered in this CEA.

- **Border Infrastructure Project (BIP)**

  Improvements to highways 10, 11, 15 and 91/91A as part of the Border Infrastructure Project are considered in this CEA with respect to air quality issues. In general it is considered that the BIP is too distant from the SFPR local study area to interact with impacts associated with the SFPR, but there is potential for it to contribute to cumulative regional air quality changes and the potential for these impacts have been considered.

- **North Fraser Perimeter Road/Pitt River Bridge Project**

  The North Fraser Perimeter Road (NFPR) project, which includes the Pitt River Bridge and Maryhill Interchange Project that is currently under construction, is considered in this CEA. With the exception of the Pitt River Bridge project, the proposed NFPR project is currently at a conceptual design stage, which assumes that improvements will occur within the existing road right of way. Given that works, when advanced, will occur within an existing and developed road right of way, there is a low likelihood of residual effects on ecological values that might interact with residual effects associated with the SFPR project. In addition, given that the corridors are spatially separated and ecologically different from one another, ecological values associated with the SFPR project do not occur within the NFPR corridor. As such, the CEA with respect to the North Fraser Perimeter Road project is focussed on potentially cumulative regional air quality changes associated with future predicted traffic in the NFPR corridor.

- **Port Mann Highway 1 Project**

  Improvements to the Port Mann Bridge and Highway 1 (part of the Gateway Program) are considered in this CEA as they pertain to air quality and noise issues, and to a small extent habitat loss.

- **Golden Ears Bridge Project**

  The new Golden Ears Bridge (GEB) crossing of the Fraser River (a TransLink project due for completion in 2009) is considered in this CEA as it contributes air emissions to the regional airshed and potential cumulative effects from habitat loss.

  Habitat fragmentation impacts on Pacific water shrew (PWS) were considered for the GEB project. However, as a result of mitigation completed for that project no residual impacts on PWS are expected. The provision of two crossing structures over Unnamed Creek (rated 'moderate' for capacity to support Pacific water shrew) allow for Pacific water shrew to cross between habitats on either side of the road. Such mitigation avoids fragmentation of its habitat. Construction of the crossing structures, one clear span (bridge) over the permanent part of Unnamed Creek and one culvert over an ephemeral part of the watercourse, was preceded by an extensive seven-day trapping programme to salvage Pacific water shrew from the construction areas. No Pacific water shrew were found during the salvage programme. On the basis of this information it is considered unlikely that residual habitat fragmentation effects from the GEB project on PWS will interact with the residual effects of the proposed SFPR project.

- **BCTC transmission line upgrade**

  Habitat loss associated with the BCTC transmission line upgrade through southwest Delta is not considered in this CEA, as the loss of habitat is negligible (replacing two lines of towers with one), and environmental values in the transmission line corridor (i.e., cultivated field values to wildlife) will likely remain after construction is complete. In addition, it does not involve additional operational activities relative to those that currently exist.

- **Deltaport Third Berth Project**

  The Vancouver Port Authority Deltaport Third Berth project (due for completion in 2009) is considered in this CEA for its potential to contribute cumulatively to regional air quality changes.

- **Terminal 2 Project**

  The Vancouver Port Authority Terminal 2 (T2) Project may occur at some time in the future, but the extent of the project is not accurately known because the VPA "has not advanced the proposal beyond the point of identifying a potential site location [Roberts Bank] and desired capacity [1.9 -2.2 million twenty foot equivalent units (TEU, a measure of goods throughput)]" (VPA 2007). With this knowledge the potential for cumulative impacts on regional air quality (i.e., number of vessels, trucks and trains) was considered in this CEA. However, the potential for cumulative impacts on habitat cannot be considered, because "on-site services and offsite road and rail requirements have not been established and will require extensive studies before they can be confirmed" (VPA 2007).

  The schedule for Terminal 2 is yet to be determined, but it is included in this CEA because it is regarded to be a foreseeable project. When the T2 project undergoes its own environmental assessment, a CEA that includes the SFPR project will likely be undertaken.

  While all the residual impacts from T2 that might interact with the SFPR are not known, an assessment of the predicted air quality impacts can be undertaken and is included in this CEA.

The projects or activities considered in the CEA have all satisfied the following test that considers the relevance of the project for analysis in the CEA (Hegmann *et al.* 1999):

- Temporal – the effects of other planned projects or activities must occur or overlap with the time when the effect of the SFPR Project is expected to occur; or
- Spatial – the effects of the other planned project or activity must be expected to overlap the spatial area affected by SFPR Project; or
- Type – the environmental effect of the other planned project or activity must be sufficiently similar or capable of interacting with the effect of SFPR Project to produce a combined effect on the ecosystem component in question.

The past, present and potential future activities assessed in this CEA satisfy at least one of the above noted tests.

It is difficult and often impossible to accurately predict the effects of future projects. However, in addition to the criteria identified above, and as outlined in the Approved Terms of Reference for the Project, the CEA for SFPR has considered, “other significant projects that: are within a defined corridor of reasonable scale and significance; that are known to have required permits and authorizations which would allow the projects to proceed to implementation; or have secured funding and schedules and timelines known to be imminent in their commencement up to the submission of the SFPR Application”.

Within the study area there are other potential projects that could take place that are not considered in the CEA. Given that they do not meet the criteria identified above, potential residual effects from the projects noted below have not been considered in the CEA. The projects and the rationale for their exclusion from CEA analysis is as follows.

- **Potential development of agricultural lands by the Tsawwassen First Nation (TFN)**

  The potential for agricultural land to be converted to other uses as a result of the treaty with TFN is unknown. All that is known is that ownership of this land and inclusion in the ALR might change, but there is no indication of the extent, if any, that this will result in a change to agricultural production. This activity is not assessed further, as the likelihood of change is highly speculative, and agricultural use of land, a socio-community issue, is not considered in a CEA unless there is a biophysical impact (section 10.3.3.2).

- **Potential expansion of rail corridors**

  While there has been some informal indication that additional railway lines may be proposed for the SFPR study area, no formal announcement of such a project has been made. In conjunction with the Deltaport Third Berth Project there will be minor expansion of a siding west of Highway 17 adjacent to Deltaport Way, but this was not judged to result in the potential for cumulative effects. The small (1.9 ha) area affected by the DP3 rail expansion is existing railway right-of-way along a 1.2 km portion of land adjacent to Deltaport Way and the existing railway line between 57B and 64th streets. It is currently occupied by a gravel road, scrub and grass vegetation with few values for wildlife. There is no potential for more fragmentation of habitat as, in addition to the habitat being of negligible value, the area is already fragmented by the existing developments. Until any other rail expansion is announced and the impacts identified no cumulative effects assessment of this activity is required.

- **Future residential/commercial and agricultural development.**

  Due to the conceptual nature of the plans for future residential/commercial and agricultural projects and activities, as described in Official Community Plans (OCPs), the assessment of potential cumulative effects of these projects and activities in combination with the SFPR has been focused on cumulative changes in air quality.

The respective OCPs in the study area have predicted and planned for the potential impacts of build-out to the extent of the OCP. The OCPs are required of each municipality by the *B.C. Local Government Act* as a statement of objectives and policies to guide decisions on planning and land use management (s.875). Their purpose is to provide (among other goals) stewardship of public assets and foster economic, social and environmental well-being (s.2). Development to the extent of the OCP will occur with or without the SFPR, but the rate of such development may be faster as a result of the SFPR (section 8.4). The potential for OCP build-out to occur faster is not predicted to lead to residual impacts, as the actual impacts on habitat loss and fragmentation, wildlife pattern changes and collision risk is the same with or without the SFPR. For these reasons, the CEA has focused its assessment on the potential for cumulative changes in air quality.

10.3.3.2 Impacts Scoping

All residual impacts from the SFPR project with a potential to interact with other past, present and future projects were included in the impacts scoping. The criteria used to determine residual impacts are detailed in the respective portions of sections 7 and 8 of the EA Application.

The following impacts were considered appropriate to the CEA analysis for the SFPR:

- **Habitat Loss.**

  A reduction in habitat potentially affects the resources available to support threatened and other wildlife species and affects the intrinsic values of the habitat. The specific habitats (VEC) that have potential residual impacts as a result of the SFPR are: riparian forest, upland forest, Burns Bog habitats, cultivated fields and wetlands. Though for many of these, proposed compensation such as protection of an equivalent or larger area will address the residual impacts. Despite this, the loss of these habitats impacts a range of species including; threatened mammal species (e.g., red-backed vole), red-legged frog and other amphibians, red-backed vole and other small mammals, sandhill crane and threatened aquatic insects. Habitat loss reduces the area available for these and other species, and also has implications for fragmentation and isolation of habitats.

  The spatial extent for these VEC will differ; for riparian forest it includes the riparian zones in the catchment of watercourses crossed by the SFPR alignment. For Burns Bog, it is the extent of the identified area required to support a viable water mound (Hebda *et al*. 2000). For upland forest it is the assessed study area; within 250-500 m of the centreline of the proposed SFPR. The study area is the area for which appropriately detailed ecosystem information exists, and was defined in consultation with review agencies (see section 7.7). The study area for vegetation and wildlife values was defined, with input from federal and provincial environmental agencies, as part of the development of workplans to collect information to support the impact assessment of the Project. This corridor was considered to be sufficiently large to identify ecological values, including habitat, which could be directly or indirectly be impacted by construction and operation of the Project.

- **Habitat Fragmentation**

  Vegetation clearance, in addition to removing the habitat for wildlife (see above), can also disrupt the continuity of previously intact habitats that support wildlife species dependent on contiguous habitat (habitat fragmentation). While small losses of habitat that lead to fragmentation might only slightly reduce the habitat available, its impacts are greater than this small loss indicates. This is because many species are unable to survive in areas that are bisected by unsuitable habitat, or the disturbances introduced by the fragmentation lead to mortality (see below), or the impacted areas are a barrier to movement (see below).

  For the SFPR, the habitats impacted by fragmentation are riparian forests that support Pacific water shrew, and amphibians, and upland forests that provide resources for raptors and songbirds.

The study area for assessing the potential cumulative effect of these impacts (and similar impacts from other projects) is the wildlife and vegetation study area 250 to 500 m from the centreline of the proposed SFPR (section 7.7).

- **Wildlife Pattern Changes**

  Wildlife pattern changes include two related types of impacts due to the location of a new road in an area; avoidance of an area by wildlife because of indirect impacts (zone of influence) and avoidance (or prevention of use) of a travel corridor currently used by wildlife.

  The introduction of noise and visual disturbances as a result of the SFPR is predicted to be a residual impact on the use of parts of the study area by wildlife. For many species such disturbances will cause them to avoid the area and these impacts are essentially habitat loss, as they reduce the resources available. The species that are affected include water associated birds such as sandhill crane and trumpeter swan, and forest and grassland passerines.

  The disturbances introduced by a linear development can also act as a barrier to movement of wildlife. In the SFPR study area there are a number of routes used by wildlife for travel corridors. These include deer, amphibians, reptiles and small mammals travelling between Burns Bog and other forest areas (Fraser Heights) and adjacent wetland and or agricultural areas for foraging.

  The study area for assessing the potential cumulative effect of these impacts (and similar impacts from other projects) is the area 250 to 500 m from the centreline of the proposed SFPR. The study area is the area for which appropriately detailed ecosystem information exists, and was defined in consultation with review agencies (see section 7.7).

- **Wildlife Mortality from Collisions**

  The impact of wildlife colliding with vehicles has potential to result in individual mortalities, and with similar impacts from other projects and activities may over time, result in population level impacts. Wildlife mortality is greater for new roads that bisect previously undisturbed habitats, than for existing roads. There were potential residual impacts as a result of wildlife mortality from SFPR-related collisions identified, especially for barn owl.

  The spatial extent (study area) of wildlife mortality from collisions is the footprint area of roads adjacent to habitat in which susceptible species are located (predicted location of potential residual impacts due to collision, see section 7.7). For the SFPR this is road segments through fields adjacent to Burns Bog and Crescent Slough near the proposed Highway 99 Interchange.

- **Aquatic Habitat Impacts**

  The potential impacts on the aquatic environment that could contribute to cumulative effects on aquatic habitats are the loss of aquatic and riparian habitat, and changes to water quality and quantity. Avoidance measures, and mitigation and compensation in conjunction with the SFPR are considered to avoid residual impacts on riparian and aquatic habitat. As no residual impacts on habitat have been identified (Section 7.4), other than a short description of the rationale for this decision, they are not considered further in this CEA. There is potential for water quality and quantity changes to have residual impacts, and these are the subject of analyses of potential aquatic habitat cumulative impacts in this CEA.

The proposed SFPR project will achieve no net loss of aquatic habitat because the impacts (estimated at 3.1 ha of aquatic habitat and 14.5 ha of riparian habitat) are less than the areas available for compensation. As a result there will be no residual impacts on aquatic habitats, and therefore no potential for cumulative effects are predicted.

The study area contains a large number of watercourses that could be impacted by changes to water quality including increased sedimentation and / or changes in water quantity (related to changes in impervious surface area). Mitigation measures, including meeting stormwater management performance objectives identified in section 4.2.2.1 and best management practices to avoid and minimize impacts on water quality are anticipated to ensure no residual impacts on water quality. In addition to these mitigation measures outlined in the EA Application, the stormwater management plan (submitted to reviewing agencies during the Application review) and computer models developed to aid design of drainage infrastructure in Delta to further demonstrate how the project will avoid residual impacts on water quality. As a result, there is not anticipated to be any interactions with the impacts of other projects and hence no potential for cumulative impacts. While no residual impacts are identified, this issue is discussed further as there are other activities in the study area that contribute similarly to water quantity and quality changes.

The study area for assessing aquatic impacts is the watercourses crossed by the proposed SFPR alignment.

- **Air Quality**

There is potential for an increase in air emissions (criteria air contaminants, CAC and greenhouse gases, GHG) as a result of the proposed SFPR, and this in conjunction with other projects and activities in the area (other roads and highways, shipping, trains, commercial and residential development) may lead to cumulative environmental impacts.

Residual impacts were identified associated with an increase in SFPR-related air emissions (section 7.2), but these impacts were not identified as being significant. Air quality has been considered in this CEA, because other projects and activities in the study area (the Canadian lower Fraser Valley airshed) contribute to air emissions, which currently exceed some regulatory standards, and there is interest in including air quality in this CEA as indicated by reviewing agencies. The GVRD emissions inventory, which was used as the basis for this assessment, includes the emissions from all mobile (cars and trucks, trains, airplanes and ships) and non-mobile (industrial and residential) sources in the study area. As such, the CEA analysis for air quality includes all the activities in the study area (the Canadian lower Fraser Valley airshed) that contribute to emissions.

The general contribution of residential, industrial, commercial and agricultural activities on emissions of air quality contaminants in the study area (Table 7.2-2) are considered in the assessment of regional air quality impacts presented in this CEA analysis. This includes the mobile sources such as cars and trucks on all highways, bridges and roads in the regional study area, ships and airplanes, and non-mobile sources such as residential housing, industrial and institutional emissions. This assessment and the data used are consistent with Greater Vancouver Regional District data on air emissions in the Canadian lower Fraser Valley airshed, which also includes all mobile (i.e., cars, trains, ships and airplanes) and non-mobile (i.e., industrial and residential) sources.

- **Change in Noise Levels**

  Impacts to the noise environment as a result of traffic on the SFPR Project identified the potential for residual impacts, and these in conjunction with other projects and activities in the area have the potential to contribute to cumulative environmental effects.

  For the SFPR, despite the application of mitigation (i.e. noise walls) as per the MOT noise policy, 'severe impacts', as defined by Health Canada[2], are predicted for 7 sites (each representing a residential enclave). However, the use of quiet pavement, coordination of traffic signals and noise walls at specific locations along the SFPR corridor will limit 'severe impacts' to just one site. Further evaluation of noise walls will be completed during detailed design to further reduce noise impacts. Health-related residual impacts from SFPR, associated with speech/sleep interference, range from minor to moderate when noise barriers and quiet pavement are utilized in the affected areas.

  The study area for the noise assessment is all residential land uses and any schools, commercial daycare centres or hospitals along the study corridor where it is reasonably expected that ten years after project completion, 24-hour Equivalent Sound Level (L_{eq}(24)[3] at ground floor level (due to the new or upgraded highway, and all other non-highway sources as appropriate), will equal or exceed 55 dBA L_{eq}(24). Section 8.1 of the Application, provides additional detail with respect to how the data used in this assessment was generated.

  Noise impact assessments are cumulative in nature because they capture, through baseline noise monitoring, noise created by all existing activities (and do not need to include historic projects that are no longer operational). In this CEA, baseline (pre-project) measurements of noise at locations in the SFPR corridor include vehicles on all existing roads, trains, airplanes, ships, industry and residential activity. The potential noise of the SFPR and future planned projects with a potential residual effect that could interact with SFPR (i.e., Port Mann Highway 1 Project) is then added to the baseline noise level.

These issues, and in particular the interaction of project-related activities with other projects are discussed below in the analysis of effects (section 10.3.4).

In addition to the issues noted above that are considered in the CEA, there are a number of issues and associated VEC and valued socio-community components (VSC) that were considered during scoping, but analysis was not undertaken in the CEA. The following provides rationale for why these were not included.

- **Archaeology**

  The study area contains significant archaeological resources that could potentially be impacted by the Project including those at the St. Mungo and Glenrose Cannery sites. However, based on work done

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2 I where the increase in the percentage of residents considered 'highly annoyed' is greater than 6.5%

3 The principal metric for the noise environment in this assessment is the 24-hour equivalent sound level, or L_{eq}(24), a single-number descriptor of the average sound energy exposure over a 24-hour day. The L_{eq}(24) is commonly used to describe noise from road and railways. In addition, to reflect the greater sensitivity of residential communities to intrusive noise at night another metric was also used. The day-night average noise level, or L_{dn}, is a time-averaged sound energy level like L_{eq}(24), but it does not treat daytime and night time noise equally. To compute L_{dn}, a 10 dBA night time penalty is applied to all noise levels projected to occur between 10:00 PM and 07:00 AM.

to-date to confirm the distribution of archaeological resources, in addition to future recommended work and proposed measures to protect archaeological resources during and post-construction, no residual adverse environmental effects on such resources are anticipated. As no residual environmental effects on archaeology were identified during the EA review, archaeology was not considered further in the CEA.

- **Hydrogeology** – There are a number of areas through the corridor, including the area adjacent to Burns Bog, where potential effects on ground water could occur. In most areas, potential effects to groundwater can be avoided through the application of standard best management practices.

  However, in some areas of the alignment adjacent to Burns Bog, it is recognized that careful planning and specialized mitigation will need to be developed in order to avoid potential impacts to local hydrogeological conditions (i.e., horizontal movement of ground water, water levels and water chemistry) as well as resultant changes to the plant communities associated with Burns Bog that are dependent on the Bog's unique hydrological conditions.

  As such, site-specific hydrology mitigation infrastructure will be integrated into the design and construction of the proposed road in order to avoid potential impacts to hydrology associated with Burns Bog. For example, along the north edge of Burns Bog, a lagg pond ecosystem complex (LPEC) is proposed in order to provide an interface, between the road and bog to assist in managing hydrological conditions and to encourage and maintain conditions necessary for conservation and restoration of Burns Bog. The LPEC will consist of a series of interconnected ponds which are separated from the highway by a vegetated berm. The vegetated berm will assist in intercepting air emission into Burns Bog, limiting access, and controlling the movement of waters exiting Burns Bog. Water levels in the LPEC will be managed, through a series of control structures, in order to maintain hydrological conditions that support conservation and restoration objectives identified in the long term management plan for the Burns Bog Ecological Conservancy Area (BBECA).

Such infrastructure will be developed using proven engineering, geotechnical and construction practices and will be required to meet the following objectives:

- **Site specific solutions –** The design, construction and operation of hydrology mitigation will be based on, and take into account, site specific conditions such as hydrology, soils, vegetation and adjacent land use.

- **Compatibility between highway water management and bog water management functions –** Mitigation concepts will provide for water level controls at the edge of Burns Bog and the ability to maintain high water levels within Burns Bog independent of highway water management. Control structures will be designed to require minimal maintenance, but allow for occasional adjustments.

- **Prevention of mineral migration into the bog –** Mitigation concepts will provide for the maintenance of water table gradients, so that water flows from Burns Bog toward the highway at all times, including droughts and extreme precipitation events. The selection of materials used for berm construction will consider the requirement for having appropriate vegetation on the berm and the need to avoid the introduction of mineral materials into Burns Bog.

- **Resilience –** Hydrology mitigation will be sufficiently robust to maintain high water levels in Burns Bog under average and extreme conditions and if bog conditions change (e.g. due to climate change or mound growth), over a 200 year timeframe.

- **Highway and mitigation construction does not preclude future restoration of Burns Bog –** Hydrology mitigation concepts will be adaptable and provide for flexibility of design and operation that allows, for example, for future water control structures that allow for raising of water levels as part of future Burns Bog restoration.

- **Holistic design –** Hydrology mitigation concepts are designed in a way that will ensure they will be compatible with, and help achieve, multiple, mitigation requirements of hydrology, aerial deposition and wildlife.

The design, construction and operation of hydrology mitigation concepts will be undertaken in partnership with federal, provincial and local governments responsible for the management of the BBECA and the restrictive covenant that guides management of this area. The design, construction and operation of the road, and hydrology mitigation will also be advanced in a way that complements and supports the long-term conservation and restoration objectives for Burns Bog that have been identified in the management plan for the BBECA.

Development of the proposed hydrology mitigation concepts will be advanced in parallel with a monitoring and follow up program that assesses the performance of hydrological mitigation measures in managing hydrology at the interface of Burns Bog and SFPR. The monitoring program will collect and assess information that supports evaluation of the performance of hydrological mitigation measures in avoiding changes to hydrological conditions in Burns Bog. The program will include monitoring of hydrological monitoring stations in and around Burns Bog and comparison of results to pre-construction baseline conditions for water levels, flows and hydrochemical conditions.

The mitigation infrastructure will be designed with the capacity to actively manage hydrology at the interface of the Bog and highway. In the event that hydrological mitigation does not achieve intended results, in terms of the performance of proposed mitigation infrastructure, steps will be taken to adaptively manage the hydrology mitigation infrastructure including:

- adding additional hydrology mitigation infrastructure to include additional areas adjacent to the alignment;

- modifying the structure and/or function of mitigation infrastructure (e.g., raising the level of berms, changing infrastructure regulating water flows etc.); or

- changing the management or maintenance processes associated with operation of the hydrology mitigation.

Based on proposed hydrology mitigation concepts and monitoring and follow-up programs, including adaptive management measures that can be taken to provide further mitigation if necessary, potential effects to hydrological conditions associated with Burns Bog can be avoided. Through this approach, potential effects to hydrological conditions in and around Burns Bog will be addressed, and it is assumed there will be negligible residual impacts. Given the Province of BC's support for the implementation of the long term management plan for the BBECA, the Ministry of Transportation will ensure that the planning, design, construction and operation of the road is done in a way that supports and compliments long-term restoration and conservation objectives for the area. In this context, over the longer-term residual effects associated with historic development adjacent to Burns Bog will be addressed and further consideration of cumulative effects to hydrogeology is not supported.

- **Agriculture**

  While there are impacts to agricultural land, associated with direct footprint impacts in southwest Delta, the impact to such land in the context of potential impacts on the agricultural sector is not evaluated in the CEA (as per CEAA guidelines). Proposed compensation (i.e., support for an Agricultural Enhancement Strategy March 2007) to offset impacts to agricultural land (section 7.1.5.4) is expected to ensure that there is no residual impact on the agricultural sector in southwest Delta as a result of the SFPR. The loss of agricultural land, in the context of it providing some wildlife habitat value (loss of agricultural land that supports waterfowl and other avian species) is discussed in the CEA (section 10.3.4.1).

- **Contaminated sites**

  While there are a number of potentially contaminated sites throughout the corridor, all contamination will be managed in compliance with relevant legislation and regulation. As such, it is anticipated that the Project will not result in adverse residual impacts from contaminated sites, and in some cases may result in improvements (i.e., reduction in the number of contaminated sites in the study area).

- **Socio-community/Socio-economic**

  While there are a limited number of potential adverse impacts on socio-community and socio-economic conditions in the SFPR corridor, the majority of these have been/will be addressed in future stages of project planning and no residual impacts were identified. Where adverse impacts have been identified (e.g., loss of commercial/industrial land), it is not expected that they will result in changes to VEC or VSC. As such, socio-community and socio-economic values potentially impacted by the Project have not been considered in the CEA. Furthermore, socio-community / socio-economic impacts (including agriculture and archaeology) are not within the scope of a CEA (as per CEAA guidelines), unless the impact is attributed to a project-related residual impact on biophysical resources. As such, in the case of SFPR socio-community and socio-economic values are not considered in the CEA.

Table 10.3-3 Potential cumulative effects identified by the interactions of residual impacts of the SFPR and other projects on VEC.

Issue	Habitat Loss					Habitat Fragmentation		Wildlife pattern changes	Wildlife Mortality	Aquatic Impacts	Air Quality			Noise
Project / VEC	**Riparian Forest**	**Upland Forest**	**Cultivated Fields**	**Wetland**	**Bog Forest**	**Riparian Forest**	**Upland Forest**	**Mammals**	**Barn owl**	**Fishery Value**	**CAC**	**GHG**	**PM**	**Change in noise**
SFPR	■	■	■	■	■	■	■	■	■		■	■	■	■
BIP (2005)			■					■			■	■	■	
Pitt R. Bridge, NFPR (2009)											■	■	■	
Port Mann / Hwy 1	■	■								■	■	■	■	■
GEB (2009)	■	■		■				■			■	■	■	
Hwy 91	■			■	■	■		■	■		■	■	■	■
BCTC power line upgrade (2008)			■											
DP3 (2009)								■	■		■	■	■	■
VPA Terminal 2											■	■	■	■
Railway growth	■		■	■				■		■			■	
Dyking Fraser River	■			■						■				
Municipal development	■	■	■	■	■	■	■	■		■	■	■	■	■
Transportation infrastructure (hwys/local rds)	■	■	■	■		■	■	■	■		■	■	■	■
Burns Bog developments	■			■	■								■	

* A full list of the projects and activities included in these headings is given in the projects scoping, section 10.3.3.1.

10.3.4 Analysis of Impacts

Each of the issues (**Table 10.3-3**) is discussed below relative to effects on appropriate issues (VEC), and in particular the residual effects related to the actions of the SFPR Project. The assessments that follow are summarised in **Table 10.3-7**.

10.3.4.1 Habitat Loss

Habitat loss in general, and habitat losses that affect particular species, are considered in this CEA. In general the gradual action (nibbling effect) of habitat removal as a result of activities is considered to be the mechanism by which cumulative effects of habitat loss may occur. The overarching principle for the assessment of habitat loss impacts as a result of the SFPR is to consider ecosystems (habitats) that in turn provide for the maintenance of individuals and populations of species. Thus, the framework for the assessment of potential for habitat loss cumulative impacts is based on the SFPR footprint impacts on habitat categories identified in the vegetation and wildlife assessment report (Technical Volume 12, and section 7.7.3.5). These include habitat loss from the SFPR on upland and riparian forests, cultivated fields, wetlands and Burns Bog. There are also indirect (non-footprint) impacts related to disturbance (i.e., zone of influence impacts) adjacent to the road where wildlife use is diminished. These indirect impacts from the SFPR are assessed quantitatively in the Zone of Influence report (August 2007). However, due to a lack of quantitative information about the indirect effects of other projects and activities, a qualitative assessment of the potential for cumulative effects is conducted in this CEA.

Within this assessment framework, the SFPR mitigation and compensation proposals are built around the maintenance and/or enhancement of regional ecosystem function (rather than addressing site- or species-specific impacts). It is acknowledged that there are species and locations (red- and blue-listed plant communities and species) vital for maintaining regional biodiversity. These components are specifically considered in the Application and in this CEA, especially where mitigation and compensation for habitat protection alone is insufficient to address residual impacts. This includes specific mitigation measures to address fragmentation, changes to wildlife movement patterns and collision risk (i.e., hedgerows to minimize the potential for vehicle collisions with barn owl and to visually screen the SFPR from foraging sandhill crane). Residual impacts on these species have been minimised through such mitigation, however the potential for cumulative impacts on these at-risk species is explored in sections 10.3.4.3 and 10.3.4.4. To ensure that the impacts were adequately quantified and that mitigation effectively addresses these impacts a monitoring program is being prepared for these and other species.

Disturbance to vegetation has the potential to affect plant communities and species that are both common and uncommon (at-risk). Habitat loss affecting rare (red- or blue-listed) communities and plant species (SARA and or red- or blue-listed) may involve only a small area, but this may have an impact because at-risk plant species may not occur elsewhere, giving the area important biodiversity value. For each habitat type in this section the potential cumulative impacts on at risk species and/or communities are considered where appropriate.

At-risk plant ecosystems are distinct from at-risk species because an association of species, some of which may be common, can have significance. Like at-risk plant species, these ecosystems may not occur elsewhere in the area, or even anywhere else at all. The reasons for their threatened status can include being naturally uncommon, or occurring in places that are prone to disturbance.

Upland Forests

Upland forests in the study area support wildlife species, some of which are threatened (e.g., western screech owl) and uncommon / notable bird species in the Fraser Heights forests (e.g., red-breasted sapsucker, northern shrike and yellow-rumped warbler). The Fraser Heights and Delta Ravines areas are particularly important locations for these forests. These forests also support threatened plant communities (e.g., western redcedar / foamflower and sitka spruce / salmonberry).

The impacts on upland forest as a result of the SFPR are 15.7 ha, of which 13 ha are threatened plant communities (1.13 ha red-listed and 11.87 ha blue-listed). All the impacts are in the forests of Bridgeview and Fraser Heights. None of these forests are formally protected for ecological or conservation purposes in reserves. While much of the upland areas of Surrey and Delta were covered in this forest type, residential housing (currently approximately 3,950 ha of the study area) has removed much of the original cover. Of what remains (including the above areas impacted by the SFPR) much is well-developed or disturbed by existing roads and residential housing, such that only components of the original forests remain (developed ecological context).

The remaining forests are valuable, because unlike other parts of the study area they do offer value to wildlife and still retain some of their original floral components. Some of the affected forest is in a portion of the study area that supports a number of species at risk (e.g., amphibians, small mammals and birds, see above). While such values are reduced compared to less disturbed areas, the presence of at-risk species shows that the cumulative impact of these past projects and activities has not been so great as to totally remove habitats and species from the study area.

Mitigation has been proposed to address the potential SFPR impacts on upland forest (minimising impact through reduction in construction footprint during detailed design and protection for similar quality blue-listed upland forest habitat owned by the MoT but not required for the project), however a residual impact was identified for predicted upland forest habitat loss. The only other recent project in the study area that also impacts on upland forests is the Golden Ears Bridge (GEB) Project. It is predicted that 12.3 ha of “combined forested and shrub woodlot and riparian edge habitat” would be impacted (GEB environmental assessment). Some of this 12.3 ha is likely to be upland forest, but the precise proportion is unknown. No information on whether this forest is red or blue-listed was available. To compensate for the impacts to these (unprotected) areas, most of which were privately owned and with development potential, the GEB project proposed implementing formal conservation protection on the areas that remain after construction of the project.

The combined impacts of the SFPR and the GEB project on upland forest are approximately 20 ha; 15.7 ha of this is SFPR, and approximately 4-5 ha is estimated to be GEB impacts on upland forest. As described above, the GEB project did not specify which proportion of the total 12.3 ha of impacts was riparian or upland forest. However, given the project’s adjacency to the Fraser River as well as riparian habitat adjacent to SFPR, it was assumed that the majority of habitat impacted (~7 ha) would be riparian forest habitat with the remainder (5 ha) consisting of upland forest. The combined SFPR and GEB projects impacts on upland forest is 15% of the upland forest in the SFPR study area, and a much smaller proportion of similar forest in the wider Surrey and Delta regions (which also includes large areas such as Tynehead Regional Park 261 ha, Green Timbers 225 ha, parts of Surrey Bend Regional Park 400 ha and the Delta Nature Reserve 60 ha). It is difficult to quantify the impacts on this wider area due to a lack of data, but the affected area represents approximately 2% of these large areas alone. While much of the affected upland forest is blue-listed (and some red-listed), none is protected and most has been affected by previous disturbances (little has reached maturity since it was last disturbed) and it has not been managed for conservation purposes. As a result the ecological values are still developing (ecological context is well-developed).

The potential cumulative effects as a result of the SFPR have been assessed as low. This assessment takes into account the existing (disturbed and unprotected) values of the habitats affected by the SFPR and GEB, the small extent (area) affected relative to the other upland forest areas in the wider region, and the mitigation and compensation associated with each of the SFPR and Golden Ears Bridge projects that will protect an area similar in area and values to that impacted.

Riparian Forests

Riparian forest in the study area provides habitat for wildlife species, some of which are threatened (e.g., Pacific water shrew and great blue heron), they also contain threatened plant communities (e.g., redcedar / sitka spruce–skunk cabbage), and are an important feature for the protection of aquatic habitat values from sedimentation and erosion.

In the study area most of the riparian forests will be unaffected by the SFPR, as a result of avoidance measures (i.e., bridges) that span these forests in the Delta Ravines and Fraser Heights. However, there are a few locations near the Port Mann Bridge, in Fraser Heights and at the proposed 176th Street Interchange where the alignment impacts on 8.3 ha of these habitats. Many of these impacts are on relatively disturbed areas, none of which are protected for conservation purposes. Nonetheless the habitat that these areas offer to wildlife and the aquatic habitat protection conferred, are of considerable value. Most of the riparian forest habitat impacted (7.4 ha) are either red-listed (0.9 ha) or blue-listed (7.3 ha), and despite the application of proposed compensation in the form of protection of 6.9 ha of red- and blue-listed riparian forest in Fraser Heights, these impacts are considered to be residual impacts.

In the study area, the Port Mann /Highway 1 and GEB projects, construction of Highway 91, local roads, and historical dyke, port and railway developments are also considered to have impacts on riparian forest habitat. The GEB Project is anticipated to impact 12.3 ha of habitat that includes some (undefined) riparian areas, some of which is habitat for Pacific water shrew. The Port Mann Highway 1 Project may impact riparian and upland forest in the study area. The likelihood, extent and significance of this potential impact is unknown at this time, but likely to be minor as the proposed corridor for the development is already intensively developed for transportation and few or no riparian forests are expected to be impacted. Construction of the BNSF Railway (approximately 1910) and Highway 91 in the mid 1980s likely impacted riparian forests adjacent to wetlands and watercourses at the break of slope between the North Delta uplands (Delta Nature Reserve) and Burns Bog. The spatial extent of such impacts is unknown. Historical railway development and port and other activities on the Fraser River banks probably impacted heavily on riparian forests, particularly on the Fraser River foreshore in the early 1900s. The time since these developments and lack of documentation of the impacts on riparian forests due to Highway 91 construction and railway development precludes a quantitative assessment of these impacts.

As a result of the above impacts, the cumulative effect of the SFPR project in combination with other projects is assessed to be low. The magnitude of the impacts from the SFPR is not predicted to result in changes above the existing baseline, and the extent is within the project area (only very small parts of the study area have overlapping impacts from the SFPR and other projects). The affected forests are already disturbed (especially by historical railway, port and dyke development along the Fraser River) and have no formal protective mechanism that will ensure any natural regeneration will be maintained in the long-term (developed ecological context). There are large areas of similar forest in the wider area; this includes parts of Surrey Bend Regional Park 400 ha, parts of Tynehead Regional Park 261 ha and the margins of Deas Island Regional Park. Mitigation and compensation is available to provide protection of aquatic and riparian forest values such that there are small residual impacts from the SFPR (8.5 ha affected, 6.9 ha in compensation all of which is red- or blue-listed). The GEB project is also providing protection for areas that are not already protected adjacent to the affected forest areas. In addition, fisheries compensation proposals for the SFPR (up to 17.5 ha of riparian habitat that will over time develop into forest) will further compensate for the impacts.

Cultivated Fields

Agriculture in southwest Delta is the predominant use of land (2,860 ha of the land use in **Figure 8.2-2a**). Of the smaller study area assessed for wildlife and vegetation impacts (section 7.7), cultivated fields are approximately 460 ha, or almost 50% of the southwest Delta part of this study area. While cultivated fields are anthropogenic, they do offer value to wildlife, particularly for water-associated birds (i.e., old-fields, grazing, forage, crops, fallow and water reservoirs), and small mammals that are prey items for raptors. Some of the species that utilize these habitats are threatened (e.g., sandhill crane).

The total impacts on cultivated fields that offer value as wildlife habitat in the study area is 48.5 ha (24 ha of forage crops, 21 ha of seasonal crops and 3.7 ha of old field habitat). These are predicted to be residual impacts for wildlife, some of which will impact habitat used by at-risk sandhill crane species (see section10.4.3 for more detail on this impact) and Townsends vole. Most of the species affected, with the notable exception of sandhill crane, are common (small mammals) and abundant in these areas, and large parts of the study area (510 ha) and beyond remain unaffected. Only small parts of the affected areas are deliberately (or through inactivity are) set-aside for wildlife purposes (3.7 ha), the remainder is actively farmed with wildlife value a by-product of this primary activity. The SFPR Project will minimise impacts to this habitat by acquiring only what is needed. In addition, it has undertaken to assist (with funding) the activities of organizations that set-aside fields for wildlife habitat. Also, much of the agricultural land purchased for the project, but that is surplus to requirements and cannot be farmed afterward (14.7 ha) may allowed to revert to old field, and act as habitat for wildlife.

Other projects and activities in the study area that have potential to impact on similar habitat include the Vancouver Island Transmission Project (negligible to nil impacts because of the small footprint) and the Border Infrastructure Project (outside the study area. Historical development of major roads like highways 17, 91, 99 and Ladner Trunk Road and minor roads such as 72nd Street, and railway development (only a small portion of the southwest Delta part of the study area), may have also contributed to either past losses of cultivated fields with value to wildlife. More likely though, these projects were developed on areas that were not previously used for farming (i.e., forest or bog areas) and therefore are not considered to directly affect the habitat values of cultivated fields. They did indirectly reduce the potential for areas to be converted to agricultural use, but his is not considered to be a residual impact.

As a result of the above assessment, no residual impacts from other activities were identified, and the cumulative impacts from the SFPR on the wildlife value of cultivated fields were considered to be low. This assessment considers that: cultivated fields largely provide value to wildlife only as a by-product of their primary use (for farming), the impacts are small in comparison with similar areas within and outside the study area that are unaffected and that the species affected are typically common.

The potential for cultivated field habitat loss impacts to cumulatively affect sandhill crane (directly and indirectly) are addressed in section 10.4.3.

Wetlands

Prior to development of the Lower Fraser there were substantial areas of wetlands. Development activities including: drainage; dyking, filling and clearing have impacted much of the wetland habitat in the study area (and in the region) and it is estimated that 70% of wetlands in the Lower Fraser have been lost since development began circa 1900 (FREMP 1994). In the study area, wetlands account for 66 ha or approximately 3% of the total area. In Burns Bog approximately 40% of the original area remains (due to agricultural, commercial, transport and residential developments), and 29% of its original dynamic storage capacity remain (Hebda *et al*. 2000). A separate section on Burns Bog habitat impacts has been provided (see below).

While effort has been made to avoid and mitigate for SFPR-related impacts to wetlands, including the Fraser Heights wetland bridge which spans an important wetland, there are impacts to approximately 6.8 ha in the study area. Many of these wetland areas are roadside ditches with lesser values, and proposed mitigation is focused on avoiding direct impacts to the most pristine wetland areas (e.g., Fraser Heights wetland). Further to this, other mitigation such as the implementation of procedures and designs (e.g., stormwater drainage) to minimise the impacts on water quality and quantity are also proposed, and all roadside ditches will be relocated (habitat will be recreated). Compensation for fisheries impacts (section 7.4.6), which includes 4 ha of habitat creation will mitigate much of this loss. In addition, long-term protection of wetland habitat will also contribute to compensating for impacts of the SFPR. Despite this, small residual impacts have been identified for wetland habitat losses.

For some of the other projects identified (**Table 10.3-1 and 10.3-2**) no impacts to wetlands were noted (Golden Ears Bridge Project, Port Mann Highway 1). For others that occurred at some time in the past and where documentation is lacking (Historical development of Burns Bog and the Fraser River, agricultural commercial and residential development, and road and railway development) it is difficult to analyse their impact on wetlands. However, it is known that wetland habitat losses occurred. While a quantitative assessment is impossible with the lack of information about the former extent of wetlands, the paucity of wetlands in the study area might point to either impacts on the wetlands that were there, or a lack of wetlands. In the case of the construction of Highway 91, it has also proved impossible to quantify the impacts, but an understanding of how construction affected Burns Bog (some of which might have been wetland) is possible (Hebda *et al*. 2000). Highway 91 was constructed on compacted sand, woodchip and sawdust, which was allowed to sink onto compressed bog material. This construction has altered the hydrology of the area, including the water supply between the upland area of North Delta and Burns Bog. Wetlands (and lagg zones) in the area between the two are now likely occupied by Highway 91. Such construction is informing the design for the SFPR on the other side of Burns Bog so that similar impacts can be avoided (see the assessment of Burns Bog below).

The lack of values in most wetlands affected by the SFPR (roadside ditches with well-developed ecological context), and low magnitude and small extent of residual impacts on wetlands due to avoiding and mitigating or compensating for impacts points to low residual impacts. While there are no definitive measures of the residual impacts on wetlands as a result of other projects, cumulative impacts are anticipated to be Low-Moderate. This reflects the existence of high values in some wetlands in the area (past and present impacts from other projects are not so great as to have destroyed all values), strong awareness and requirements for wetland protection in the future, and commitment to mitigation that will minimise the residual impacts of the SFPR.

Burns Bog

Burns Bog (which is defined here and in the Burns Bog Ecosystem Review, Figure 6.10 (Hebda *et al*. 2000) as the area required for or supporting Burns Bog) covered an area estimated to range between 4,000 and 4,800 ha in the 1890s, but no data are available to precisely quantify this. By the 1930s the area had been reduced to about 4,300 ha (mostly through agricultural conversion) – though again no definitive measure is available. In the 1970s the Burns Bog area was estimated to be 4,000 ha, reductions due to the establishment of the landfill and industrial development on the north edge. Since that time reductions to the present size (~3,000 ha) have occurred through agricultural development, development of Highway 91, expansion of the landfill and more development on the north margin. Peat mining, while an expansive disturbance to the condition of the bog, has not acted to reduce overall area.

Currently Burns Bog as defined in the Burns Bog Ecosystem Review encompasses an area of 3,041 ha, 2,821 ha of this area is considered “ecologically available” (the remaining 220 ha is cranberry and blueberry fields). The Burns Bog Ecosystem Review identifies 2,450 ha of remaining bog as “required to preserve Burns Bog as a viable ecosystem”. The acquisition of bog land, in Burns Bog, by provincial, regional and local governments created the Burns Bog Partnerships Lands, which total 2,033 ha. In Burns Bog approximately 40% of the original area remains (due to agricultural, commercial, transport, landfill and residential developments reducing the original size), and 29% of its original dynamic storage capacity remains (Hebda *et al*. 2000). As a result of these activities, Burns Bog has been substantially reduced in size and hydrological activities have been affected (by loss of area on the margins, and peat mining and other developments in the centre). Its ability to support wildlife has likely been reduced as a result of habitat loss and fragmentation from forests in the uplands area of Delta and Surrey by the BNSF Railway and Highway 91. The upland forest areas have also been reduced in extent affected wildlife in Burns Bog. Despite the above changes Burns Bog retains high values, both intrinsically as one of very few examples of a raised peat bog and as habitat for vegetation communities and wildlife that are both common and rare. The Burns Bog Ecosystem Review (Hebda *et al*. 2000) noted that there are favourable conditions for the recovery of Burns Bog ecosystems; in particular reporting on the presence of bog vegetation (including regenerating sphagnum moss) in the disturbed core and a large natural zone surrounding this. Such information suggests that with the implementation of the recommendations of Hebda *et al*. (2000) noted in the following paragraphs, that the existing cumulative impacts are manageable so as to ensure long-term sustainability of Burns Bog.

Impacts to hydrological conditions in Burns Bog associated with the SFPR will be mitigated through specialized design and construction, therefore, there is considered to be a low probability of residual impacts on the hydrology of the area. The probability of residual effects to hydrology, as a result of the Project, takes into account a number of considerations. First, based on MOT’s observations of existing conditions, MOT is of the opinion that the road and its associated mitigation can be designed and constructed in a such a way that it will not cause a negative change to the existing hydrological conditions Along the north boundary of Burns Bog, where there is currently an uncontrolled groundwater flows that threaten the viability of the bog, MOT is also of the opinion that an opportunity exists, through the design of hydrology mitigation, to improve the existing hydrological conditions through the design and construction of mitigation that will control drainage for a better groundwater management. With the application of mitigation measures identified in the EA documentation, MOT predicts there is a low likelihood that a cumulative effect on bog hydrology will occur.

The effectiveness of efforts to avoid impacts to water levels and water quality in Burns Bog also has potential implications for wildlife habitat (i.e., potential habitat loss) if such measures are not effective. However, given the monitoring and adaptive management measures that will be taken, as required by the federal Follow-up Program, it is considered a low probability that mitigation will not be effective and that effects might occur. In addition, Burns Bog is recognized as a dynamic ecosystem and experiences changes in water levels and water chemistry on a seasonal basis. Wildlife in Burns Bog are adapted to such changes in conditions and only long term changes in water levels and water chemistry, that significantly exceed seasonal fluctuations, have been considered as an impact to wildlife habitat in the CEA.

Given the capacity of the hydrology mitigation to actively manage water levels (and to some degree water chemistry) in the Bog, the likelihood of indirect impacts to wildlife habitat, as a result of failure of the hydrology mitigation, is considered negligible.

While it is predicted that there is a low likelihood of residual impacts on hydrology, there are small residual footprint impacts to land in zones required for, or supporting, the viability of Burns Bog.

The land required for or supporting Burns Bog was divided into four zones by the Burns Bog Ecosystem Review (Hebda *et al*. 2000). The zones, and the impacts on these from the SFPR, are:

- Zone 1, areas with attributes required to preserve the viability of Burns Bog (0.4 ha);
- Zone 2, areas with several attributes supporting, but not required for the viability of Burns Bog (12.12 ha);
- Zone 3, areas with few or no attributes supporting the viability of Burns Bog (9.25 ha); and
- Zones with insufficient data (nil).

Of the 21.77 ha of footprint impacts only a very small area (0.4 ha) is in the most important zone to Burns Bog (zone 1) land of the rest (21.3 ha) is in zones 2 and 3 (not required for Burns Bog viability, but supporting it). Large areas of the impacts to zones 2, 3 are on lands that have been impacted by past development (rural/industrial, berries, seasonal crops, upland shrub or disturbed). The potential residual impacts to areas recognised as required for the viability of Burns Bog is 0.4 ha. While this considered to be a residual impact, the extent and magnitude of the impact is very small compared to the area of Burns Bog, 0.0001% of the 2,800 ha total area. Compensation for these impacts is proposed to include a financial contribution to ongoing management of Burns Bog, including controlling water flow out of the bog, which was recommended as a requirement for the survival of the bog (Hebda *et al*. 2000).

Hebda *et al*. (2000) recommended “the entire extant water mound and most of the lagg zone are required [to be protected]” and that to sustain the water mound and peat-forming vegetation, ditches that drain the core of the Bog must be blocked to ensure the survival of the bog. It also indicated a requirement to undertake further studies of hydrology and wildlife to define the areas of the bog margin that were required for Burns Bog viability. While most of the key areas for Burns Bog viability have been purchased by various governments (and there are no impacts on these areas due to the SFPR), there has been limited success in ongoing management such as the blocking of drainage and ongoing monitoring. Investigations conducted by the MoT have increased the hydrological knowledge of some peripheral areas of Burns Bog (especially the north and west edges) and have indicated existing values. In the context of SFPR development the MoT has proposed means of improving hydrological conditions on the north edge. On the west edge of Burns Bog it is now known that lagg conditions are disconnected from the core of the bog, and while there are intrinsic values associated with this area, the SFPR will not impact on this area. Avoidance (shifting the SFPR alignment away from the forest areas) and mitigation (hedgerows and quiet pavement) will be implemented adjacent to the lagg zone forest near 72nd Street to protect the intrinsic values.

Highway 91, on the east side of Burns Bog and west of the adjacent North Delta uplands, was constructed on compacted sand, woodchip and sawdust, which were allowed to sink onto compressed bog material. This construction has reduced the area of Burns Bog and likely altered the hydrology of the area (Hebda *et al*. 2000), including the water supply and runoff between the upland area of North Delta and Burns Bog. However, construction of the Northeast Interceptor Canal (also known as Cougar Canyon Creek) is understood to have contributed most to the impacts on hydrology in this area. While runoff from the North Delta uplands is understood to have previously flowed both north and south, it now flows under Highway 91 into Burns Bog, reducing the area and quality of bog habitat on both sides of Highway 91. The SFPR is not expected to affect hydrological conditions in these locations.

Burns Bog also contains Pacific water shrew (PWS) habitat. While the refinement to the alignment along the western edge of Burns Bog has generally served to reduce residual effects to PWS habitat, other habitat is known to exist along the northern edge of Burns Bog. For this area, mitigation measures have been identified in the EA documentation and will include (but will not be limited to): suitable compensation, a salvage program for Pacific water shrew from high suitability habitat adjacent to the SFPR, construction of a bridge crossing at the Fraser Heights wetland complex, and construction of wildlife crossings to facilitate movement of PWS between habitat on either side of the alignment. The northern boundary of the bog also includes habitat identified by MOE as *"proposed 'critical habitat'* (Preliminary Partial Critical Habitat Identification for Pacific water shrew (Sorex bendirii)- DRAFT Pacific Water Shrew Recovery Team, 19 October, 2008 (MOE, 2008). The designation of critical habitat is considered preliminary and will require further evaluation by the PWS Recovery Team to confirm the extent of such habitat. As a detailed understanding of the extent and magnitude of the critical habitat is available, MoT will receive advice from MOE to ensure that mitigation to address potential effects to PWS are applied. A mitigation monitoring program, developed with input from MOE, will be implemented to ensure that mitigation, to address potential effects to PWS, are effective, where additional mitigation may be required or compensation may required. The implementation of the mitigation monitoring program, to be overseen by MOE, is considered to be effective in ensuring that significant adverse effects to PWS habitat do not occur as a result of the project. Throughout the design and construction phases of the project, the MOT will ensure that measures are taken to mitigate effects on PWS and that potential effects that could occur are monitored. All measures to mitigate against effects to PWS will be taken in a manner that is consistent with applicable recovery strategy and actions plans.

A low to moderate cumulative impact has been identified as a result of the SFPR and other projects and activities on habitat loss in Burns Bog. This assessment is based on a number of factors. The avoidance of residual impacts from SFPR on hydrology (as a result of mitigation proposed) and therefore no impacts to one of the key values for a raised peat bog. The footprint impacts (residual impacts) of the SFPR on land required for Burns Bog are very small (0.4 ha), and those on land supporting Burns Bog are largely on land that is already disturbed (developed ecological context). The availability of large areas of bog habitat with similar values - impacts to about 0.0001% of the available land in Burns Bog (low magnitude). Attention to avoiding areas through the relocation of the SFPR west of Burns Bog that are important to Burns Bog (i.e., Nottingham Forest) and avoiding the partnership lands in the core of the Bog. In addition, the proposed mitigation for impacts to species associated with Burns Bog (e.g., quiet pavement for reducing noise impacts, hedgerows to reduce particulate matter, barn owl collisions and visual impacts on sandhill crane), as well as compensation (habitat rehabilitation funds) and ongoing monitoring, points to low to moderate cumulative impacts as a result of the SFPR.

10.3.4.2 Habitat Fragmentation

Fragmentation of upland and riparian forests in the study area have the potential to impact on species that require these habitats to be contiguous (e.g., large and small mammals and amphibians). Some of these species (i.e., red-legged frog and Pacific water shrew) are threatened. SFPR-related fragmentation impacts were identified, but mitigation in the form of the provision of wildlife crossings, and alignment of the SFPR on the edge of habitats reduces the magnitude of residual impacts. The mechanisms by which potential cumulative effects, associated with habitat fragmentation, may occur include spatial crowding (i.e., too much development in an area such that ecosystem resilience is overwhelmed) and gradual habitat removal (nibbling loss) that results in areas of habitat that are too small to be resilient and ecologically self-sustaining

In general, the SFPR alignment skirts areas that have wildlife and vegetation values (i.e., Burns Bog), thus fragmentation impacts are avoided (i.e., in the case of wetlands) or confined to the periphery of such areas. In locations where the alignment does bisect upland and riparian forest habitat (i.e., Delta Ravines and Fraser Heights Wetland), structures are proposed to retain habitat connectivity across the SFPR. Previous activities in the study area that have contributed to habitat fragmentation include the development of railways and roads (e.g., River Road) that have isolated habitat on either side of the development. Residential housing development in the past, and potentially in the future as build-out to the OCP continues, fragments and isolates habitats, particularly upland forest habitat in the study area. Municipal approvals against the OCP are required for residential and commercial developments, and this is likely to reduce the impact of fragmentation in the future for these developments. Other projects in the area have or are proposed to be developed on existing developed corridors (e.g., DP3 utilises Deltaport Way and The BIP upgrades existing roads) which will also serve to minimize habitat fragmentation.

As such, there are limited predicted synergistic interactions between impacts of the SFPR on habitat fragmentation, most of which can be mitigated, and other projects and activities in the study area. In general, other projects in the study area that have contributed to residual habitat fragmentation (e.g., previous development of railways, River Road and Highway 91 and residential development in upland forests) have limited interactions with residual effects from the SFPR such that cumulative fragmentation impacts could become worse. As a result, the cumulative effects of the project on habitat fragmentation, as a result of the SFPR, are predicted to be low.

10.3.4.3 Wildlife Pattern Changes (Indirect habitat loss)

Roads have been shown to have adverse impacts on plants, amphibians and many bird species in adjacent habitats. Such indirect impacts include reduction in habitat quality, species avoidance, barriers to movement and habitat fragmentation. Conversely, positive impacts can occur for some species (i.e., small mammals and certain raptors) by increasing their access to food resources. A qualitative assessment of the potential for cumulative impacts of the SFPR and other projects and activities was conducted, though a quantitative assessment of indirect habitat loss for the SFPR was conducted in the Zone of Influence report (August 2007). The mechanisms by which potential cumulative impacts, associated with indirect habitat loss, may occur are gradual habitat removal (nibbling loss) and or spatial or temporal crowding; where indirect habitat loss is considered to result from too much development in certain locations or at certain times such that the threshold for species to tolerate indirect disturbance is exceeded by the combination of many activities.

Project-related sensory impacts (indirect habitat loss or zone of influence impacts) on the use of parts of the study area by wildlife was predicted to be a residual impact. In particular, habitat used by sandhill crane and other water-associated birds, and forest passerines were considered to be impacted. The visual and noise disturbances introduced by the SFPR were predicted to indirectly reduce the area available to these wildlife, forcing them to use other areas. This is likely to be an impact felt more in upland forest habitats and cultivated fields used by water-associated birds adjacent to the SFPR, than elsewhere in the study area. Throughout the study area there are existing noise and visual disturbances from roads and railways that already exert such an influence on habitat, in some areas the habitats are so small and already affected such that there are no additional impacts from the SFPR. The wildlife pattern change impacts of the SFPR during construction are anticipated to be greater (but temporary) than those during operation. For some species, particularly cosmopolitan species that can adapt to changes in disturbance, the impacts even during operation are likely to be temporary, as these species will return to habitat under the lower-level disturbances of highway operations.

Raptors may be affected by sensory impacts during construction, but they are not considered to be affected by long-term operations. Many raptors are noted to utilise road corridors preferentially, as habitat for their prey (small mammals) is common on the road verges and carrion is present on and adjacent to roads. Their presence in road corridors and unfortunate collision mortalities is evidence that roads do not discourage their presence; such collision mortality risk, especially to barn owl, is assessed below (section 10.3.4.4). Raptors nesting close to the proposed SFPR have been surveyed, and mitigation (temporal and spatial construction exclusion zones or nest relocation) will be provided for those that are close enough to be affected.

For many of the species living adjacent to the proposed SFPR (e.g., small mammals, reptiles and amphibians), sensory disturbances were not considered to be a residual impact of the SFPR (Zone of Influence Report, August 2007) as wildlife crossing structures (Wildlife Mitigation Crossing Plan submitted to reviewers April 2007 and update February 2008) will allow continued passage on existing routes between habitats on either side of the road (section 10.3.4.4).

For cultivated fields there may be an indirect impact (i.e., habitat loss) on sandhill crane and waterfowl that currently use areas between Highway 17 and Highway 99 and on the west of the SFPR north of Highway 99 to about the proposed 72nd Street overpass. There is also a direct habitat loss as a result of the footprint of the SFPR (approximately 7.9 ha). The spatial extent of indirect impacts is confounded by the influence of activities on existing roads (e.g., Ladner Trunk Road and Highway 99) and railway lines, and agricultural activities, which currently have indirect habitat loss impacts. Raptors also use cultivated fields, but no residual indirect impacts on these were identified because raptors are generally not affected by sensory disturbances (their presence in road corridors and unfortunate collision mortalities is evidence that roads do not discourage their presence), and their prey (small mammals) are relatively abundant and not likely to be a limiting factor.

For wetlands (and some riparian forests) in the SFPR study area, there are not considered to be indirect habitat loss impacts on the species that utilise these areas (i.e., small mammals and amphibians). This is because noise and visual impacts are not considered to be as important an influence as fragmentation and isolation of habitat (a direct footprint effect). As a result of proposed wildlife crossing corridors (Wildlife Mitigation Crossing Plan submitted to reviewers April 2007) at the locations of important wetland habitat for amphibians and small mammals, no residual impacts are anticipated as a result of the SFPR; no cumulative impacts from indirect habitat loss of wetlands have been identified.

For upland forests there could be is likely to be an indirect habitat loss impact on passerines as a result of the SFPR. This is limited to the upland forest areas at Fraser Heights where noise and other abiotic impacts could extend further into the forest than they do at present (note existing effects from CN Intermodal Yard in this location). The Fraser Heights upland forest is the largest affected in the study area, and others along the alignment (Delta Ravines and Bridgeview) are so small that they already have confounding influences from the other activities (roads and residential developments) around their perimeter such that there are no additional indirect effects from the SFPR. Notwithstanding that there are potentially residual indirect impacts on passerines in upland forests, there are also confounding influences on these forests from other road, rail and residential activities around the periphery of these forests that reduce the potential for any additional sensory impacts from the SFPR. Wildlife in upland forest areas that are already affected by noise from existing activities such that they cannot live there cannot be affected more. The area of indirect habitat loss can increase through, and this was identified as a potential residual impact for the SFPR.

Other projects and activities in the study area also have an indirect impact on species inhabiting upland forests, these include the Vancouver Landfill, railways and other major (highways 17, 91 and 99) and minor roads. For some of these projects and activities such as the Border Infrastructure and Golden Ears Bridge projects and local roads that pass through similar areas, there might be similar impacts on wildlife patterns to those of the SFPR. However, these other impacts are located at some distance from those of the SFPR, and they are unlikely to have synergistic or additive impacts. Highways 17, 91 and 99, and the railways, which are located closer to the SPFR have likely also had an indirect impact on the use of upland forest habitat by passerines in the study area. Other projects and activities that have introduced linear (e.g., utilities, railways and regional and municipal roads) or large-scale developments (e.g., residential housing and industrial developments) have also contributed to these effects in the study area.

The impacts from all these projects are negative, but there is not considered to be a cumulative impact on most species, as the species involved are typically common and adaptable to change such that they are acclimated to high activity levels. The magnitude of such impacts is likely low because of the largely modified habitats and common species involved (well developed ecological context) and their continued presence despite ongoing indirect impacts from other projects is indicative of a lack of negligible to low cumulative impacts.

For more sensitive species (e.g., sandhill crane) there is potential for a residual impact as a result of direct and indirect impacts from the SFPR on cultivated field habitat. However, a number of points indicate that the residual impacts will be moderate and not result in population-level effects (to the overall sandhill crane population and the Georgia Depression sub-population. The Georgia Depression sandhill crane population (10 – 15 pairs) that utilise agricultural fields adjacent to Crescent Slough in spring and fall are difficult to differentiate from migrants that also use these fields. However, total numbers (residents and migrants) in fall appear to be increasing or stable relative to previous population estimates (Technical Volume 12).

This is despite the indirect loss of habitat from increased sensory disturbance of other roads and railways (increase in road and railway traffic). Site observations, by a qualified biologist with the MoT (2005 and 2007) indicate that fall numbers over the past few years are relatively stable or increasing, and the number of juvenile cranes has increased. They are consistently using the same fields, as well as a few additional ones not used previously. They are also utilising areas in the spring (corn stubble fields southeast of Burns Bog that are unaffected by the SFPR. Further, additional observations by the MoT indicate that existing small roads are not the deterrent to habitat use that has been reported in the literature (see Zone of Influence Report August 2007). Sandhill crane in fields adjacent to the proposed SFPR infrequently use habitat that is within 100m of existing busy roads like Highway 99, indicating some habituation to roads (Dwyer and Tanner 1992, cited in Zone of Influence Report, April 2007). Sandhill crane use alternative but similar cultivated fields (mostly corn stubble) in the wider area, especially in the spring, but the extent to which sandhill crane might use the many hundreds of hectares available beyond the predicted zone of influence from the SFPR is unclear.

Despite the above information there remains some uncertainty as to the impact of the SFPR on sandhill crane (direct and indirect habitat loss), and the potential for such impacts to affect the Georgia Depression population. To address these issues, the MoT is developing a comprehensive mitigation and monitoring program in consultation with the Canadian Wildlife Service. It will monitor the impacts of the SFPR on sandhill crane foraging use, and the effectiveness of mitigation measures (quiet pavement and hedgerows to visually screen views of the road). The need for additional measures (e.g., provision of alternative habitat) will be identified as a contingency measure. Further to this, the monitoring program will attempt to better understand the composition of sandhill crane using affected fields (Georgia Depression breeding population versus breeding populations from elsewhere that are staging near Crescent Slough), such that the impacts on birds breeding in Burns Bog and elsewhere in the Lower Mainland can be better understood.

The above information indicates that the potential residual impacts on sandhill crane from existing road activities and other activities (farming) are nil to low. The mitigation and monitoring proposed in association with the SFPR is considered to be appropriate in addressing the uncertainties around the impacts, such that the residual impacts are moderate. The combined impacts of the SFPR (moderate residual impacts), and those of other activities (nil residual impacts), indicates that any potential cumulative impacts are moderate. There are no residual impacts from other projects and SFPR mitigation in the form of hedgerows (to reduce visual impacts) and quiet pavement (to reduce noise impacts) is anticipated to minimize the indirect SFPR impacts on this species and its habitat. While residual impacts may occur from the SFPR, mitigation and monitoring proposed for the SFPR will test impact predictions and apply follow-up measures (more hedgerows, visual screening and artificial barriers) if it is shown that additional mitigation is necessary to ensure that sandhill crane continue to exhibit similar behaviour patterns in the study area.

The continued presence of sandhill crane in this area, and the stability in population numbers noted during SFPR studies, is evidence that there is not likely to be a significant cumulative impact on sandhill crane. As a result any SFPR-related residual impacts, which as noted above would be moderate and manageable through proposed monitoring of mitigation with follow-up measures where it is determined that additional mitigation is necessary, are thought to result in non-significant cumulative impacts.

10.3.4.4 Wildlife Mortality from Collisions

The potential for increased risk of collision between wildlife and vehicles as a result of the SFPR was identified as a residual impact in one location of the study area (in other locations wildlife crossings avoid residual impacts). Where the SFPR alignment runs between the fields adjacent to Crescent Slough and Burns Bog there are known deer and barn owl movement corridors. Barn owl travelling from roosting areas east of Crescent Slough to the fields immediately to the west, and deer crossing the proposed alignment to and from these fields and Burns Bog are potentially impacted. Mitigation is proposed to minimize the impacts on barn owl such that they are not significant (small residual impact); vegetated buffer plantings to force barn owl to fly over roads at a greater height and reduce their chance of collision with vehicles (section 7.7) and road verge maintenance. The Zone of Influence Report (August 2007) contains a discussion of the effectiveness of such mitigation, which has proved effective for barn owl in England (Ramsden 2003) and France (Massemin and Zorn 1998), and is recommended in the lower Mainland (Preston and Powers 2006). At this location, and north of this area (between 80th Street and Nordel Interchange) wildlife crossing locations for deer are proposed, these too are expected to reduce the impacts to deer such that there are no residual impacts. For many of the small terrestrial species living adjacent to the proposed SFPR (e.g., small mammals including the at-risk Pacific water shrew and red-backed vole, reptiles and amphibians), wildlife crossing structures (Wildlife Mitigation Crossing Plan April 2007) will allow continued passage on existing routes between habitats on both sides of the SFPR, avoiding or reducing potential collision risks. These mitigation measures are expected to minimise the impacts, and in conjunction with the proposed mitigation monitoring program that will significantly reduce the intensity of impacts such that there are no residual impacts. Low residual impacts to barn owl are predicted as a result of the SFPR, but monitoring of the mitigation measures and an adaptive management program to address identified impacts are proposed to reduce the potential for significant adverse impacts.

The other projects or activities that are also considered to have wildlife mortality residual impacts in the study area are the Deltaport Third Berth Project (on barn owl), Highway 91 (on deer) and municipal roads (on barn owl), but to a lesser degree because traffic volumes and speeds are lower. Deltaport Third Berth was predicted to have an impact on barn owl (DP3 Environmental Assessment Application), and mitigation that included the provision of nest boxes in areas outside of risk zones was proposed for that project. Barn owl numbers in the study area were surveyed in the early 1990s (by L. Andrusiack) and in 2007 (by S. Hindmarch), and while these two surveys were different, the data show that the number of breeding pairs and number seen roosting has increased over this time (S. Hindmarch *pers comm*.). Some of the sites where breeding and roosting was noted in the 1990s were also used in 2007, indicating fidelity in locations used by this species in the study area. The above information indicates a degree of stability in barn owl populations in the area, despite the increase in traffic in the region (see Section 3.1.1). More detailed traffic data for Highway 99 shows an increase of about 4,000 vehicles per day since 1999. That barn owls are continuing to use historic nest sites and continuing to be present in the study area shows that collision mortality (which is known from the area) may not be affecting the population.

Highway 91 potentially impacts deer living in Burns Bog, but the accuracy of predictions that indicated no impacts on deer populations as a result of Highway 91 (contained in the impact assessment report) are unknown because no data are collected on deer collisions on this highway. Similarly no data on the impacts of traffic on local roads is collected. Permits are issued for hunting deer in Burns Bog. For deer the population is currently maintained even with the risk of collision from vehicles on Highway 99 and the issuance of hunting licences for areas of Burns Bog. No residual impact on deer was identified from these other projects, and therefore the lack of residual impacts on deer from the SFPR indicate no cumulative impact.

The extent and significance of the combined residual impacts on barn owl from Deltaport Third Berth Project and the SFPR is expected to be a low cumulative impact. The mechanism for potential cumulative impacts is spatial crowding (potential inability for the population to maintain sufficient numbers due to collision impacts). This assessment of a low cumulative impact on barn owl is largely due to the separation of individuals that are potentially affected by each project. Barn owl are relatively territorial with ranges in the order of 1 km^2 and are highly faithful to their nesting sites (Hindmarch *pers comm*. 2007). This indicates that the impacts on barn owl from DP3 traffic on Deltaport Way are not likely to overlap spatially with those of the SFPR (except potentially near the Highway 17 / SFPR / Deltaport Way interchange). In addition, the population of barn owl in the area has been similar or increasing between recent surveys, indicating low potential for existing residual impacts. The collision risk from Deltaport Third Berth is the result of more traffic on an existing road (Deltaport Way), and is likely to be a lower risk than for the SFPR, which is a new road in a largely undeveloped (for transportation) corridor. However, the mitigation proposed to avoid SFPR-related impacts (vegetative barriers forcing birds to fly higher over the road and vegetation / prey management to avoid attracting barn owls to the road) in conjunction with the proposed mitigation monitoring program will reduce the magnitude of potential residual impacts. The mitigation proposed is recommended by researchers in France, England and the lower Mainland (Massemin and Zorn 1998, Ramsden 2003 and Preston and Powers 2006 respectively) as being either effective or recommended for barn owl. The Deltaport Third Berth project committed to the establishment of barn owl nesting boxes in locations away from Deltaport Way and other busy roads (outside risk zones) as mitigation for impacts.

The mitigation proposed for each project, and the physical separation of the two locations (Deltaport Way and SFPR north of Highway 99) where impacts are predicted, as well as the low level of residual impacts (due to mitigation and effectiveness monitoring) indicate that there are likely to be low cumulative impacts.

10.3.4.5 Aquatic Impacts

As required under the *Fisheries Act*, the fisheries assessment for SFPR has focused on ensuring that potential effects to fisheries values, as a result of the project, are either avoided, mitigated, or where necessary compensated for in order to achieve the objective of no-net-loss to fish habitat. As outlined in habitat balance in section 7.4, the Project currently shows a positive balance for both aquatic and riparian fisheries habitat and no residual effect are anticipated.

However, it is recognized that fisheries values in the corridor have been impacted by historic development including: dyking of the Fraser River; development of the rail corridor, as well as residential and commercial development. The magnitude of the impact is difficult to assess though some information is available. For example it is known that:

- since 1948 approximately 300 km of the Fraser River foreshore has been dyked. Such activity has reduced the amount of riparian habitat along the foreshore and impeded access to upland watercourses that provided rearing habitat (Steve Litke, Fraser Basin Council *pers. comm*.);
- development of rail corridors and ports through the SFPR study area has also contributed impacts to riparian and aquatic habitat where stream crossings occur;

- over 70% of wetland in the Lower Fraser have been lost to development including: drainage; filling; dyking and clearing. Such wetlands would have formed part of the upland system of watercourses that supported fisheries populations;
- of 148 streams existing in the Steveston to Langley section of the Fraser River, 45 streams have been lost, there are no wild streams remaining and the remainder are threatened (8) or endangered (95).

Projected-related impacts (before compensation) are estimated at 2.8 ha (aquatic) and 14.1 ha (riparian).. As there are still important values in watercourses in the project corridor a range of best management practices will be followed during construction and operation for the project to minimize impacts to remaining values. For impacts that are unable to be avoided or mitigated and where a residual effect on habitat remains, compensation measures will be implemented to achieve no-net-loss of fisheries values. Proposed compensation of 7.7 ha (aquatic) and 17.3 ha (riparian) means a positive habitat balance is achievable, and no residual impact is anticipated. While historic losses of, and impacts to, fisheries values in the study area can be considered a cumulative impact of past development, there are no opportunities for cumulative impacts in conjunction with the SFPR, as it is projected that proposed avoidance, mitigation and compensation associated with the SFPR will result in a positive habitat balance.

Residual impacts on stormwater (changes to water quality and quantity) are predicted to be negligible as a result of the SFPR, largely as a result of avoidance and mitigation measures proposed in the development of stormwater infrastructure (Stormwater Management Plan, July 2007). The SFPR will use an integrated stormwater management approach with performance objectives that provide for no net impact on water quality and quantity. Current best management practices will be used in the design and management of stormwater from the SFPR (sediment control and integration with existing stormwater systems with respect to impervious area). There is potential for small residual impacts to act in concert with those of other projects such as residential and commercial developments and other roads that also add to impervious area in the catchment. The mechanism for the potential cumulative impact is spatial crowding; where changes to water quantity and quality cannot be assimilated into the environment.

As a result of the potential for a cumulative effect as noted above, an analysis of the impervious surfaces and riparian vegetation in the study area was conducted to assess the potential for cumulative impact of the SFPR and other projects and activities in the study area on stormwater (water quantity) and catchment health. This analysis compared estimated changes in impervious area and riparian vegetation in the project corridor to impervious area and riparian integrity thresholds in a watercourse classification system developed for the Greater Vancouver Sewerage and Drainage District (GVSDD 1999). The combination of impervious area and riparian integrity (wetland and forest vegetation cover) describes catchment health (healthier watersheds have more riparian vegetation to filter overland flow and less impervious area to increase ground-water inputs. There were three steps in the analysis;

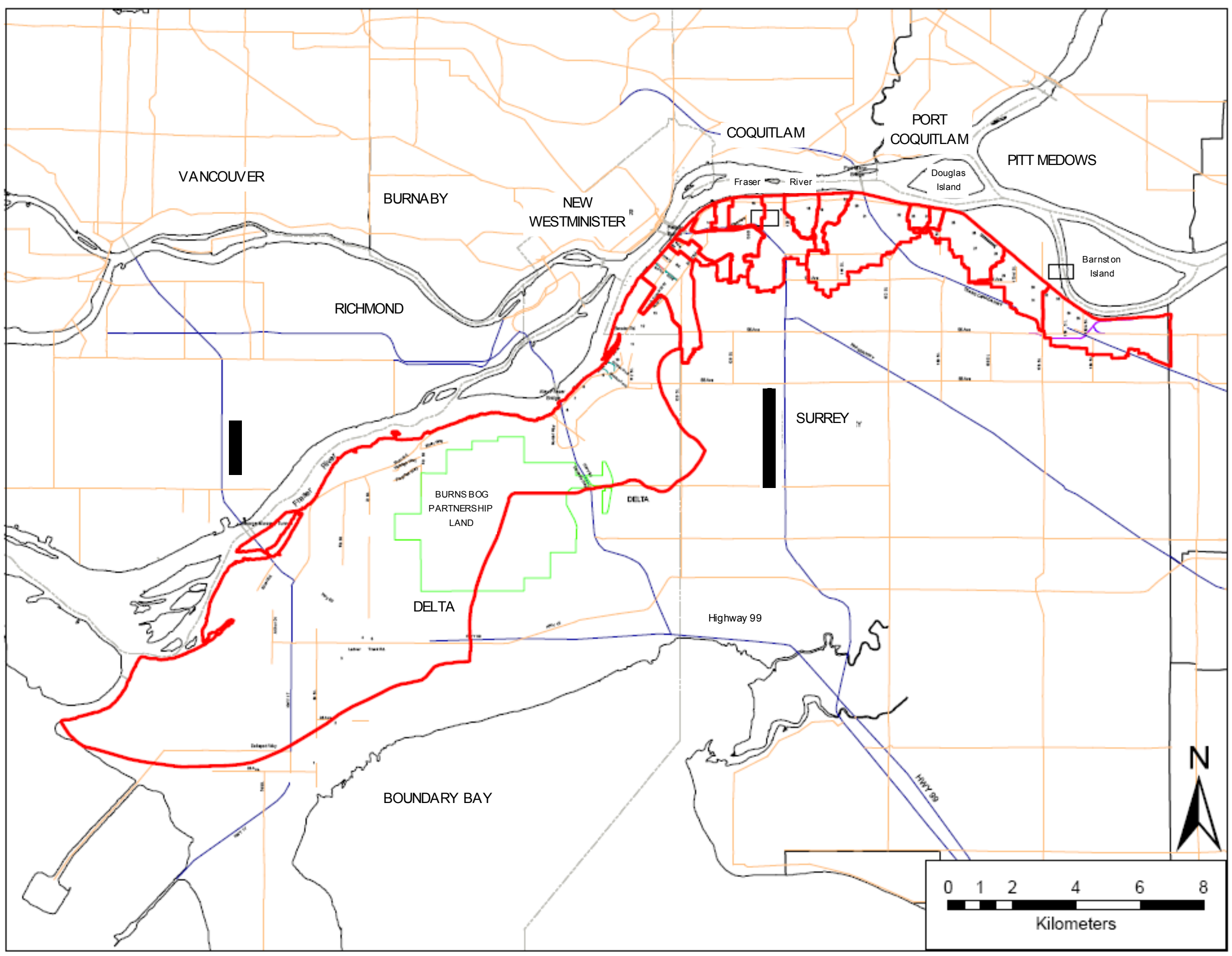
- assessment of impervious area (existing and predicted changes due to SFPR);
- assessment of riparian vegetation (existing and predicted changes due to SFPR; and
- analysis against thresholds established by GVSDD (1999). Each step is described below.

This analysis is conservative. It does not take into account SFPR mitigation measures such as the Stormwater Management Plan and fisheries habitat compensation that would effectively reduce the impacts of any changes to impervious area.

Step 1 – Impervious area assessment

The catchment boundaries used for the assessment of SFPR-related impacts on stormwater and the design of stormwater infrastructure were used for this analysis (**Figure 10.3-1**). The land cover classifications developed for the vegetation and wildlife assessment (Section 7.7) were extended to the boundaries of the catchments and used to estimate impervious area. The resolution of the land cover classifications for those portions of the catchments analysed in the vegetation and wildlife habitat assessment was higher than that for the area beyond the habitat study area (aerial photographic interpretation only, no ground truthing or biogeoclimatic zone assessments were conducted).

Figure 10.3-1. Catchment boundaries.



The proportion of impervious area (multiplication factors) for each of the 90 types of land use / cover was estimated using air photographs. These estimates were verified as being similar to estimates in GVSDD

(1999), variations were explained due to specific features or characteristics of the SFPR corridor, or the mapping used in this study (**Table 10.3-4**).

Table 10.3-4. Impervious area multiplication factors for major land cover classes.

Land use / cover	**Multiplication factor**	**GVSDD (1999) multiplication factor**
Medium density residential (single family dwelling)	65%	40%
High density residential (single family dwelling)	65%	40%
Multi-family residential (multiple family dwellings)	65%	80%
Commercial	90%	90%
Industrial	90%	75%
Transportation (road and rail)	99% and 75%	90%
Communication	50%	unspecified
Parks, protected areas, forests and wetlands	1%	1%
Agricultural	2% or 5%	5%
Rural infrastructure	80%	unspecified
Exposed soil and landfills	50%,	1%
Upland herb and scrub	30% and 20%	unspecified

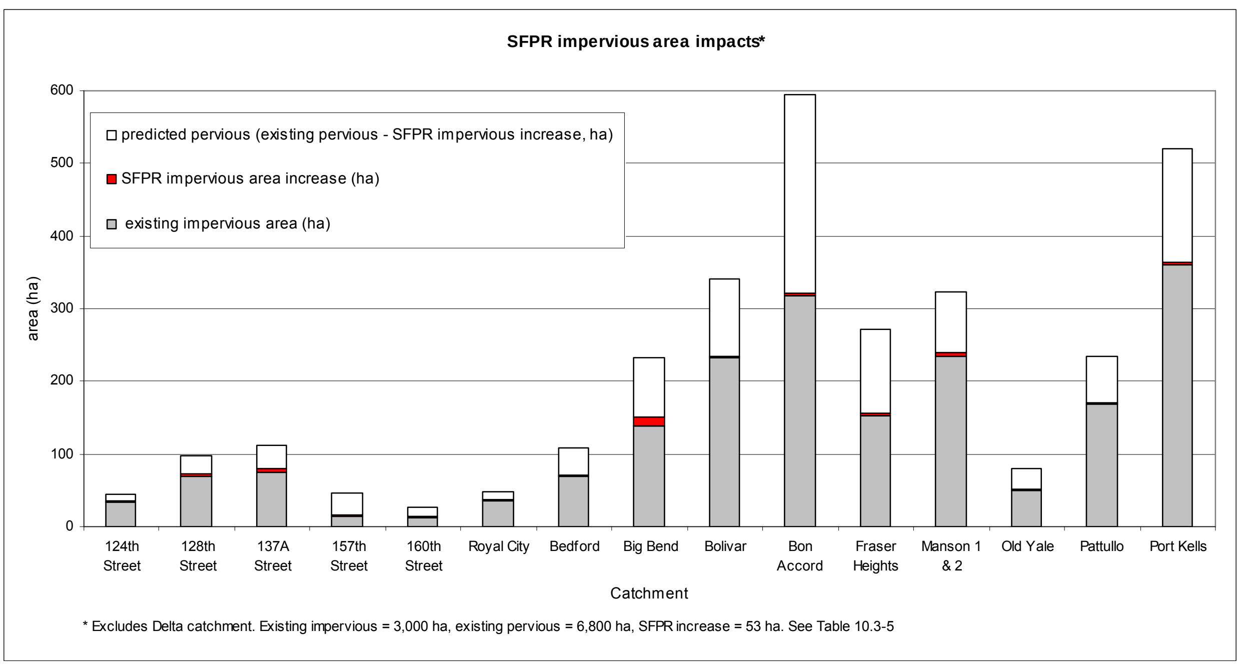
The existing proportion of impervious surfaces in the study area was calculated for each catchment by multiplying the land use / cover types by the appropriate multiplication factor (**Table 10.3-5**). Residential and industrial dominated catchments in the study area (Surrey and north Delta) are 50 to 75% impervious. Only three catchments, Delta and 157th Street and 160th Street catchments (forest escarpment below Fraser Heights) have less than 50% impervious area.

A separate analysis of the predicted increase in impervious area as a result of the SFPR was also conducted by subtracting the existing impervious areas under the proposed SFPR footprint (existing roads, parking lots and buildings) from the predicted final impervious area of the SFPR for each catchment (**Table 10.3-5**). The increase in impervious area due to the SFPR in each catchment is small, typically 1 to 4 ha per catchment. Based on this analysis, it is estimated that the proportional increase in impervious area (due to the SFPR) is small, 10 of the 16 catchments have less than 2% increase, and all are less than 5% (**Table 10.3-5** and **Figure 10.3-2**). Small and less-developed catchments have the greatest increases. Overall (all catchments), the increase is 0.76 % (**Table 10.3-5**).

Table 10.3-5. Impervious area assessment.

Catchment Name	total catchment (ha)	existing impervious area (ha)	existing proportion impervious (%)	SFPR impervious area increase (ha)	SFPR-impervious + existing impervious, proportion of total (%)	proportion impervious increase as a result of SFPR (%)
124th Street	44.94	34.2	76.11	1.23	78.84	2.73
128th Street	98.15	69.5	70.79	3.02	73.87	3.08
137A Street	112.23	75.1	66.95	3.88	70.41	3.46
157th Street	46.40	14.7	31.72	1.55	35.05	3.33
160th Street	26.33	12.2	46.44	1.16	50.84	4.40
Royal City	48.80	36.3	74.35	0.63	75.64	1.28
Bedford	108.24	68.6	63.41	2.22	65.47	2.06
Big Bend	232.66	139.0	59.74	11.12	64.51	4.78
Bolivar	340.61	233.0	68.40	1.42	68.81	0.42
Bon Accord	594.43	317.6	53.43	4.54	54.20	0.76
Fraser Heights	271.72	152.5	56.14	3.58	57.45	1.32
Manson 1 & 2	322.26	234.7	72.84	4.17	74.13	1.29
Old Yale	80.58	49.3	61.15	1.41	62.90	1.75
Pattullo	234.79	169.2	72.06	0.73	72.37	0.31
Port Kells	520.73	359.8	69.10	3.42	69.76	0.66
Delta	9733.48	2928.8	30.09	53.28	30.64	0.55
All catchments	**12816.34**	**4894.58**	**38.19**	**97.36**	**38.95**	**0.76**

Figure 10.3-2. Pervious, impervious and increase in impervious area due to SFPR.



Step 2 – Riparian area assessment

The area in each catchment where there was at least 30 m of riparian vegetation (forest or wetland vegetative cover ≥ 30 m from the watercourse) along the watercourses was calculated (**Table 10.3-5**). Information from the land uses analysis and the watercourse locations were used for this calculation. The portion of the riparian vegetation area that is likely to be affected by the SFPR was also calculated (**Table 10.3-5**). The existing riparian forest and wetland greater than 30 m (as a proportion of total riparian area) is variable, but most catchments (11 of 16) have less than 20%. Two catchments, 157th Street and 160th Street catchments (the forest escarpment below Fraser Heights), have more than half their riparian area with greater than 30 m of wetland or forest vegetation. The SFPR has no impact on riparian vegetation in five catchments, reduces it by less than 2 ha in nine catchments and in the remaining two, Fraser Heights and Delta, the impacts are 2.3 and 4.5 ha respectively. Overall, riparian vegetation in all catchments is reduced by 1.1%. This assessment does not consider the additional riparian area that would be created by SFPR fisheries compensation projects.

Table 10.3-5. Assessment of SFPR impacts on forest and wetland area >30 m by catchment.

Catchment Name	total riparian area (ha)	existing riparian forest & wetland >30m (ha)	existing proportion riparian forest & wetland >30m (%)	predicted SFPR impact on riparian forest & wetland > 30m (ha)	predicted proportion riparian forest and wetland >30m after SFPR (%)
124th Street	23.9	0	0	0	0
128th Street	49.9	1.4	2.8	0	2.8
137A Street	41.9	2.2	5.2	0.69	3.5
157th Street	18.6	12.4	66.5	1.69	57.4
160th Street	6.0	3.3	55.5	1.29	33.8
Royal City	32.7	0.1	0.3	0	0.3
Bedford	47.8	4.3	9.0	0.47	7.9
Big Bend	85.7	19.9	23.2	1.54	21.4
Bolivar	88.5	0.2	0.2	0.07	0.1
Bon Accord	157.9	50.1	31.7	1.32	30.8
Fraser Heights	45.0	22.4	49.7	2.34	44.5
Manson 1 & 2	128.3	2.9	2.3	0.28	2.04
Old Yale	25.2	2.7	10.7	0	10.6
Pattullo	88.4	4.6	5.1	0	5.15
Port Kells	140.3	9.3	6.6	1.08	5.8
Delta	442.2	76.8	17.4	4.48	16.3
All catchments	**1422.3**	**212.4**	**14.9**	**15.25**	**13.8**

Step 3 – Analysis of catchment health

The existing and predicted impervious area and riparian vegetation data from the above analyses were graphed according to the thresholds in a proposed watercourse classification system developed for the Greater Vancouver Sewerage and Drainage District (GVSDD 1999). The existing impervious area and riparian vegetation (**Figure 10.3-3**) shows that one of the SFPR catchments is in the ‘fair’ category established by GVSDD (1999); the 157th Street catchment is centered in the fair category. The remaining 15 catchments are in the ‘poor’ category, where high proportions of impervious area and low proportions of riparian vegetation are considered to affect catchment health.

The predicted change in impervious area and riparian vegetation as a result of the SFPR (**Figure 10.3-4**) shows that all catchments remain in much the same location in the graph space; indicating that there is little change in watershed health relative to GVSDD (1999) thresholds.

Figure 10.3-3. Existing impervious area and riparian vegetation in SFPR catchments.

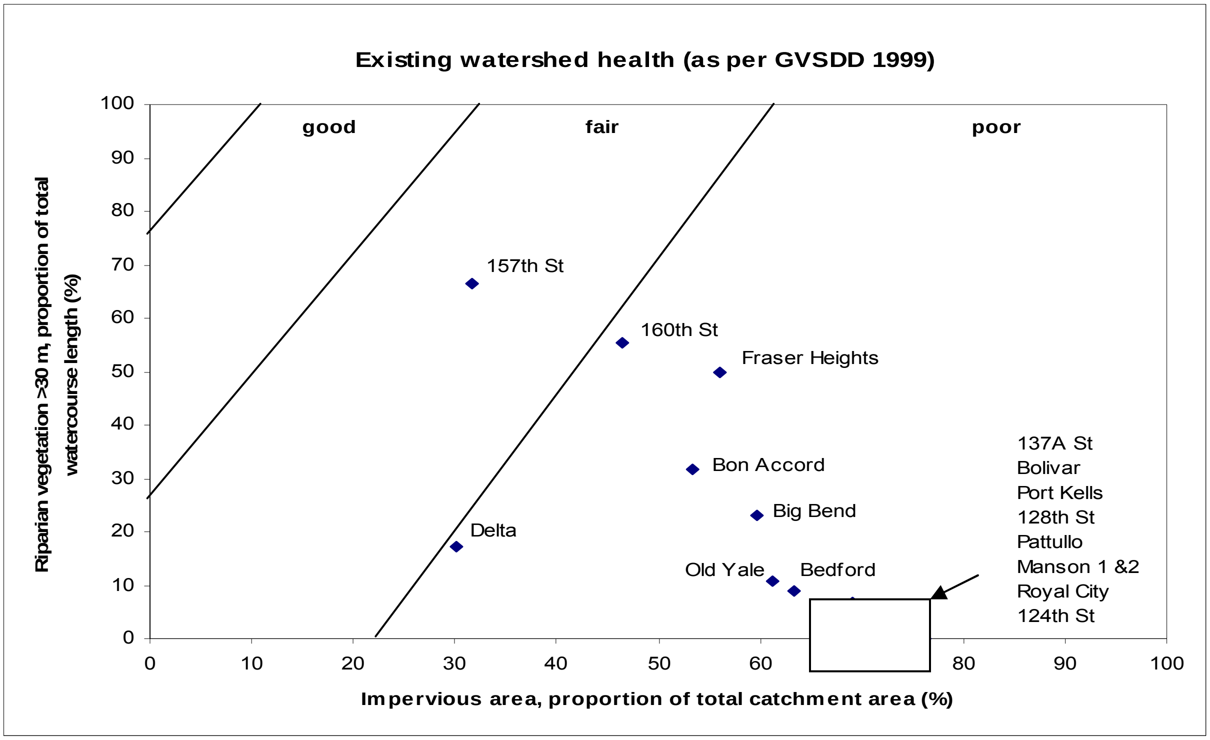
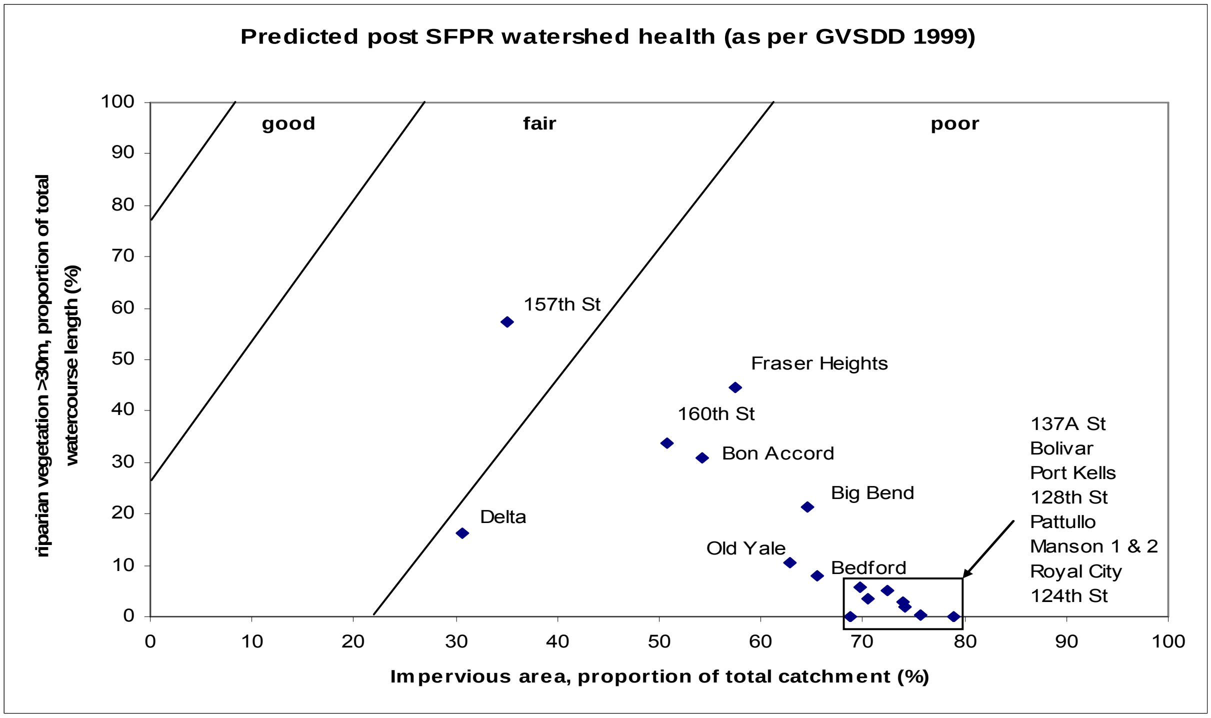


Figure 10.3-4. Predicted change in impervious area and riparian vegetation in SFPR catchments.



This analysis indicates that most of the SFPR catchments are rated as "poor" compared to the thresholds identified by the GVSDD (1999), due in large part to the existing high levels of development (well-developed context) and lack of planning to retain riparian areas and maintain pervious surfaces. These catchments typically have over 50% impervious area and less than 50% of their riparian areas are considered to be protected by riparian vegetation. One catchment, 157th St Catchment (small forest escarpment below Fraser Heights), with less impervious area and more riparian vegetation is rated as "fair".

The overall findings of the analysis are that the predicted impacts due to the SFPR (**Figure 10.3-4**) are low in magnitude and do not result in changes in the ratings of watershed conditions (i.e., no catchments experience a change in their rating based on the GVSDD thresholds).

While there are predicted to be no changes in the ratings of catchments in the project corridor, there is the potential for small changes to impervious area and riparian vegetation that could lead to localized effects on water quality/quantity. However, the SFPR project has committed to the development of integrated stormwater management infrastructure, with defined performance water quality and flow objectives which will mitigate potential effects to habitat associated with potential changes in water quality and quantity. In addition, fisheries habitat compensation initiatives will ensure that there is no net loss of aquatic or riparian habitat in the project corridor. Neither of these mitigation/compensation initiatives is taken into account in the analysis of potential changes in catchment conditions presented above.

As a result of the above analysis of changes to impervious area in catchments affected by the SFPR, there is probably an existing cumulative impact based on the GVSDD (1999) thresholds for catchment health. However, no residual impacts are predicted as a result of the SFPR because there are no changes in catchment ratings as a result of the project. In addition, stormwater management mitigation and fisheries compensation initiatives will address potential changes in water quality and quantity that could occur as a result of small increases in impervious area. As such, it is predicted that the project is not expected to result in a residual impact on runoff water quantity or quality or catchment health that could interact with existing cumulative effects associated with previous development in the study area.

10.3.4.6 Air Quality

CAC

Local air quality conditions were assessed for the SFPR (section 7.2 and Technical Volume 7). Regional air quality conditions (using the analysis from the SFPR, Port Mann Highway 1 and North Fraser Perimeter Road (Pitt River Bridge) local air quality assessments) were assessed for the Gateway Program (Technical Volume 16). The regional air quality assessment for the Gateway Program, plus other air quality analyses for other projects, was used for the assessment of cumulative impacts (also Technical Volume 16).

There were no significant adverse effects on local air quality predicted as a result of the SFPR (section 7.2) due to anticipated improvements in the efficiency of fuel use by the vehicle fleet by 2021, and reduced sulphur in the fuel. However, small residual impacts are likely. Contaminant emissions on the existing road network in 2021 (with or without SFPR) will be reduced compared to the 2003 scenario and the difference between the SFPR and non-SFPR scenarios is a small increase (section 7.2). Such residual impacts (though small) in the lower Fraser Valley (LFV) airshed, where vehicle emissions form a significant portion of total air emissions, require an assessment of the potential for cumulative impacts. The assessment takes into account the relationship of SFPR to the other Gateway Program road improvement projects (i.e., Port Mann Highway 1 and North Fraser Perimeter Road) and other projects in the region. The mechanism by which it is considered that cumulative impacts of CAC emissions could occur is spatial crowding, where CAC from the SFPR adds to CAC from other sources such that the impacts on receptors are additive.

The assessment of regional air quality, and the cumulative effects assessment, considered the regional air quality data and data from other regional projects that could impact air quality (e.g., the Golden Ears Bridge, Sea to Sky, Border Infrastructure, Canada Line, Deltaport Third Berth and Terminal 2 projects). The collection of such data was guided by a work plan and the Approved Terms of Reference (EAO 2004), both of which were developed in consultation with the Biophysical and Socio-Community Working Groups involved in the SFPR review (Technical Volume 16). This assessment used the GVRD emissions inventory as the basis for the analysis. This emissions inventory considers all mobile (cars, trucks, trains, ships and airplanes) and non-mobile (residential and industrial) activities that currently contribute to emissions. Predicted growth in population, the economy, employment and travel were used for forecasts of future emissions from these same emissions sources. The basis for future air quality predictions is the GVRD growth management strategy (GMS), which uses population and land uses changes predicted and planned for in municipal OCP. Refinements to the GVRD emissions estimates for vehicle traffic were used to incorporate more accurate data obtained during the development of the SFPR and other Gateway Program projects (section 3.1.1.5). Predicted emissions from other large future projects in the study area were obtained from impact assessment reports for each of the projects.

The results of the regional air quality impact assessment show that regional traffic-related emissions of all CAC, except NH_3, decrease compared to the existing 2003 situation for both projected 2021 scenarios (with and without the Gateway Program). This decrease is despite a projected increase in regional traffic from 2003 to 2021, because of improved vehicle emission standards (emission technologies such as AirCare and catalytic converters required by law on new vehicles) and reduced sulphur content in diesel and gasoline that is currently being phased in. When considered in the context of regional emissions from all other existing mobile and non-mobile sources in the GVRD and future growth associated with municipal OCP, the projected 2021 with Gateway scenario is expected to result in emissions that are marginally higher than the projected 2021 without Gateway scenario (except for VOC which decreases in both scenarios). The differences in ambient concentrations between 2021 with and without the Gateway Program are:

- -0.01% for VOC;
- 0.004% for O_3;
- 0.01% for SO_2;
- 0.04% for PM_{10} and 0.08% for $PM_{2.5}$; and
- 0.1% for NH_3; and NO_2.

These differences are due to a variety of factors including: an increase in capacity; reduction in congestion on the regional road network; a projected increase in the estimated total vehicle-kilometres travelled in the region; and the provision of congestion reduction measures on Highway 1, such as HOV extension, improved transit and electronic tolling on the Port Mann Bridge, which help to reduce the growth in single-occupancy vehicle traffic.

The cumulative impacts assessment, takes into account emissions associated with other planned (future) regional transportation projects not specifically accounted for in current predictions of future air quality (e.g., Border Infrastructure, Sea to Sky, Golden Ears Bridge, Canada Line (RAV), Deltaport Third Berth and Terminal 2 projects), in conjunction with the Gateway Program (**Table 10.3-6**). In the cumulative impacts assessment of air quality, ambient concentrations of air contaminants are predicted to increase as follows:

- 0.1% VOC;
- 0.1% 0_3
- 0.3% NH_3;
- 0.4% PM_{10};
- 0.6% $PM_{2.5}$;
- 0.9% SO_2; and
- 1.4% NO_2.

From a regional perspective, the contribution of Gateway Program-related emissions to GVRD predictions of changes in future ambient CAC concentrations in the Lower Fraser Valley is predicted to be small (-0.01% (a decrease) for VOC to 0.1% increase for NO_2). When the contribution of CAC from other proposed regional infrastructure projects is taken into account, the cumulative impact of the SFPR on regional emissions and ambient air quality is not considered significant (negligible impacts) in the context of forecast regional air quality trends.

Table 10.3-6 Summary of CAC and GHG (CO_2E) emissions from other projects in the SFPR regional air quality study area.

Project	Scenario	Emissions (tonnes/year)							
		CO	NO_x	PM_{10}	$PM_{2.5}$	SO2	VOC	NH3	CO_2E
Highway 10 Expansion	Future Baseline 2021	1,137	54	3.3	1.6	1.0	41	12	50,139
	Project Operation 2021	1,353	71	4.6	2.1	1.4	49	17	60,235
	Net Change in Emissions	+216	+17	+1.3	+0.6	+0.4	+8	+5	+10,096
Highway 15 Expansion	Existing Baseline[1]	754	30	1.9	1.1	1.7	29	7	33,133
	Project Operation 2021	1,859	74	5.3	2.5	1.8	70	18	79,799
	Net Change in Emissions	+1,105	+44	+3.4	+1.4	+0.1	+41	+11	+46,666
Sea to Sky	Future Baseline 2025	2,090	190	10	5.5	2.7	216	32	136,331
	Project Operation 2025	2,293	206	11	6.0	2.9	237	35	149,178
	Net Change in Emissions	+203	+16	+1.0	+0.5	+0.2	+21	+3	+12,847
GEB	Project Operation 2021	4,514	184	9.0	4.2	2.8	211	32	76,642
	Net Change in Emissions	+4,514	+184	+9.0	+4.2	+2.8	+211	+32	+76,642
Canada Line	Project Operation 2021	-9	-14	-0.6	n/a	n/a	n/a	n/a	-23,014
	Net Change in Emissions	-9	-14	-0.6	n/a	n/a	n/a	n/a	-23,014
DP3	Project Operation 2021	92	189	13	12	53	12	0.7	20,611
	Net Change in Emissions	+92	+189	+13	+12	+53	+12	+0.7	+20,611
Terminal 2	Project Operation 2021	404	730	51	50	219	48	3	84,791
	Net Change in Emissions	+404	+730	+51	+50	+219	+48	+3	+84,791
Total Net Change in Emissions[2]		+6,364	+1,154	+78	+69	+275	+324	+52	+218,490

GHG

Unlike emissions of most CAC, which are expected to decrease over time due to improvements in emissions control technologies and fuels, emissions of GHG from mobile sources including road vehicles, are expected to increase, with or without Gateway Program projects. The increase is a result of expected increases in vehicle kilometres driven in the region, which are associated with future population and economic growth. Increases in global concentrations of GHG are linked to climate change related impacts including: increases in sea-level rise, increased frequencies of storm events and extreme weather events.

The mechanism by which it is considered that cumulative impacts on GHG emissions could occur is spatial crowding, where GHG from the SFPR adds to GHG from other sources such that the impacts on receptors are additive.

A regional assessment of Gateway Program projects on GHG emissions, in concert with predicted growth in the GVRD (from the growth management strategy) indicates that, currently, mobile sources (i.e., vehicles, planes, trains and marine transportation) contribute 34% of regional GHG emissions in the LFV (Technical Volume 16). By 2020 total regional GHG emissions are projected to increase by approximately 20%, with the contribution of GHG from mobile sources increasing to 38% of total regional GHG emissions in the lower Fraser Valley (LFV) by 2020.

A specific analysis of GHG emissions illustrate that traffic on the existing (2003) regional roadway network in the Canadian LFV (not all mobile sources as above), accounts for 25.4% of the total GHG emissions from all sources in the Canadian LFV. In the projected 2021 without Gateway scenario, GHG emissions from traffic on the regional roadway network in the Canadian LFV are predicted to increase compared to the existing situation, and account for 27.0% of forecast total regional GHG emissions. In the projected 2021 with Gateway scenario, traffic-related GHG emissions in the Canadian LFV are expected to increase compared to the projected 2021 without Gateway scenario and account for 27.4% of forecast regional GHG emissions. This regional assessment of Gateway Program projects on GHG emissions from traffic indicates a net increase in total regional GHG emissions due to the Gateway Program of 0.4%.

The cumulative impacts assessment of traffic-related GHG emissions in the Projected 2021 Gateway Program scenario (i.e., including all Gateway Program related emissions, and emissions from other proposed projects not specifically identified in GVRD GHG forecasts) shows a net increase of regional GHG emissions of 0.6% compared to the projected 2021 without Gateway or other planned projects. This magnitude of increase is considered low in the context of the total GHG inventory for the region and the magnitude of predicted increases from other sources (**Table 10.3-6**). As a consequence negligible cumulative impacts on GHG emissions affecting air quality are predicted as a result of the Gateway Program.

While cumulative effects to air quality associated with Gateway Program projects are considered in the CEA, it should be noted that the Gateway Program is part of a suite of overall Provincial initiatives to reduce vehicle emissions and improve air quality. These include:

- Reducing GHG emissions by 33% by 2020;
- Expanding the transit network reducing GHG emissions;
- Introducing new tail pipe emissions standards to reduce CO_2 by 30%;
- Reducing vehicle emissions from congestion related idling;
- Expanding HOV and cycling choices; and
- Tolling the Port Mann to help limit growth in traffic over time.

Particulate Matter in Burns Bog

Cumulative effects to air quality, as a result of the project, are anticipated to be negligible in the context of current and forecasted trends in emissions and existing air quality guidelines. Comments raised during the subsequent review of the project identified there was a potential for cumulative effects on Burns Bog as a result of the deposition of particulate matter (PM) from the SFPR, given the unique and sensitive ecological conditions that define this area.

The mechanism by which air emissions could impact Burns Bog involve the introduction of PM which, given sufficient volumes of deposition, could lead to changes in hydrochemical conditions (i.e., low pH and low levels of nutrients) and facilitate a change in the plant communities that exist within the Bog, for example, from predominantly bog species (i.e., low pH/low nutrients) to species associated with richer wetland conditions (i.e., higher pH and /minerotrophic). In this cumulative effects assessment these mechanisms are considered to be spatial and temporal crowding (i.e., too much PM from all sources for the environment to assimilate).

The basis for the concern regarding the potential effect of PM emissions on Burns Bog is related to the suggestion that the development of Highway 91 may have contributed to increased PM loadings to the Bog and facilitated the introduction of minerotrophic plant species and the exclusion of bog species (i.e., Sphagnum) in some areas. However, evidence from the literature suggests that mineralization noted close to Highway 91 has been present since prior to that road being built. Specifically, the EA conducted for the Highway 91 Project (Beak Consultants 1982) indicates that the conditions in the eastern portion of Burns Bog were getting drier before the introduction of Highway 91. Such a change appears to have been caused by the changes to Cougar Canyon Creek (also known as the North East Interceptor Canal). “Prior to 1917, when the Northeast Interceptor was built, Burns Bog received a considerable amount of the runoff from the Surrey-Delta upland, which was a major contributor to the maintenance of a high water table in the Bog. When the Northeast Interceptor began to collect runoff that had previously reached the Bog, the water table dropped, and the Bog’s eastern edges have slowly dried out in the succeeding years. As a result, a progressive change in vegetation has been observed along the eastern edge of the Bog, from typical bog species to those characteristic of a coastal forest” (Beak Consultants 1982). In addition, observations from the 1930s noted the existence of lodgepole pine encroachment into Burns Bog, which is suggestive of drier conditions (Osvald 1933 cited in Hebda et al. 2000).

Notwithstanding that there is some evidence to suggest that changes in the plant complex in some areas of Burns Bog were underway in advance of the development of the Highway 91 corridor, and are the result of some other mechanism, additional work was undertaken by the MoT in order to provide a more thorough analysis of the potential risk associated with PM deposition to Burns Bog. This work included predictive air quality dispersion modelling to determine: the potential magnitude of rates of deposition of PM to Burns Bog; and where emissions would be distributed within the Bog, given meteorological trends and prevailing wind conditions. Based on a range of assumptions regarding rates of PM deposition to Burns Bog, additional work was done to predict how the hydrochemical conditions of Burns Bog would be impacted by such deposition. Given the sensitive nature of the hydrochemistry of bog ecosystems and the importance of Burns Bog to the integrity of the regional ecosystems, conservative assumptions were made regarding the PM levels that could enter Burns Bog. In particular, for the purposes of hydrochemical modelling, it was assumed that appreciably higher rates of PM would be distributed on Burns Bog than are known to exist in the Lower Mainland. In addition, it was assumed that these high rates of PM deposition would be distributed on the most sensitive hydrological conditions within Burns Bog (i.e., Type 1 water).

Even with the conservative assumptions used (i.e., much higher rates of PM emission from SFPR than are expected or demonstrated to occur on similar roads with similar vehicle fleets and traffic flows), the results of the studies showed that:

- Rates of PM deposition decrease to 10% of the predicted maximums within 100 m from the edge of road (Levelton, 2008);

- Even within 25 m of the edge of the road (where the highest rates of PM deposition occurred), rates of SFPR-related PM deposition combined with PM deposition from existing background emissions are not sufficiently high to change the hydrochemistry of Type 1 waters associated with Burns Bog (Levelton, 2008);

- Hydrochemical modeling undertaken by an independent technical specialist (Gladwell, 2008) indicates that, given current climate and drainage conditions, Burns Bog has the capacity to buffer existing rates of particulate deposition over the long term without a significant adverse effect to the Bog's hydrochemistry (Gladwell 2008); and

- Rates of particulate deposition, from existing regional sources and modelled SFPR scenarios, pose no risk to the hydrochemistry of Burns Bog (Gladwell, 2008).

Based on predictive modelling of both expected and conservative scenarios (Levelton, 2008), rates of particulate deposition at 100 m are predicted to range from 1.4 to 10.5 $g/m^2/year$. This rate of deposition takes into consideration past, present and known future sources of dust particulate within the project corridor. While increases in particulate deposition, over baseline conditions, would be defined as a cumulative effect, the effect is assessed as low based on the following considerations. In the case of both the expected and conservative scenarios, the cumulative effect is predicted to be low in magnitude as rates of particulate deposition, while over baseline conditions, would fall within generally accepted guidelines.

For the areas of Burns Bog beyond 100m, the findings of air quality and hydrochemical modelling indicate that:

- There is a residual effect to Burns Bog, from existing anthropogenic PM emissions (without SFPR), in that such emissions result in a PM loading to the Bog over and above that which would normally be expected to occur without human activities that occur in the Lower Fraser Valley airshed. However, the residual effect is not significant since it has been demonstrated that Burns Bog has sufficient capacity to assimilate such emissions without a change to the hydrochemical conditions which support the plant communities which define the Bog;

- While SFPR would result in a residual effect (i.e., increases in PM deposition over and above current loading from other sources), even appreciably higher rates of PM deposition than are expected to occur in the project corridor would not result in a significant residual effect as it is has been demonstrated that the Burns Bog could assimilate such rates of PM deposition without change to the hydrochemistry of the Bog; and

- The potential for cumulative effects as result of PM deposition, from the proposed project, to Burns Bog is considered to be negligible.

10.3.4.7 Change in Noise Levels

The noise assessment for the project considered 36 sites, representing multiple residences and one school, throughout the project corridor. The assessment identified 25 sites which are predicted to experience increases in noise levels that, consistent with the MoT's noise policy (1993), warrant the application of some form of noise mitigation. The application of such mitigation would decrease SFPR traffic noise levels at most of the 25 sites by 5dBA or more .

Of the 36 study sites, 7 sites were identified that could potentially require additional mitigation to avoid 'severe impacts', as defined by Health Canada,(i.e., where the increase in the percentage of residents considered 'highly annoyed' is greater than 6.5%). At 6 out of the 7 sites, the construction of noise walls, use of quiet pavement and coordination of traffic signals would reduce the noise generated by the SFPR to below the 'severe' threshold. While further assessment work will be conducted during detailed design to confirm the effectiveness of noise wall mitigation at residential enclaves identified as requiring mitigation, preliminary analysis indicates that noise walls (as well as quiet pavement and coordinated signals) would achieve at least 5 dBA of SFPR traffic noise reduction (Technical Volume 13) at these 6 sites.

Site 17, near 136th Street in Bridgeview represents 16 residences and is considered to be within an area where noise walls may not completely reduce the impacts below the 'severe' threshold. Additional noise modelling and mitigation design will be completed during detailed design to minimize the impacts in this area.

The noise impact assessment takes into consideration the current noise levels from traffic on existing roads (including the Port Mann Bridge and Highway 1 where it is close to the SFPR). It also considers noise from other existing activities (e.g., existing railway, residential, port and industrial activities). However, it does not include an assessment of increased noise from these activities. There is no information available to undertake such a quantitative assessment from railway, residential and port activities, but baseline noise measurements found that that existing noise levels from sources such as Port Mann and Highway 1 traffic, local traffic, trains and aircraft at Sites 21 and 22 (the sites closest to both projects) are greater than projected SFPR traffic noise levels, leading to marginal increases, for example:

- Site 21 has a baseline of 58.3 dBA and SFPR would add 50.3 dBA, leading to 58.9 dBA total noise (a 0.6 dBA increase); and
- Site 22 has a baseline of 48.2 dBA and SFPR would add 49.9 dBA, leading to 52.1 dBA total noise (a 3.9 dBA increase).

With the Port Mann Highway 1 expansion added to this, Site 21 would increase to 60.1 (approximately 1 dBA additional as a result of Port Mann Highway 1) and Site 22 would increase to 56 dBA.

The impact on the noise environment in the study area from other projects and activities is not considered to lead to cumulative effects, because these activities are too far away from the SFPR for cumulative effects to occur, existing activities already produce relatively high levels of noise and mitigation measures are thought to be effective.

In conclusion, after the application of mitigation (e.g., noise walls, quiet pavement and coordination of traffic signals), it is anticipated that one site may continue to exceed the 'severe' impact threshold. As the preliminary assessment has shown that the operational noise impacts associated with the project can be mitigated to below ‘severe’ at all but one site (comprised of 16 residences), and the average increase in traffic noise levels can be limited to less than 2 dBA, the magnitude of the residual effect across the corridor was assessed as low. Recognizing that at a minority of sites, additional mitigation may be required to bring noise levels to below the ‘severe’ threshold, the cumulative effect was determined to be low-moderate in recognition of site-specific challenges in fully mitigating operational related noise.

10.3.5 Significance Evaluation

The significance of adverse cumulative environmental impacts identified in the analysis (section 10.3.4) and summarised in the right column of **Table 10.3-7**, was determined by taking into account characteristics of the impact. These included:

- magnitude – the degree of change relative to the baseline;
- geographic extent or spatial area;
- duration - the length of time over which the environmental effect occurs;
- frequency – how often the effect occurs within a given period;
- reversibility – the potential for the impact to lessen and for the baseline conditions to re-establish; and
- ecological context – an indication of the extent to which the area affected is relatively pristine and / or ecologically fragile.

The significance of the potential cumulative impacts is discussed below, and summarised in **Table 10.3-7**. This significance assessment is the opinion of the MoT, and the responsible authorities will make a final determination of significance.

This assessment details only the negative cumulative impacts of the proposed SFPR project, and other projects and activities in the study area. However, there are also positive impacts, in particular relating to the provision of better transportation and access as a result of the project. The study area relies heavily on transportation, and as the existing network is becoming increasingly congested (section 3) the provision of a new road to replace the under performing existing routes in the area have the potential for positive cumulative impacts associated with direct and indirect economic growth.

10.3.6 Conclusion

The scope of the CEA undertaken for the Project (**Table 10-3-3**) considered 14 VEC where residual impacts were considered. Aquatic impacts were considered in the CEA, as discussed with DFO, in the context of considering residual impacts from historical development and the SFPR on water quality and quantity (including impervious area increases) with respect to fish values, not on fisheries habitat loss due to the SFPR which is not expected to result in residual impacts.

For three VEC (habitat fragmentation riparian/upland forest and aquatic impacts) no residual impacts were noted from the SFPR and other projects, and the cumulative impact was considered “nil”.

For the remaining 11 VEC related to: habitat loss (bog, wetland, cultivated fields, riparian forest and/or upland forest); changes in wildlife movements (mammals); wildlife mortality (collisions); air quality (CAC and GHG emissions and PM inputs to Burns Bog); and noise (change in noise levels) residual impacts from other projects were identified and cumulative impacts were assessed.

For all but one of the potential cumulative impacts (indirect impacts to wildlife habitat – zone of influence) the cumulative impact is considered negligible, low or low-moderate. The indirect impacts to wildlife habitat, i.e., zone of influence effects the cumulative impact was considered moderate. Air quality (CAC emissions) as a result of SFPR in conjunction with Gateway Program projects plus other regional transportation projects is considered negligible. Low-moderate cumulative effects were identified for noise (change in noise levels), though cumulative effects for noise are considered site specific and the assessment of significance does not apply to the entire corridor.

A summary of the conclusions for each VEC is included as the last paragraph in each assessment section (section 10.3.4), and these are tabulated in **Table 10.3-7**.

Table 10.3-7 Significance evaluation of potential cumulative effects (from Table 10.3-3).

Potential cumulative effect	Extent	Magnitude	Duration	Reversibility	Ecological / social context	Probability	Significance (level) [1]
Habitat Loss Bog habitat	Local (SW Delta)	Low	Long	No	Well-developed	Low	**Low-Moderate**
Habitat Loss Cultivated fields	Local (SW Delta)	Low	Long	Yes	Developed	Low	**Low**
Habitat Loss Upland Forest	Regional (Delta/Surrey)	Low	Long	No	Well-developed	Low	**Low**
Habitat Loss Riparian Forest	Local (corridor)	Low	Long	No	Developed	Low	**Low**
Habitat Loss Wetland / open water	Regional (Delta/Surrey)	Low	Long	No	Developed	Low	**Low-Moderate**
Fragmentation Riparian forest	Regional (Delta/Surrey)	Low	Long	No	Developed	Low	**Low**
Fragmentation Upland forest	Regional (Delta/Surrey)	Low	Long	No	Developed	Low	**Low**
Wildlife patterns (indirect habitat impact)	Local (corridor)	Moderate	Long	Yes	Well-developed	Moderate	**Moderate**
Wildlife mortality (collisions)	Local (corridor)	Low	Long	Yes	Developed	Low	**Low**
Aquatic Impacts Fish habitat	Regional (Lower Fraser)	Low	Medium	No	Well-developed	Low	**Low**
Air quality CAC emissions	Local (corridor)	Low	Long	Yes	Well-developed	Low	**Negligible**
Air Quality GHG emissions	Local (corridor)	Low	Long	Yes	Well-developed	Low	**Negligible**
Air Quality PM input to Burns Bog	Local (corridor)	Low	Long	Yes	Undeveloped	Low	**Negligible**
Change in noise after mitigation	Local (site specific)	Low-Mod (site-specific)	Long	Yes	Well-developed	Low	**Low -Moderate**

[1] This significance assessment is the opinion of the MOT, and the regulatory authority will make a final determination of significance.

Notes for Table 10.3-7:

Extent: geographic extent of the cumulative effects identified.

- **Project Area** – Project footprint and beyond to 2 km.
- **Local** – Project footprint and beyond to 5 km.
- **Regional** – Project footprint and beyond to greater than 5 km.

Magnitude: magnitude of the cumulative effect**.**

- **Negligible** – no change over the baseline
- **Low** – impact expected above baseline, but in generally accepted standards.
- **Moderate** – impact expected to be considerably above baseline or could cause a change in ecological, social or other parameters.
- **High** – impact expected to exceed accepted criteria and to cause a measurable change well beyond the natural variability.

Duration / frequency: likely duration of the potential cumulative effect.

- **Short** – less than 60 days.
- **Medium** –60 days – 2 years.
- **Long** – Greater than 2 years /duration of operation

Reversibility: potential for the cumulative effect to be reversed or naturally ameliorated back to the baseline level after the duration of the effect.

- **Yes** – environment could return to baseline after effect is removed.
- **No** - environment could not return to baseline after effect is removed

Ecological / Social Context: the ecological or social context and its' ability to absorb change.

- **Intact** – a near-pristine landscape, ecological situation or social environment.
- **Developed** –developed or altered landscape, ecological environment or social situation.
- **Well developed** - Intensely developed or altered landscape, ecological situation or social environment.

Probability: likelihood of cumulative effect occurring if the Project proceeds:

- **Low –** up to 25 % chance of predicted total cumulative effect occurring.
- **Moderate** – 25 to 50 % chance of predicted total cumulative effect occurring.
- **High** - over 75 % chance of predicted total cumulative effect occurring.

References

Additional to those in the previous version of this CEA.

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