ANNIEDALE - TYNEHEAD - NCP AREA
OVERVIEW ENVIRONMENTAL ASSESSMENT

for:

City of Surrey
14245 – 56th Avenue
Surrey, BC V3X 3A2

by:

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September 25, 2009 Dossier 09.0110

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EXECUTIVE SUMMARY

We conducted an overview environmental assessment of the Anniedale-Tynehead NCP Area in North Surrey. The assessment was requested by the City of Surrey in preparation for a Neighbourhood Concept Plan (NCP). The study area, also known as the Anniedale - Tynehead area, is an area of low-density residential lots with interspersed patches of forest and farmland south of Highway 1. Our study consisted of a combination of office-based research and mapping, and field investigations. Our findings are summarized as follows:

Bedrock and surficial geology

We saw no bedrock exposures, not surprisingly since bedrock in the area is buried by as much as 100 m of glacial sediments. These sediments consist of a surface layer of glaciomarine silts and sands, laid down in a shallow sea some 10 to 12000 years ago. This overlays a thick deposit of glacial till (called 'Vashon Till') consisting of a rather dense mix of stones, gravel, sand, silt and clay. Vashon Till is relatively impermeable, but exhibits good bearing strength and low erodibility.

Terrain

The study area consists of a broad, east-west trending ridge. Slopes are mostly gentle (less than 15%) but in certain areas in the south may exceed 30%. Most of the area slopes to the south. We noted one small landslide scar (specifically a slump-earthflow) and we identified and mapped a number of areas of sensitive terrain that would require further, more detailed, geotechnical evaluation prior to development.

Soils

Over most of the upland portions of the study area, soils are well drained and have developed as Brunisols or Podzols. They tend to have a silty loam to sandy loam texture with a variable amount of coarse fragments. Along the southern margin, and locally on the lower parts of slopes, soils are imperfectly or poorly drained. We mapped and identified areas of sensitive soils, especially poorly drained ones that should be the subject of more detailed investigation.

Hydrology

We identified two main stream systems in or near the study area, namely the Serpentine and a catchment area draining into Parsons Channel of the Fraser River (in the northeast). In general, streams are small for several reasons;

1. the study area is a broad ridge which means that catchment areas are small, and

2. much of the natural drainage has been modified by drainage ditches along roads and in fields.

The groundwater regime contains a deep, high capacity, confined aquifer of low vulnerability. The Vashon Till (mentioned earlier) is of relatively low permeability which restricts groundwater recharge. The majority of infiltrated water probably flows in a shallow subsurface zone (within 1 m of the surface) away from the ridge crest to the south and, to a lesser extent, to the north. Several springs – caused by shallow groundwater emerging at the surface - were noted along the lower slopes on the south side of the study area. Recharge of the aquifer underlying the study area is likely to occur mainly from lower lying land to the south.

Redevelopment will likely be accompanied by an increase in impervious area which promotes surface runoff over groundwater recharge. We expect that these impacts will be addressed in an Integrated Stormwater Management Plan or similar exercise.

Climate

The total precipitation in the Anniedale-Tynehead NCP Area is 1370 mm, average for the Greater Vancouver area; less than the North Shore, but more than Richmond or Delta to the south. About 70% falls between October and March, inclusive with the wettest period being October through December. Most recharge of groundwater takes place at that time. Summer droughts can stress native and ornamental trees, and this effect may worsen with continued climate change.

Vegetation and Ecosystems

The study area contains a mix of regenerated forest, abandoned fields, and areas of housing with introduced ornamental trees.

Our ecosystem map shows a preponderance of forested ecosystems (37%), and rural residential areas (33%) with lesser areas of cultivated or old fields (25.4%) and less than 0.2% wetlands. Most of the forested area is dominated by deciduous forest of bigleaf maple, black cottonwood, red alder, and paper birch (71 ha). We mapped 56 ha of mixed broadleaf and conifer forest and only 8 ha of coniferous forest.

Significantly, most of the forest area (over 150 ha) contains ecosystems that are officially red or blue-listed, despite the fact that most of them are immature. Ultimately they will develop into mature forests, if undisturbed, but in certain cases this will take centuries. In the CWHxm variant, we suggest that only maturing conifer forests (structural stage 6 and fine examples of structural stage 5) should be considered a priority for retention.

We did not find rare plants in our surveys, but this does not rule out their presence.

We used a ranking system to identify and map areas of significant conservation values. High value areas are large, contiguous areas with high diversity and species richness.

Wildlife and Habitat

We assessed the habitat suitability for 13 focal species. Of these, we determined that habitat in the study area had a moderate suitability for Western Screech Owl, Barn Owl, Great Blue Heron (foraging only), Band-tailed Pigeon, Barn Swallow, Townsend's shrew, Red-legged frog, Pacific sideband (a snail) and Pacific water shrew. During our fieldwork we observed Great Blue Heron, Barn Swallow, Red-legged frog as well as having anecdotal evidence of Barn Owl. We also recorded 26 species of songbirds, as well as plentiful deer sign.

Fish

Fish habitat in the study area is located mainly in roadside ditches and seasonal drainages altered by anthropogenic influences. Fish habitat values are, therefore, highly constrained; however, we did identify opportunities for habitat restoration and/or enhancement.

The Serpentine River contains the most significant fish habitat. It provides perennial habitat for a range of fish species, including anadromous and resident salmonids.

The headwaters of "Leoran Brook" (local name) occur in the central northern portion of the study area. Leoran Brook represents the only other fish-bearing watercourse located inside the property boundaries. We observed salmonids in headwater creeks and ditches during the field assessments. In addition to cutthroat trout, Leoran brook is known to support populations of coho salmon and rainbow trout.

Latimer Creek, which is a tributary to the Serpentine, is known to contain a diverse range of fish species, including anadromous and resident salmonids.

There are several measures that can be taken to improve habitat diversity and increase fish productivity. In-stream habitat enhancement projects include: log bank cover construction, rock/log weir construction, strategic instream boulder placement, gravel catchment/placement, installing wing/flow deflectors, LWD placement and off channel habitat development.

Riparian planting (including planting to increase bank stabilization) would be a habitat improvement option adjacent to existing fish habitat (for example the Serpentine River). Several specific recommendations are made in this report.

Conservation Priorities

We identified areas of high priority based on vegetation characteristics and inferred wildlife habitat values. These are as follows:

Polygon	Location	Composition	Structural Stage	Area (ha)
28 Serpentine River	East of 168th Street, South of 94A Avenue, West. of Bothwell Drive.	Riparian and floodplain mixed forest; a variety broadleaf trees and scattered conifers.	Pole forests with some interspersed shrubby areas.	3
43	East of 15th., North of 92nd Street	Conifer forest; hemlock/redcedar-sword fern. Dominant trees >30 m tall.	Maturing forest (stage 5)	7 (adjacent to polygon 45)
45	North of 43rd.	Mixed forest, hemlock and broadleaf; scattered conifers.	Pole and maturing forest (stages 4 and 5)	7 (adjacent to polygon 43)
102	South of 92nd Avenue, between 184th Street and 187th Street	Mixed forest, with components of conifer forest; redcedar and hemlock.	Maturing and mature forests (stages 5 and 6).	4.2 ha
98	North of 92nd Ave., East. of 184th Street.	Broadleaf with some mixed forest; some residential area.	Pole forests with lesser maturing (mainly stage 4 with minor stage 5)	9.3
124	Adjacent to 98th Avenue	Broadleaf, immature forest; some cleared areas	Pole forests with some interspersed shrubby areas.	2.5
71	East of 180th Street, North of 92nd Avenue	Mixed conifer and broadleaf forest; hemlock and redcedar.	Maturing forest; (structural stage 5)	4.6
81	East of 182nd, North of 94th Avenue	Mixed conifer and broadleaf; hemlock alder maple.	Maturing forest (structural stage 5)	4.6
61	South of 92nd Avenue, West of 180th Street	Mixed, with patches of pure broadleaf forest; alder maple, hemlock.	Maturing forest (stage 5) with minor pole (stage 4)	6.3

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ANNIEDALE - TYNEHEAD NCP AREA - ENVIRONMENTAL OVERVIEW

1.0 INTRODUCTION

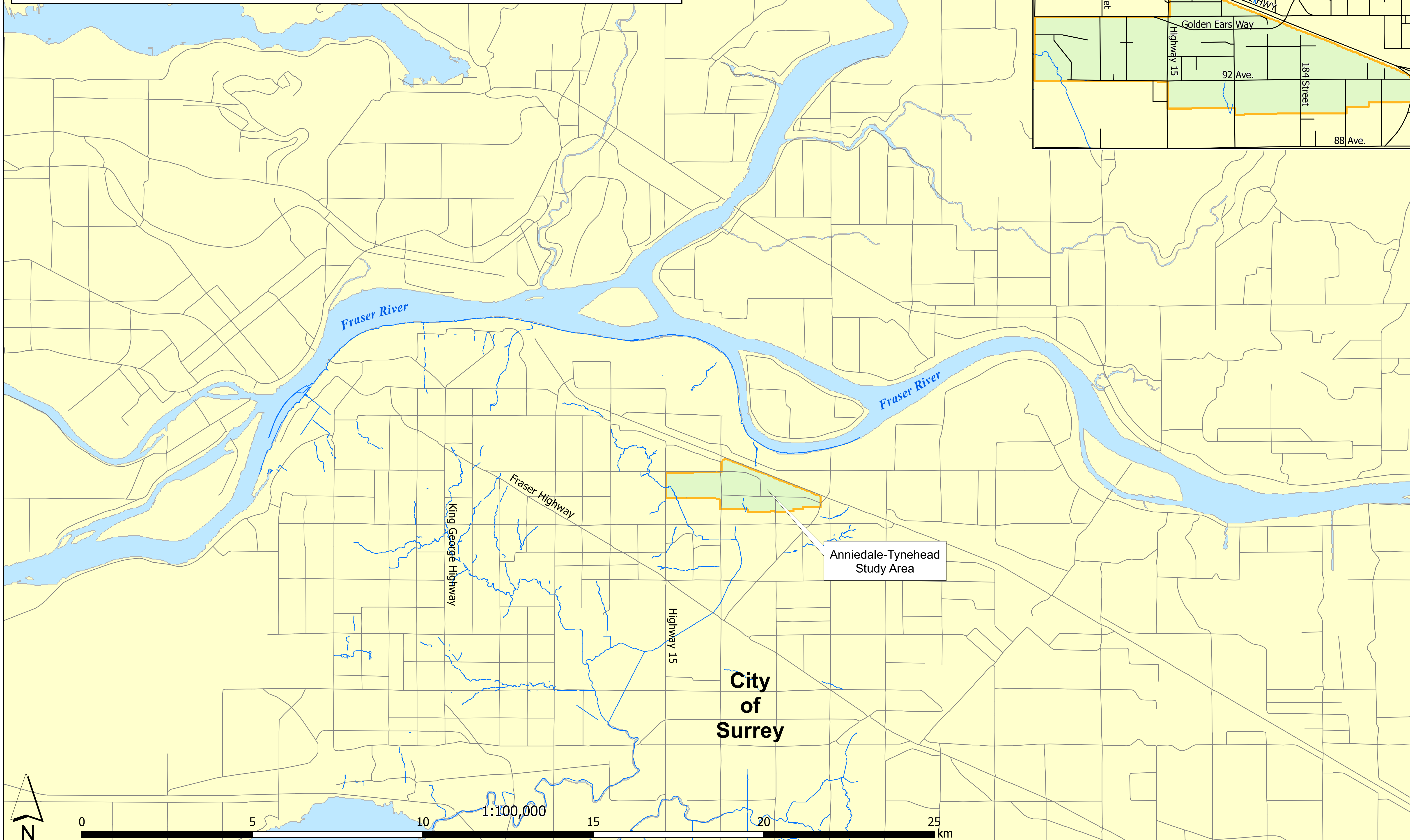
This study was requested by the City of Surrey to provide the necessary environmental background to develop neighbourhood concept plans (NCPs) for the Anniedale-Tynehead NCP Area. The City of Surrey is committed to protecting key greenspaces, but must balance this with a requirement for economic growth, both in agricultural production and urban development. In order to effectively manage greenspace while maximizing developable area, the City needed an updated inventory of all vegetated areas, sensitive ecosystems, and other ecologically important features.

The study area is located south of Highway 1, and is generally bounded by 96th Avenue, to the north, and 168th Street, to the west. The southern boundary is marked generally by the Agricultural Land Reserve (ALR) between 168th and 184th Streets and approximate alignment with 90th Avenue jogging northward from 184th Street to Harvie Road. The eastern boundary is marked by Harvie Road's termination at Highway 1. The study area is approximately 374 hectares in size and is predominantly zoned RA One-Acre Residential Zone, and A-1 General Agriculture Zone.

The Anniedale/Tynehead NCP Area is presently primarily a residential area, with a rural ambience characterized by, pastures, mature trees and panoramic views of the Serpentine Valley and Mount Baker. There are many large estate type homes in the area along with small farms, home businesses and treed areas.

Lots range in size from 2115 sq. ft. to a little over 14.5 acres. The most common lot sizes are 1/3 acre, 1 acre, and 3 acres. One elementary school exists at the southeast corner of Highway 1 and Highway 15. There is also a small commercial area with a convenience store and various offices at the northeast corner of Highway 15 and 96th Avenue.

Figure 1: Anniedale-Tynehead Study Area - Surrey, BC



2.0 OBJECTIVES

The objectives of the environmental assessment were to:

- Identify, inventory, map, prioritize and make recommendations about the protection, restoration, and enhancement of key environmental features in the Anniedale "B" and Tynehead NCP areas.
- Update the original Anniedale "A" environmental assessment.
- Integrate the Anniedale "B" and Tynehead environmental assessments with the Anniedale "A" environmental assessment.
- Incorporate the environmental requirements of the City of Surrey and relevant regulatory agencies.
- Provide scientifically sound advice to the City of Surrey.
- Provide scientifically sound recommendations for environmental management strategies for the preservation and expansion of biodiversity within the NCP areas.
- Provide information in a public open house.
- Provide a final report and maps with recommendations for preserving ecological features.

We met the objectives of the project with the following approach.

Madrone recognizes that the Initial Environmental Assessment Reports produced by Phoenix Environmental Services Ltd. are quite comprehensive and cover the entire study area. Our approach was to gather and analyze available information, and identify data gaps.

We conducted overview map interpretation to identify areas that required more detailed fieldwork. Fieldwork was carried out to gather inventory data on soils, terrain, hydrology, vegetation and ecosystems, wildlife, and fish.

NCPs are designed to assist the City in identifying important or sensitive ecological features and to design appropriate development plans. Requirements for the environmental assessment included:

- a fisheries watercourse assessment,
- a Wildlife Act Section 34(b) wildlife survey,
- Species at Risk Act (SARA) and Provincial red-listed species suitability mapping, as well as the identification of environmentally sensitive areas such as rare vegetation types, marshes, wetlands and critical wildlife hubs, sites and corridors,
- a tree survey including significant trees, remnant patches and forests,
- a public open house,
- a final report and maps with recommendations for preserving ecological features.

The City will be able to integrate the final report and map products with existing and developing Integrated Stormwater Management Plans (ISMPs) and other digital mapping products.

3.0 BEDROCK GEOLOGY AND SURFICIAL MATERIALS

We did not observe bedrock outcrops in the study area. The bedrock is buried under thick glacial deposits. The BC Geological Survey (MEMPR, 2009) mapped bedrock in the area as comprising of Eocene aged undivided sedimentary rocks of the Kitsilano formation.

Surficial materials in the area are a legacy of the last ice age, when ice up to 1500 m thick covered the region. The surficial geology we now see is a result of complex interactions between advancing and retreating ice masses, and a fluctuating sea level, which at times was up to 200 m higher than at present. This complexity makes it difficult to summarize the deposits we observed in our study.

The Geological Survey of Canada (1998) mapped glaciomarine deposits throughout the study area with a band of till deposits along the base of the slopes in the southern portion of the study area.

Till was laid down under ice masses and contain a mix of gravels, sands, silts and clays. This material tends to be relatively dense and impermeable. Glaciomarine deposits were laid down in front of (usually retreating glaciers) in a shallow sea. They can be quite variable, but in the study area they are typically coarse-textured (sandy or gravelly sandy) reflecting their deposition in a shallow, high-energy (perhaps deltaic or beach) environment.

The glaciomarine deposits in this area have been named the Capilano Sediments (Armstrong, 1981) and are up to 10 m deep.

The glacial till is identified as Vashon Drift (Hicock and Armstrong, 1985). Vashon Drift is comprised of mixed, unsorted boulders, rocks, sand, silty and clay and is unstratified. The deposit is up to 100 m thick. It was deposited directly by glacial ice during the Vashon Stade between 13,000 to 20,000 years BP. The Vashon Drift is underlain by the Quadra Sands, which are deposits of outwash sand that were formed as glaciers flowed south down Howe Sound and Georgia Straight.

Other types of surficial materials exist as well. For example, we observed sandy glaciofluvial deposits and diamictic sandy till deposits in isolated exposures. We also observed isolated areas of a silty eolian (wind-blown) veneer overlying till at the center of the study area, near 180th Street. A discontinuous organic veneer is present in gently sloping areas with imperfect to poor drainage.

Topographically, they study area is located on a broad southeast-northwest trending ridge, with the rounded (and barely discernible) crest running across the northern part of the study area. The majority of the study area slopes gently down towards the south and the Serpentine River. Slopes in the northeastern portion of the study area slope towards the north. Slopes in the area are variable, but tend to be gentle, not exceeding 15% in most areas. A few exceptions were noted, where short sections of slope (ranging from approximately 2 m to 10 m in length) exceed 30%. In general, the steepest slopes are found along the southern fringe of the study area where slopes steepen near the base of the gentle south-facing slope.

The soils derived from these materials exhibit variable drainage tends to be variable throughout the study area, depending on topography. The drainage ranges from imperfect to poorly drained in low-lying areas to moderately well and well drained on slopes.

Soils in the area generally reflect the nature of the gravelly sandy to sandy silty glaciomarine parent materials. In some soils the underlying till may impede percolation of water, resulting in imperfect or poor drainage, particularly where the land is flat or along the lower portions of slopes. Poor drainage and firm subsoils can present complications for septic disposal.

4.0 SOILS AND TERRAIN

4.1 Introduction

The terrain and soils component of the study was undertaken to provide a GIS map layer identifying areas of potential concern in regards to potentially unstable terrain and slopes greater than 30% and sensitive soils. These data will be used to assist the City in planning future development in the area. This is not meant to be a detailed terrain hazard study or a detailed soil survey.

We conducted the study in two phases. The first phase included an overview of the study area as a whole: reviewing orthophotos, previous soil mapping by Luttmerding (1980) and mapping of the study area at a 1:5 000 scale. During this phase, steep or potentially unstable slopes and areas with potentially sensitive soils were identified.

The second phase of the project involved the field investigation of terrain and soil, with specific focus on areas of interest identified in Phase 1. Based on field investigations and post field work mapping, we identified potentially sensitive soils and areas where slopes exceed 30%.

4.2 Methods

We identified and mapped areas of potentially sensitive soils, potentially unstable terrain, or slopes greater than 30%. The mapping process included:

1. Orthophoto and map interpretation and delineation of potentially unstable terrain and potentially sensitive soil polygons.

2. Field checking to confirm or modify polygon boundaries.

3. Post-field work modification of polygons and plot data entry.

4.2.1 Orthophoto and Map Interpretation

The first stage of mapping included a review of orthophotos and mapping of the study area. We analyzed a 1:5 000 scale topographic map, provided by the City of Surrey, with 1 m contour intervals to identify areas with slopes greater than 30%. In the preliminary stage, we identified several polygons of interest. These polygons focused primarily on slopes along the southern boundary and areas surrounding creek channels.

We also reviewed existing soil maps by Luttmerding (1980) to gain a general sense of soils occurring in the study area. We conducted a review of orthophotos in conjunction with the terrain portion to identify areas of potentially sensitive soils.

4.2.2 Field Checks

The second stage of mapping included field inspection of areas of interest identified during the preliminary orthophoto and map interpretation.

We collected terrain and soil information such as slope, drainage, texture, coarse fragment content, soil-subgroup, and parent material in conjunction with wildlife and arborist tree surveys. At each plot location we collected, information on surficial materials, slope and drainage. Where sites permitted, we excavated a soil pit and collected detailed soil observations. Soil horizons were described, identified and photographed and soils were classified to sub-group, as defined in the *Canadian System of Soil Classification* (2002).

We conducted our field work in the summer of 2009 between July 7 and 9. Access to plots was via car and on foot, where permitted.

Due to the opportunistic nature of sampling (sampling where access was available and permission granted) plots are not distributed evenly throughout the study area; however, we were able to access the majority of areas of interest identified in the initial mapping phase and plot information collected is representative of the study area.

4.2.3 Post-Field Work Updating

Upon completion of field work, we modified polygons of steep or potentially unstable terrain and potentially sensitive soils identified in the initial stages of mapping, to reflect our field checks.

We assigned each polygon a number and entered plot data falling within each polygon into a database. Finalized polygons were digitized and final maps produced.

4.2.4 Reliability

We collected terrain and soil information at thirty six sites within the study area. We verified six of the seven terrain and soil polygons identified in the study area, or 86% of the polygons. One terrain polygon, Polygon 4, has not been field verified due to problems with access. Due to the large size of these polygons only small portions of each polygon were sampled. During our field investigation, we observed some spatial variability in slopes, drainage, surficial materials. It is important to keep in mind that soils and terrain are never completely uniform within any one polygon; some variability should be expected.

4.3 Results

4.3.1 Terrain – Steep Slopes (>30%) and Potentially Unstable Terrain

We reviewed orthophotos covering the study area. For the most part, we did not identify any geomorphic processes or evidence of potentially unstable terrain; however, during our field investigation, we noted a concavity with slopes of 40% to 45% near the southern boundary of the study area. This suggests that a debris slide occurred in the past. The scar is approximately 15 m wide with slopes of 40% to 45% for approximately 5 m to 10 m. Undulating irregular material at the base of the slope suggests material deposited at the base of the slope, approximately 10 m to 15 m from the headwall of the failure. Vegetation within the scar indicates that the slide scar is at least 50 years old. Further evidence of localized instability is present in the area in the form of trees leaning upslope.

Preliminary mapping and field investigation revealed no large continuous areas with slopes greater than 30%. While in the field we observed scarp slopes and creek sidewalls greater than 30%; however, these slopes were all very short (<10 m). Although we identified polygons where slopes exceed 30%, not all slopes within the entire polygon area were greater than 30%. We identified four polygons which contain slopes exceeding 30% (Figure 2).

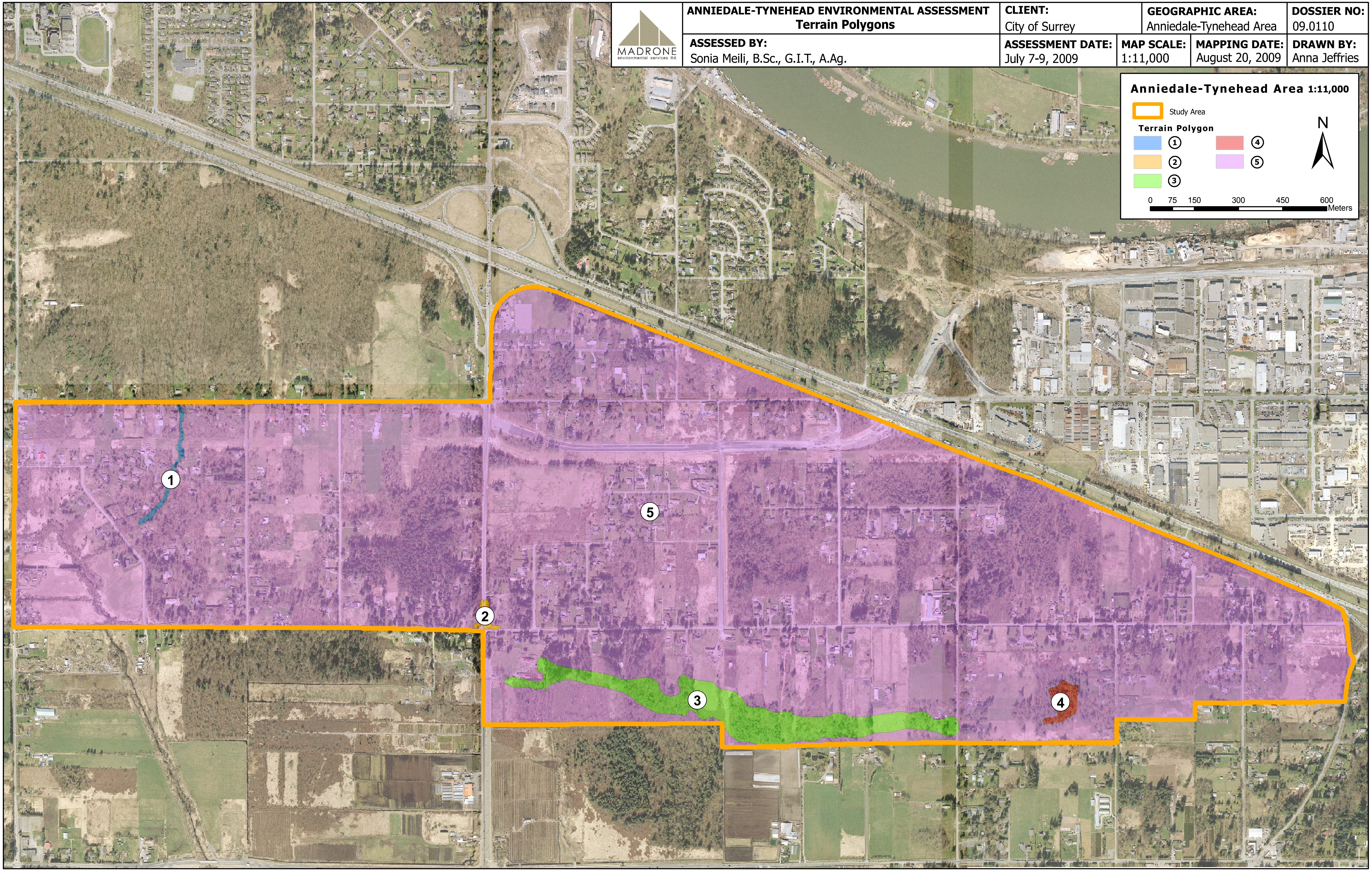
Polygon 1 consists of the sidewalls of an unnamed creek located in the northwestern corner of the study area. We noted slopes of 50% to 60% for 1 m to 3 m parallel to the creek channel.

Polygon 2 is located on the northeast and northwest corners of 176th Street and 92nd Avenue and consists of a steep road cut of approximately 50% slope. At the time of inspection, the areas had been grass-seeded. Soils in this polygon have a gravelly sandy texture, resulting in high erosion potential.

Polygon 3 parallels the southern study area boundary between 176th Street and 184th Street. Slopes in the polygon range from 20% to 45%. Steep slopes in this polygon tend to be linear, extending east-west and between 5 m and 10 m long, sloping down towards gentle terrain towards the south. During our field investigation we also identified slopes less than 30% in Polygon 3; however, due to the discontinuous nature of steep slopes, we were unable to further define the polygon to exclude areas having slopes less than 30%.

At the base of Polygon 3, we observed a debris slide scar approximately 15 m wide and 1.5 m deep. Material appears to have deposited at the base of the slope within 15 m of the headwall of the failure. Slopes of 40% to 45% are present within the slide scar, extending 5 m to 10 m down to gently sloping terrain. Upslope of the scar slopes range from 15% to 20%. Additional evidence of instability is present in the form of trees tilted in-slope.

Polygon 4 consists of the slopes surrounding an unnamed creek channel located between 184th Street and 187th Street. Due to the isolated nature of the area, we were unable to access the polygon. As a result, we are unable to confirm whether steep slopes are present in the area. A plot west of the polygon revealed slopes ranging from 15% to 17%.


ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Terrain Polygons
MADRONE environmental services ltd.
CLIENT:
City of Surrey
GEOGRAPHIC AREA:
Anniedale-Tynehead Area
DOSSIER NO:
09.0110
ASSESSED BY:
Sonia Meili, B.Sc., G.I.T., A.Ag.
ASSESSMENT DATE:
July 7-9, 2009
MAP SCALE:
1:11,000
MAPPING DATE:
August 20, 2009
DRAWN BY:
Anna Jeffries
Anniedale-Tynehead Area 1:11,000
Study Area
Terrain Polygon
1
2
3
4
5
N
0 75 150 300 450 600
Meters
1
2
3
4
5

Polygon 5 consists of the remainder of the study area. Slopes in this polygon generally range from 0 to 15% with isolated small areas of up to 25%. Moderately sloping terrain ranging from 15% to 25% is present in the northeastern portion of the polygon, north of 92nd Avenue and east of 184th Street. Field checking in the area did not reveal any slopes exceeding 30%.

Land use in the entire study area is generally rural residential and agricultural use. The steeper areas identified in Polygon 1 through 4 are generally undeveloped and forested.

Table 1 summarizes the terrain data collected while in the field.

Table 1. Terrain Observations

Terrain Polygon	Soil Observation	Topography (%)	Drainage	Slopes >30%
1	SM1	10% – 12%; 50% – 60% into creek	M	yes
5	SM 2	10% – 20%	M - I	no
5	SM3	3% – 5%	M	no
5	SM4	8% – 10%	M	no
5	SM5	20% – 25%	W	no
5	SM6	15% – 20%	M	no
5	SM7	15%	M - I	no
5	SM8	0 – 5%	M - I	no
5	SM9	15% – 17%	M	no
2	SM10	50%	W	yes
5	SM11	2%	M	no
5	SM12	0 – 2%	M	no
5	SM13	5% – 10%	M	no
5	SM14	5% – 20%	M - W	no
5	SM15	5% – 7%	M - I	no
5	SM16	5% – 15%; short section up to 26%	M - W	no
5	SM17	2% – 5 %	M - I	no
5	SM18	15%	M	no
5	SM19	3% – 5%	M	no
5	SM20	5% – 6%	M	no
5	SM21	6% – 7%	M	no
5	SM22	3% – 10%	M	no
5	SM23	5%	P	no
5	SM24	2% – 3%	M	no
5	SM25	5%	M	no
5	SM26	2% – 3%	M	no
5	SM27	0 - 3%	I - P	no
5	SM28	6%	M	no
5	SM29	10% – 15%	M	no

Table 1. Terrain Observations (continued)

Terrain Polygon	Soil Observation	Topography (%)	Drainage	Slopes >30%
5	SM30	0 – 2%	P	no
3	SM31	15%	M	no
3	SM32	15% – 20%	M - W	no
3	SM33	40% – 45%	W	yes
5	SM34	0 – 5%	M	no
3	SM35	40%	M - W	yes
5	SM36	2% – 3%	M	no
5	SM37	0 – 3%	M	no

Key to soil drainage: P; Poor, Imp; Imperfect, M; Moderately Well, W; Well

4.3.2 Soils

Soils mapped within the area by Luttmerding (1980) consist of soils of a number of soil associations including the Albion, Bose, Cloverdale, Heron, Judson, Milner, Nicholson, Scat, Summer, and Sunshine soil associations; however, the Bose soil association is most common throughout the study area.

Bose soils consist of moderately-well to well drained Ortho Humo-Ferric Podzol (O.HFP) and Duric Humo-Ferric Podzol (DU.HFP) which consist of 30 cm to 160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits (Luttmerding, 1980).

In addition to the Bose soil association, we also observed soils consistent with the Heron and Scat soil associations. Soils classified in the Orthic Gleysol, Gleyed Humo-Ferric Podzol, Orthic Dystric Brunisol and Gleyed Dystric Podzol sub-groups were not consistent with mapped soil associations in the study area. This may be in part due to soil disturbance which has occurred in the area due to previous logging, clearing of land and addition of fill material. These practices would have altered the soil structure, mixing soil horizons and altering drainage in the areas due to soil compaction, ditching, and filling.

Eight soil sub-groups in the study area were identified and classified as Orthic Dystric Brunisol (O.DYB), Gleyed Dystric Brunisol (GL.DYB), Ortho Humo-Ferric Podzol (O.HFP), Dystric Humo-Ferric Podzol (D.HFP), Gleyed Humo-Ferric Podzol (GL.HFP), Orthic Gleysol (O.G), Orthic Humic Gleysol (O.HG), and Rego Humic Gleysol (R.HG). Four of the soil types observed do not conform to the soils mapped by Luttmerding (1980).

These include Gleyed Humo-Ferric Podzol (GL.HFP), Orthic Dystric Brunisol (O.DYD), Gleyed Dystric Brunisol (GL.DYB), and Orthic Humic Gleysol (O.HG).

Orthic Dystric Brunisols having a weakly developed brownish B horizon and are commonly associated with coniferous forests where cool temperatures, and coarse parent material often result in moderate soil development. Gleyed Dystric Brunisols have general characteristics of those of a Brunisol but have faint to distinct mottling in the B horizon within 50 cm of the surface or prominent to distinct mottling between 50 cm and 100 cm. Soils in the Brunisolic Order are characterized by having less well-developed profiles than other soils, such as Podzols, in this case because they are less intensively leached.

Ortho Humo-Ferric Podzols have a more strongly developed Bf horizon at least 10 cm thick, enriched by an accumulation of humified organic matter in combination with aluminum and iron. These soils are commonly associated with coniferous forest in cool to cold humid climates and develop in course to medium textured, acidic parent materials. Duric Humo-Ferric Podzols and Gleyed Humo-Ferric Podzols have similar characteristics to Ortho Humo-Ferric Podzols. Duric Humo-Ferric Podzol contain strongly cemented subsoils while Gleyed Humo-Ferric Podzols have distinct to prominent mottles within 1 m of the soil surface.

Orthic Gleysols are defined by their colour and in many cases the presence of mottling which indicates periodic of sustained reducing conditions. These soils tend to occur in imperfectly to poorly drained materials. Orthic Humic Gleysols have general characteristics of those of the Gleysolic order, having well developed Ah horizons overlying gleyed B and C horizons. Rego Humic Gleysols differ from Orthic Humic Gleysols as the lack a B horizon at least 10 cm thick. In most cases, a well developed AH horizon overlies a gleyed C horizon (Pedosphere, 2009).

Orthic Dystric Brunisols, Orthic Gleysols, and Orthic Humo-ferric Podzols are the dominant soils occurring in the Anniedale-Tynehead NCP Area. These soil types occurred at approximately 35%, 22% and 17% of our plot locations. Ortho Humic Gleysols were observed at approximately 9% of plot locations while Gleyed Humo Ferric Podzol, Gleyed Dystric Brunisol, Duric Humo-Ferric Podzol, and Rego Humic Gleysol were each observed at approximately 4% of the sites where soil observations were made.

The soil textures noted in the study area ranges from sandy loam to silt loam. Approximately 48% of sampled soils have a sandy loam texture and 43% of sampled soils have a silt loam texture. In addition, we occasionally observed sandy clay loam and silt clay loam textured soils. We observed Orthic Dystric Brunisols, Ortho Humo-Ferric Podzols, and Duric Humo-Ferric Podzols at moderately-well to well drained sites. Orthic Humic Gleysols, Gleyed Dystric Brunisols, and Gleyed Humo-Ferric Podzols commonly occurred in moderately to imperfectly drained areas while Orthic Humic Gleysols and Rego Humic Gleysols were encountered in poorly drained areas.

Coarse fragment content throughout the entire study area ranges widely between 0% and 45%. In general, we observed coarse fragment content ranging from 30% to 45% in the Orthic Dystric Brunisol, Ortho Humo- Ferric Podzol, and Duric Humo-ferric Podsol soil subgroups. Coarse fragment content ranges more widely in the Orthic Gleysol soil sub-group in which coarse fragment content ranges from 0 to 40%. In addition, soils of the Orthic Humic Gelysol sub group have coarse fragment content ranging from 0 to 20%. Coarse fragment content tended to be lower, ranging from 15% to 25% in the Gleyed Dystric Brunisol and Gleyed Humo-Ferric Podzol soil sub-groups; and less than 5% coarse fragments in the Orthic Humic Regosol sub group. Soil development in the area reflects the coniferous forest of Douglas-fir, redcedar, hemlock, and spruce that covered the area prior to the logging which took place in the 19th and 20th centuries.

Table 2 summarizes the soil characteristics gathered while in the field.

Table 2. Soil Observation Plot Descriptions

Soil Observations	Texture	Total Coarse Fragment Content (%)	Topography (%)	Drainage	Soil Subgroups *	Notes
SM1	SiL	35%	10% – 12% with 50% – 60%	M	O.DYB	50% – 60% slope for 2 m – 3 m each side of creek channel.
SM3	SiL	0 – 5%	3% – 5%	M - I	O.G	Texture becomes SiCL at depth.
SM5	SL	35%	20% – 25%	W	D.HFP	Highly consolidated layer at approximately 0.75 m to 1 m depth

Table 2. Soil Observation Plot Descriptions (continued)

Soil Observations	Texture	Total Coarse Fragment Content (%)	Topography (%)	Drainage	Soil Subgroups*	Notes
SM8	SiCl	0 – 5%	0 – 5%	M - I	O.G	Observation of ditch cut.
SM9	SL	35%	15% – 17%	M	O.HFP	
SM14	N/A	N/A	0 – 3%	P	N/A	The area south of the study area is poorly drained and appears to have organic soil. This observation is consistent with Luttmerding's 1980 soil mapping. No soil pit was excavated at this site.
SM15	SiL	25%	5% – 7%	M - I	GL.DYB	
SM16	SiL	30%	5% – 15%	M	O.DYB	Short slope up to 26% for ~1 5m.
SM17	SiL	20%	2% – 5%	M - I	GL.HFP	May have eolian cap. Insufficient evidence of eolian veneer from this soil pit.
SM18	SL	35^ – 45%	10% – 15%	M – I	O.DYB and O.G	Highly variable soils exposed in ditch.
SM19	SL	40%	3% – 5%	M	O.DYB	
SM20	SL	35%	5% – 6%	M	O.DYB	Soils disturbed by clearing. May have been O.HFP prior to disturbance.
SM21	SL	35% – 40%	6% – 7%	M	O.DYB	
SM23	SiL	15% – 20%	5%	P	O.HG	
SM24	SL	35%	2% – 3%	M	O.DYB	Soil appears disturbed. No distinct horizons.
SM25	SiL	0 – 5%	5%	M	O.HFP	Eolian cap of loose silty material
SM26	SiL	35%	2% – 3%	M	O.DYB	Soil disturbance likely due to clearing
SM27	S	0 – 5%	0 – 3%	P	R.HG	Pure sand underlying thin organic veneer.
SM28	SL	35%	6%	M	O.HFP	

Table 2. Soil Observation Plot Descriptions (continued)

Soil Observations	Texture	Total Coarse Fragment Content (%)	Topography (%)	Drainage	Soil Subgroups *	Notes
SM30	SiL	0 - 5%	0 – 2%	P	O.HG	Thin discontinuous organic veneer present.
SM31	SL	35%	15%	M – I	O.G	This area appears to have been filled.
SM32	SL	40%	15% – 20%	M	O.HFP	
SM35	SiL	35% – 40%	15% – 20% then 40% down to gentle bench	M - I	O.G	Steep 35% – 40% scarp slope for ~ 5 m – 8 m down to bench. Thin Ah horizon over consolidated till.
SM36	SL	40%	2% – 3%	M	O.DYB	

Total Coarse Fragment Content is defined as gravel, cobbles, stones, or rubble particles with mean diameter greater than 2 mm.

Key to Soil Taxon: O.HFP; Orthic Humo-Ferric Podzol, GL.HFP; Gleded Humo-Ferric Podzol, D.HFP, Duric Humo-Ferric Podzol, O.G; Orthic Gleysol, O.HG; Orthic Humic-Gleysol, O.DYB; Orthic Dystric Brunisol, GL.DYB; Gleyed Dystric Brunisol.

Key to soil drainage: P; Poor, Imp; Imperfect, MW; Moderately Well, W; Well

4.3.3 Sensitive Soils

Prior to fieldwork, we defined sensitive soils and soils possibly inappropriate for development as:

- Areas containing steep slopes (>30%).
- Organic soils (soils consisting of organic horizons that extend from the surface to a depth > 60 cm if the surface layer is fibric of a depth of > 40 cm if the surface layer consists of mesic of humic material.
- Poorly drained soils, especially glaciomarine soils with poor drainage.
- Erodible soils developed from glaciofluvial sands.
- Fans, gully sidewalls, and floodplain deposits.

Soils derived from tills are not sensitive.

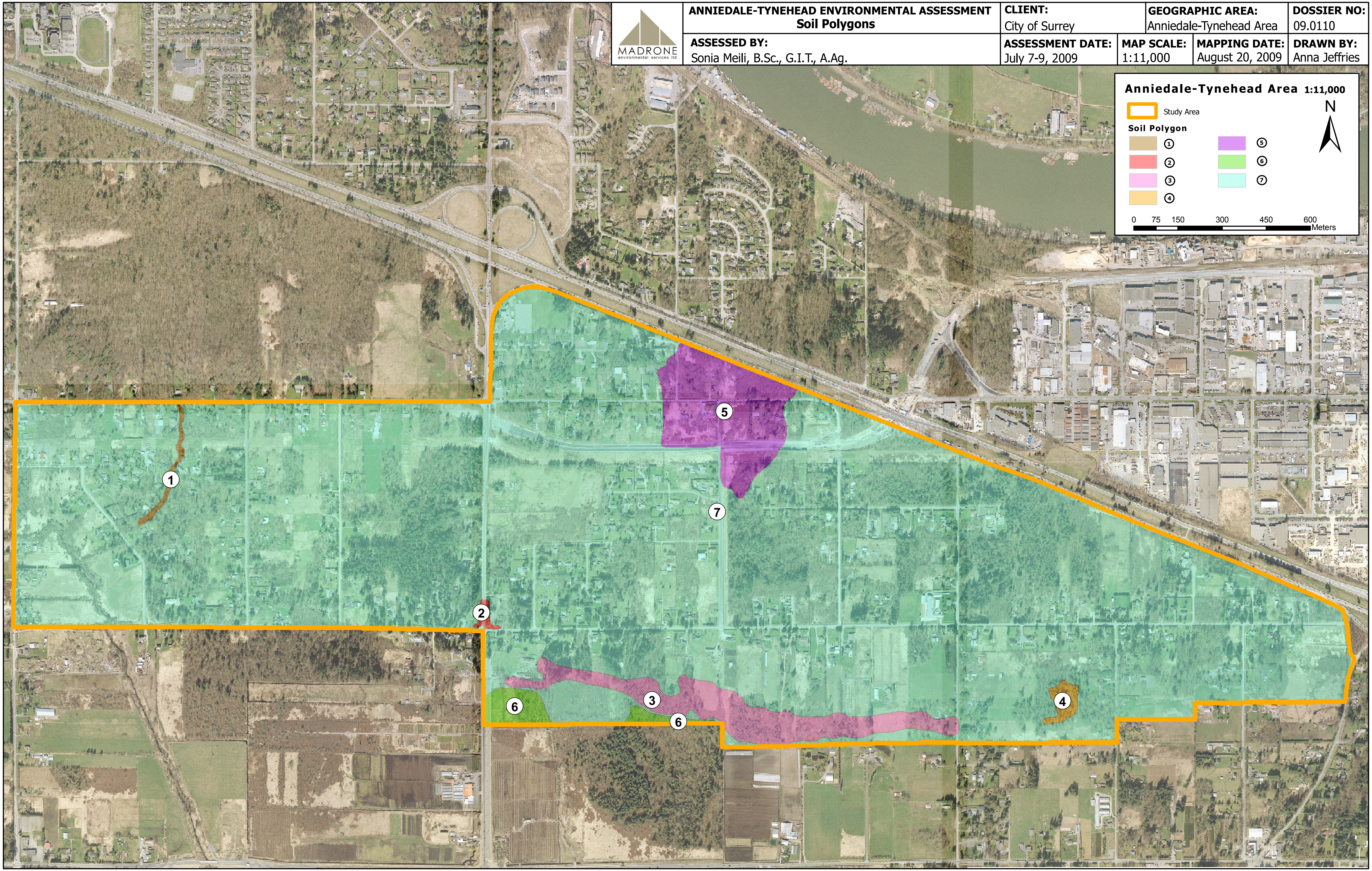
We did not observe organic soils within the study area; however, organic soils appear to be present along the southern boundary and just outside of the study area. Poorly drained soils are present in the northern portion of the study area, near 96th Avenue and 180th Street and along the southern boundary of the study area, at the base of the steep slopes identified in the terrain section. In the remainder of the study area, soils have textures ranging from sandy loam to silt loam with glaciomarine and till parent materials. An isolated area of sandy-textured glaciofluvial material is present in a poorly drained area near 179th Street and 97th Avenue. Sandy fill material is also present along the cutslope of 176th Street at 92nd Avenue. Due to the relatively compact nature of soils and the sandy loam to silt loam texture, the majority of the study area is not highly prone to erosion or compaction, although these can always occur under certain conditions, such as the use of heavy machinery when soils are wet.

We identified seven soil polygons having similar boundaries as those defined in the terrain section of this report (Figure 3). Polygons 1, 2, 3, and 4 are considered sensitive due to slopes which exceed 30%. Soil within these polygons generally consists of Ortho Humo Ferric Podzol and Orthic Dystric Brunisol with Orthic Gleysol near the base of slopes.

Polygon 5 is located near the northern boundary of the study area east of 179th Street. Soils in this area are poorly drained and consist of Orthic Humic Gleysols and Rego Humic Gleysols. Surficial materials consist of sandy glaciofluvial material overlain be a thin organic veneer and glaciomarine deposits generally having a silt loam texture. Due to the presence of sandy material and poor drainage in the area, soils in this polygon are considered sensitive.

Polygon 6 is located on low lying terrain along the southern boundary of the study area. Surficial materials in this polygon consist of poorly drained glaciomarine deposits overlain by a thin organic veneer. We observed Orthic Gleysol and Orthic Humic Gleysol in this area. In addition, Lutmerding (1980) mapped Teric Humisol, Typic Fibrisol, Typic Mesisol (organic soils) and Rego Gleysol in the area; however, we were unable to access these areas. Due to the presence of organic soils, and poorly drained glaciomarine deposits, soils in this polygon are considered sensitive.

ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT Soil Polygons	CLIENT: City of Surrey		GEOGRAPHIC AREA: Anniedale-Tynehead Area	DOSSIER NO: 09.0110
ASSESSED BY: Sonia Meili, B.Sc., G.I.T., A.Ag.	ASSESSMENT DATE: July 7-9, 2009	MAP SCALE: 1:11,000	MAPPING DATE: August 20, 2009	DRAWN BY: Anna Jeffries



Polygon 7 consists of the remainder of the study area. Soils in this polygon consist of Orthic Dystric Brunisol, Ortho Humo-Ferric Podzol, Orthic Gleysol, Gleyed Dystric Brunisol, Gleyed Humo-Ferric Podzol, and Duric Humo-Ferric Podzol. Surficial materials consist of glaciomarine and till deposits with texture ranging from sandy loam to silt loam. Drainage ranges from imperfectly drained to well drained; however, the majority of soils tend to be moderately drained. Soils in this polygon are not considered sensitive; however, soil degradation can still occur.

Luttmerding (1980) mapped Judson and Nicholson soil associations in the central and northern portion of the study area. Soils in the Judson soil association consist of Terric Humisol (organic soils) and range from poorly to very poorly drained. We did not observe any soils in the area consistent with the Judson soil association; however, we did observe poorly drained Orthic Humic Gleysol and Rego Humic Gleysol (Polygons 5) in the area where Judson soils are mapped.

Nicholson soils consist of Podzolic Gray Luvisolic soils. These soils tend to be moderately well drained and develop on moderately fine to fine textured compact glaciomarine deposits containing few pebbles and stones capped by silty eolian material. These soils tend to be prone to erosion when slopes exceed 5% (Bertrand, 1991). We observed Ortho Humo-Ferric Podzol, Gleyed Humo-Ferric Podzol, and Gleyed Dystric Brunisol in the area; however, soils were not consistent with the descriptions of Nicholson soils. At a limited number of sample locations (Soil pits SM15, SM17, and SM25) we observed soils having a silty cap. Slopes in the vicinity did not exceed 5%. As a result, soil sensitivity is considered low; however, poor management practices may result in significant erosion.

The map scale of this project is 1:5,000 and Luttmerding's mapping is at a 1:25,000 scale. Therefore, the soil association boundaries may not be precise

4.4 Summary and recommendations

We identified an old debris slide scar in Polygon 3, indicating slope instability in the past. Steep slopes in this polygon generally range from 20% to 45% and extend east-west along the southern boundary of the study area. At the limited number of sites observed in this polygon, we observed only one instance of slope instability; however, slopes throughout Polygon 3 are similar to that in which the slide occurred.

We observed four areas in which slopes exceed 30%. Steep slopes (>30%) generally tend to occur in short stretches, ranging from 2 m to 3 m in Polygon 1 to 5 m to 10 m long in Polygon 3.

The majority of slopes in the Anniedale-Tynehead NCP Area range from 0 to 15% with slightly steeper terrain in the northeastern and southern portions of the study area. We mapped five terrain polygons, four of which (Polygons 1, 2, 3, and 4) contain short slopes greater than 30%. Due to the presence of steep slopes in these polygons, further detailed investigation would be required should future development occur within the area.

Soils in the four polygons identified as having steep slopes (>30%) are considered sensitive. In addition, soils in Polygons 5 and 6 are considered sensitive due to the presence of poor drainage and fine textured glaciomarine or sandy glaciofluvial deposits. In addition, organic soils have been mapped in portions of Polygon 6. This was confirmed by field observation in a limited number of sites; however, and no soil pits were excavated in organic soils.

Soils in Soil Polygons 1, 2, 3, 4, 5, and 6 are considered sensitive and, as a result, further detailed investigation should be undertaken if development is to occur within these polygons to determine site specific characteristics.

5.0 HYDROLOGY AND GROUNDWATER RECHARGE

We conducted the hydrology and the groundwater recharge study in three phases. The first phase included an overview of the study area as a whole: reviewing orthophotos, identifying watersheds and local drainage networks; and background research into the nature and condition of aquifers underlying the Anniedale-Tynehead NCP Area.

In the second phase, we conducted a field review and collected information on seepage areas, ditch and creek connectivity, channel characteristics, and form and recharge areas.

The third phase of the project involved the integration of the background research, orthophoto interpretation and field observations to identify and prioritize landscape values as they pertain to protecting the integrity of local aquifers and groundwater recharge.

5.1 Project scope

We undertook the hydrology and groundwater recharge component of the study to identify areas of potential groundwater recharge and to provide recommendations on how to maintain and protect the natural hydrological functions of the study area. This data will be used to assist the City in planning future development in the area. The project scope does not include confirming the dimensions or detailed nature of groundwater flow in the area, nor characterizing any existing or future contamination of the groundwater.

5.2 Methods

We identified the primary aquifers underlying the study area using provincial government databases (Province of British Columbia, 2009), and identified the surficial materials in the study area to provide information on the nature of regional groundwater flow in the area. We reviewed aquifer mapping and databases, Quaternary geology mapping, and regional groundwater information. The mapping process included:

1. Orthophoto and map interpretation of local hydrology and delineation of watersheds.

2. Evaluation of the effectiveness of landscape values such as stream channel characteristics, vegetation type and density, and anthropogenic drainage network location, to protect water quality and to promote groundwater recharge.

We gained insight to the local groundwater system in the area through the extensive mapping that is available for Fraser Valley groundwater as a whole.

5.2.1 Orthophoto and Map Interpretation

The first stage of mapping included a review of orthophotos and mapping of the study area. We analyzed several local and regional groundwater maps to identify any local aquifers and to identify if there was potential for groundwater recharge in the study area.

In an orthophoto review of April 2008 colour orthophotos in combination with a review of 1:5,000 scale maps provided by the City, we identified local drainage networks, areas of wetlands and other hydrologic features.

We also used information documented in other components of the Environmental Review of the Anniedale-Tynehead NCP Area of Surrey, such as terrain and soils data as well as TEM information.

5.3 Physical Environment

5.3.1 Regional Groundwater Setting

A portion of the potable water used in the southern Lower Mainland is derived from aquifers in modern and Ice Age sediments (Province of British Columbia, 2009). There are many aquifers identified in the Fraser Valley. Major aquifers are usually named, and their extents, depths and other defining characteristics are well known (for example the Abbotsford-Sumas aquifer or the Brookswood aquifer in south Langley), while numerous minor or transitory groundwater features such as seasonally-present perched water tables may not be formally named or mapped.

The hydrologic cycle (Figure 4) consists of several components including surface drainage networks such as streams and ditch networks, and a subsurface framework which consists of surficial materials (sands, gravels etc). Precipitation, falling in the form of rain or snow, either evaporates and is lost back to the atmosphere, runs off the surface into stream networks, or infiltrates into the soil. Of the portion of water infiltrating into the soil, a portion becomes shallow groundwater flow which eventually flows in the surrounding water bodies (streams and lakes) over a matter of hours or weeks, while the remainder infiltrates deeper, reaching aquifers (Smerson *et al*., 2009).

5.3.2 Surficial Geology and Quaternary Sediments

The Anniedale-Tynehead NCP Area is located in the Fraser Lowland, a sedimentary basin. Bedrock is present only at great depth. There are three dominant layers of Quaternary sediments present in the study area, which control the groundwater hydrology of the region. The uppermost and youngest layer present in the Anniedale-Tynehead NCP Area is the Capilano Sediments. This layer generally consists of a veneer to blanket of glaciomarine and marine sediments. Capilano Sediments overlying uplands (as is the case in the Anniedale-Tynehead NCP Area) are generally less than 10 m thick but can range from 1 m to 12 m thick. (Armstrong, 1981).

We did not observe any marine sediments in the study area. Glaciomarine sediments in the study area have a texture ranging from silt clay loam to sandy loam. Due to the medium to fine texture of these sediments, the Capilano Sediments generally have a low to moderate permeability.

Underlying the Capilano Sediments is the Vashon Drift. The Vashon Drift typically consists of lodgement till, glaciofluvial sand and gravel, and glaciolacustrine deposits (Armstrong, 1981). During our field investigation we observed medium to fine-textured till deposits ranging in texture from silt loam to loamy sand. At a number of locations, the till exhibited very firm consistence, suggesting consolidation. Due to the highly consolidated nature of till observed at depth, the Vashon Drift deposit has a relatively low permeability.

The Quadra Sands underlie the Vashon Drift. No exposures of Quadra Sands are present within the study area; however, aquifers underlying the study area occur in these sediments. The Quadra Sands are characterized by glacial outwash deposits consisting of sands and gravels. It is likely, based on exposures of Quadra Sands in other areas of the Lower Mainland, that the depth of the Quadra Sediments in the study area ranges from tens to a hundred meters or more. Due to the coarse texture of these deposits, the Quadra Sands have a high permeability, high storage capacity, and high hydraulic conductivity, resulting in good storage of groundwater.

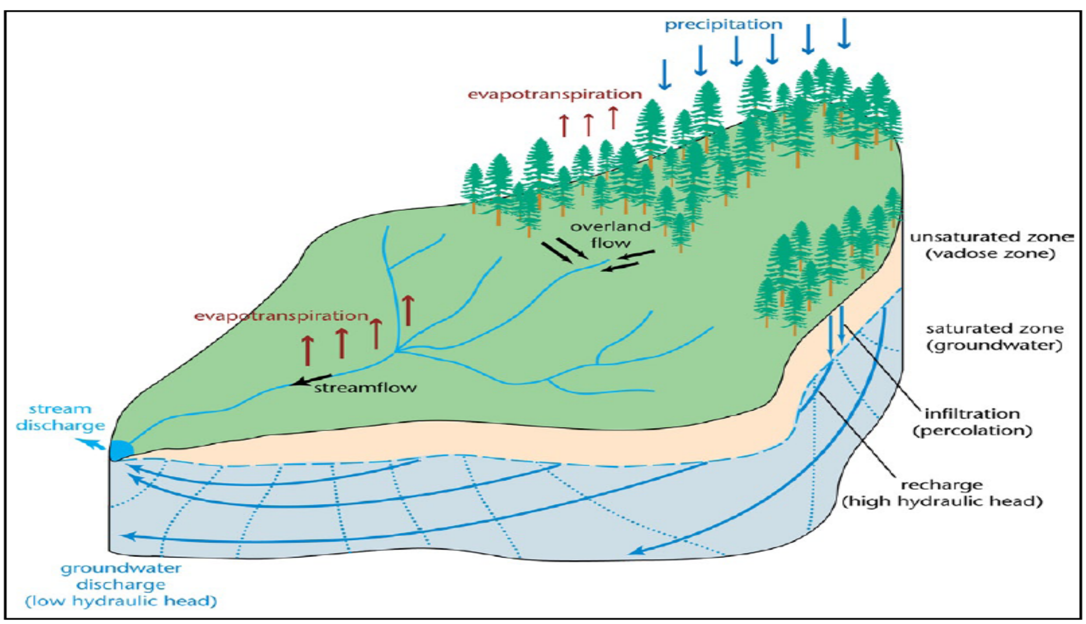


Figure 4. Hydrologic cycle.

(Figure from Smerson *et al*., 2009.)

5.3.3 Subsurface Hydrology

The aquifer underlying the study area is identified as a confined aquifer (Kreye and Wei, 1994) that extends outside the study area boundaries and underlies much of the Surrey upland area. This aquifer underlies much of the Newton Uplands. It does not have a formal name, but is referred to as 61IIIC(11) in the provincial aquifer classification system (Province of British Columbia, 2009). The aquifer occurs in sand and gravels of the Quadra Sands unit and is classified as having low vulnerability, low demand and high productivity. The aquifer is capped by low permeability sediments consisting of Vashon Drift and a thin veneer of Capilano Sediments (Armstrong, 1981). Confined aquifers recharge more slowly than unconfined aquifers and are less susceptible to contamination as they are protected from contaminated surficial drainage by impenetrable layers.

The Nicomekl – Serpentine aquifer (58IIC(11)) is located south of the study area. Terrain in the southern half of the study area slope down to a low-lying area and the Serpentine River. The Nicomekl – Serpentine aquifer is derived in sand and gravel and is classified as having low vulnerability, moderate demand and moderate productivity (Province of British Columbia, 2009).

The study area is underlain by thick deposits of Vashon Till which is relatively impermeable (at least compared to the Quadra sands below it). Most water infiltrating into the surface in Anniedale-Tynehead NCP Area will likely flow laterally downslope, forming a shallow groundwater flux. We believe this flow will largely be confined to the top 1 m of soil. Some of this flow will recharge discharge in ditches and native watercourses, and some will feed springs that occur on the lower slopes, particularly in the southern part of the study area.

The low vulnerability of the aquifer in the study area results from two factors. First, the relatively impermeable overlying sediments act as a cap which prevents some potential contaminants from reaching the aquifer. Secondly, both the overlying sediments and the fine sand component of the aquifer itself provide effective filtration, trapping some potential contaminants and preventing their propagation through the aquifer.

On a regional scale, the uplands of Surrey are considered to be an area of groundwater recharge because of their topographic location (Clague and Turner, 2003). Groundwater infiltrating the upland soils flows mainly laterally along the surface, contributing to surface and groundwater on the adjacent lowlands along the Fraser and Serpentine Rivers.

The majority of the recharge of the aquifer underlying Anniedale-Tynehead likely occurs indirectly from these lowlands, rather than directly from the uplands.

Previous studies in the area have identified the underlying aquifers as experiencing low to heavy use (depending on density of water wells located throughout the region) and having a low vulnerability to contaminants (Kreye and Wei, 1994). Much of the groundwater recharge occurs during the rainy winter months. Due to its proximity to the ocean, a significant snowpack does not develop in the study area and therefore does not play a major role in the local groundwater regime.

5.4 Study Area Hydrology

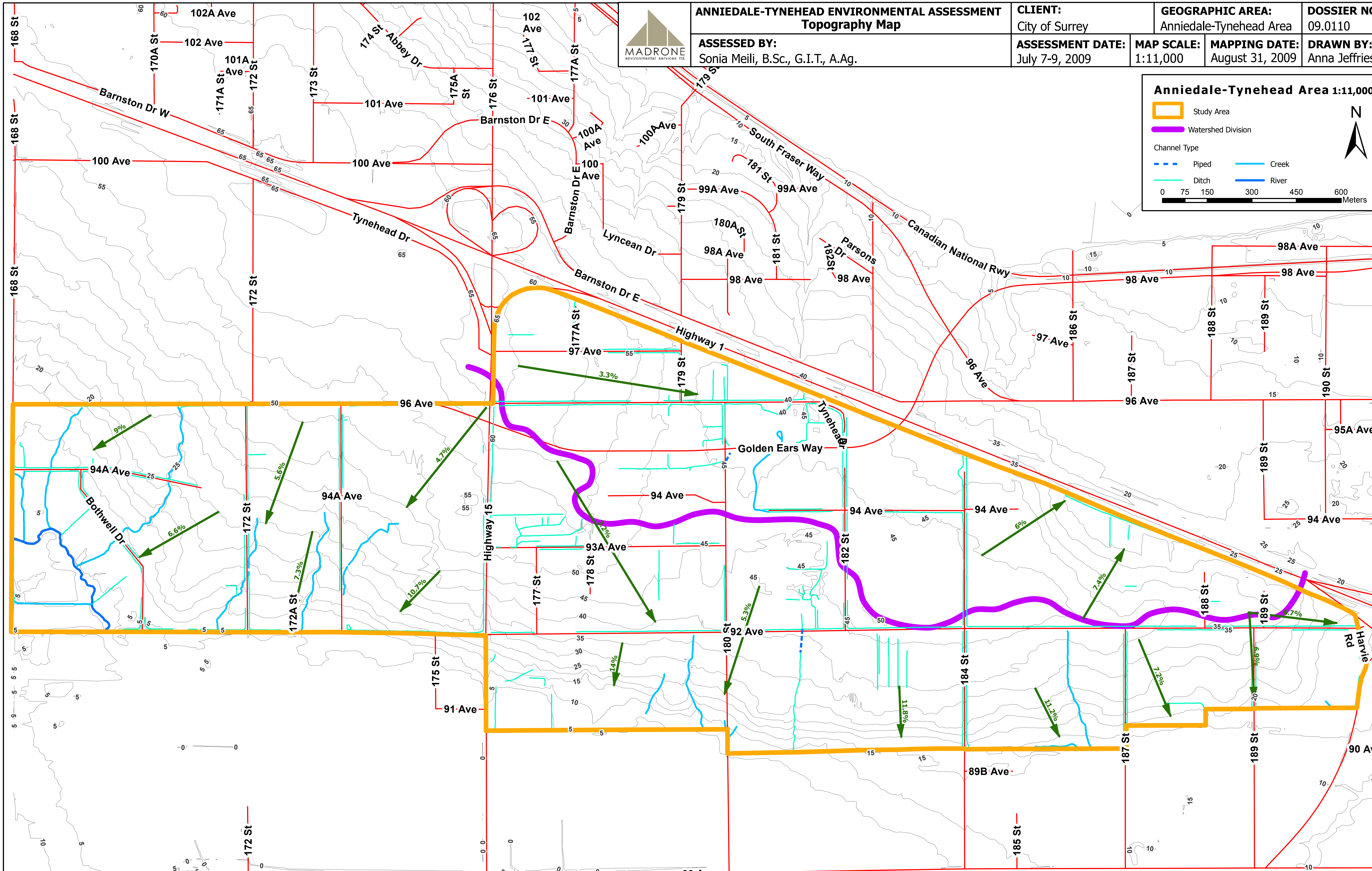
Precipitation falling on the Anniedale-Tynehead area flows into one of two watersheds, which have been previously identified in the study area (Figure 5). They include:

- **Serpentine River** - consisting of the southern half of the study area where land slopes down toward south, southeast and southwest towards the Serpentine River. Creek channels and ditches in the area are tributary to Serpentine River.

- **Parsons Channel** – consisting of slopes in the northeast of the watershed. In this area, lands slopes gently down towards the north and north east. Ditches and creeks drain into two unnamed creek channels which flow roughly north, to Parsons Channel of the Fraser River.

As indicated during the orthophoto review, and confirmed during field investigation, there are few natural watercourses in the study area. The limited number of natural watercourses is due to the subdued topography and moderately well-drained surficial materials, and the fact that much of the drainage in the study area is facilitated by ditches. It also reflects the fact that the study area consists of a broad, southeast-northwest trending ridge.

Drainages that are apparent on the orthophotos are typically located in the southern half of the study area along moderately steep slopes. These channels tend to originate from forested areas; however, in some cases forest cover has been removed due to development. Clearing of natural forest vegetation may affect stream flow which in turn affects channel morphology and sediment load. Drainage ditches are present throughout the study area paralleling road networks and in agricultural areas.


MADRONE environmental services ltd.
ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Topography Map
CLIENT: City of Surrey
GEOGRAPHIC AREA: Anniedale-Tynehead Area
DOSSIER NO: 09.0110
ASSESSED BY: Sonia Meili, B.Sc., G.I.T., A.Ag.
ASSESSMENT DATE: July 7-9, 2009
MAP SCALE: 1:11,000
MAPPING DATE: August 31, 2009
DRAWN BY: Anna Jeffries
Anniedale-Tynehead Area 1:11,000
Study Area
Watershed Division
Channel Type
Piped
Creek
Ditch
River
0 75 150 300 450 600 Meters
N
Highway 1
Highway 15
Canadian National Rwy
South Fraser Way
Golden Ears Way
Barnston Dr W
Barnston Dr E
Tynehead Dr
Lyncean Dr
Bothwell Dr
Parsons Dr
Abbey Dr
Harvie Rd
102A Ave
102 Ave
101A Ave
101 Ave
100A Ave
100 Ave
99A Ave
98A Ave
98 Ave
97 Ave
96 Ave
95A Ave
94A Ave
94 Ave
93A Ave
92 Ave
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90 Ave
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3.3%
9%
5.6%
4.7%
6.6%
7.3%
10.7%
5.3%
14%
6%
7.4%
5.7%
7.2%
11.8%
11.2%

5.5 Observations and Discussion

5.5.1 Surface Drainage and Water Courses

We did not note any major landscape features affecting area hydrology, such as gullies or geomorphic processes.

Much of the northern half of the study area is drained by ditches which run parallel to roads as well as being located within or adjacent to residential and agricultural areas. These low-gradient ditches have effectively intercepted and redirected the natural drainage network, but still facilitate, to some degree, recharge of the groundwater by collecting water, holding it and allowing it to infiltrate into the subsurface through the wetted perimeter of the ditch system.

Several creek channels are located in the southern half of the study area, generally initiating along mid to upper slopes. Creeks flow downslope to low-lying poorly drained terrain. In addition, the Serpentine River cuts through the southwestern corner of the study area.

A 2006 TAARA Environmental report entitled: *Watercourse Mapping and Assessment of 17928 92nd Avenue Surrey, BC*, assessed a watercourse initiating from ditch flow along 92nd Avenue and flowing south into a poorly drained swamp area at the base of the slope. The authors found that the upper portions of the watercourse consist of a ditch fed by discharge from ditches parallel to 92nd Avenue. The ditch then flows into a ravine approximately 130 m downslope of 92nd Avenue. An abandoned water license is present on Walt Spring, located in the ravine approximately 250 m south of 92nd Avenue. TAARA Environmental indicated that flows in this creek appear to be ephemeral to intermittent with the watercourse terminating in the low-lying area south of 92nd Avenue.

Points of Diversion mapped on iMapBC indicate two springs are present in the southern portion of the study area. The Points of Diversion are located along mid to lower slopes between 15 m and 25 m above sea level.

Two additional springs were brought to our attention by a land owner in the area. These springs are located at mid slopes between 29 m and 31 m above sea level in the southern, more steeply sloping portion of the study area. No alluvium or channels are present downslope, indicating overland surface flow. At the time of our field assessment, no flow was present. We understand that flow only occurs during periods of heavy precipitation.

Both of these springs are located at roughly the same elevation along the slope and may occur due to the presence of a seam of higher hydrologic conductivity relative to surrounding materials. As a result, it is possible that additional springs or seepage areas may be present at similar elevations to those observed, along the southern slope of the study area.

We did not observe any large-scale wetlands, ponds or lakes in the study area that have not already been impacted by agricultural or recreational use; however, a poorly drained swampy area is located immediately south of the study area in the low-lying area at the base of the southern slopes in the study area.

5.5.2 Seasonal Flow Patterns

A decommissioned hydrometric station is located in the western portion of the study area on the Serpentine River. Hydrometric data is available for the six year period between 1961 and 1966. Due to the size of the Serpentine River Watershed, it is difficult to determine the contributions and changes in flow due to the Anniedale-Tynehead NCP Area; however, hydrometric data gives an insight into when peak flows tend to occur.

Snowmelt does not play a significant role in annual floods on the river. Hydrologic data indicates that the river has higher flows in the fall and winter during times of higher precipitation. Numerous peaks in stream flow over the winter month are likely due to the small size of the watershed (13 km^2) and suggests that peak flows area associated with heavy rainfall events. Highest peak flows tend to occur in the late winter, generally between February and March. Higher peak flow in the spring months is likely related to groundwater recharge over the course of the winter. Although heavy rainfall also occurs in the fall, groundwater levels tend to be low and, as a result, there is less baseflow contributing to stream flow. Over the course of the winter the water table rises, increasing the baseflow to creeks. Due to the increase in water table and baseflow over the winter months, a storm delivering similar rainfall to that in the fall will produce larger peak flows due to increased baseflow.

5.5.3 Land Use and Development

The study area consists of a mix of low density housing and widespread agricultural development, along with minor areas of standing forest, undeveloped areas and fallow land.

We noted few examples of flooding, channel degradation, erosion or other hydrologic problems; however, our fieldwork was carried out in the summer when evidence of these problems may not be obvious.

Significant erosion has occurred at the outlet of the culvert at 92nd Avenue, where ditchwater is discharged into a ditch running downslope, draining into a ravine south of 92nd Avenue. At the culvert outlet, the watercourse is deeply incised and undercut banks are present downslope of the culvert, indicating significant erosion and scour. We understand that erosion of this ditch began following the extension of 180th Street. A drainage ditch paralleling 180th Street feeds into the ditch parallel to 92nd Avenue. A culvert connects the ditch paralleling 92nd Avenue to the ditch in question. Erosion of the ditch is likely associated with increased flow due to the extension of 180th Street. Diversion of additional water into this ditch will result in further erosion. Armouring on the culvert outlet at 92nd Avenue will help to protect against further erosion.

If the study area undergoes densification, one highly probable result will be an increase in impervious area. Such an increase can result in a shift in the balance away from infiltration and towards increasing runoff. The stream response to storms is usually magnified and accelerated, and in certain cases can result in overwhelming existing infrastructure. The reduction in infiltration in certain cases can result in local impoverishment of the underlying aquifer. This is unlikely to occur in the Anniedale-Tynehead area; however, poorly planned stormwater management can lead to local problems with flooding, waterlogging, erosion and overwhelming of pipes and ditches.

These impacts can be mitigated by best practices in stormwater management, especially those which detain runoff in swales, ponds, wetlands or other features, or measures that encourage infiltration rather than runoff. Examples are permeable pavements, grassed waterways and infiltration galleries in built-up areas.

5.6 Recommendations for protecting groundwater

We have stated that most infiltrated water flows laterally as subsurface flow, rather that directly down through thick Vashon Till to the aquifer. Recharge of the Quadra Sand aquifer underlying the Anniedale-Tynehead area is likely accomplished via lateral flow from the low-lying area south of the study area.

Within the study area, undeveloped areas of standing forest, farm fields, abandoned fields and yards facilitate the steady influx of water to the subsurface. Developed areas with impermeable surfaces, such as roads and buildings, effectively intercept, divert and concentrate water to specific locations, and preferential flow of runoff in storm drains and water control systems results in surface water completely bypassing the groundwater recharge system.

The study area at this time supports a low density of housing, mainly in single family residences built on larger, individual lots with large yards. While there are many benefits from a social, economic and environmental perspective, high-density developments can affect groundwater recharge.

High-density developments can result in much of the land surface being covered with impermeable surfaces, including buildings, driveways, new roads, and recreational features such as swimming pools and sports courts. In many areas, this essentially disconnects the supply of water from the atmosphere to the aquifer, although the effect is diffuse in the study area because of the indirect pathway between infiltrated water and the aquifer.

Reduction in green space, such as lawns and yards, will similarly reduce groundwater recharge.

While the issue of aquifer contamination was not included in the scope of the report, it can be an important consideration when designating areas appropriate for protection of groundwater integrity. Naturally vegetated areas such as forestland and parks are critical for absorbing pollutants and to protect water quality (GeoMap, 2008).

Agricultural fields, while maintaining recharge to the aquifer, can potentially be a source of pollutants when fertilizers, pesticides or manure are incorrectly or inappropriately applied to fields. In addition, fill is present in several developed areas. Should imported fill materials contain contaminants such as petroleum products, asphalt, building materials or pesticides, or if the fill used is itself chemically contaminated, contaminants may enter into the groundwater system, potentially impacting the aquifer.

The key to protecting groundwater recharge in the study area is to not only protect intact tracts of undeveloped land and parks, but also to implement development principles that maintain the hydrologic cycle.

These principles have already been implemented in other housing developments in Surrey, such as the East Clayton Neighborhood (Connelly, 2008), where natural stormwater infiltration systems were installed to allow rainwater to reach the natural ground surface.

When identifying areas for management in terms of groundwater recharge protection, the first and simplest recommendation is to protect existing watercourses and associated riparian areas. A watercourse protected for fisheries or riparian values facilitates groundwater recharge since there should be effective riparian vegetation cover, stable supply of water of good quality, and buffers from adjacent development.

Thus, the greater the protection of existing watercourses, and the larger the riparian buffer along each watercourse, the greater the protection of aquifer recharge and the greater the protection of aquifer water quality.

Several stands of intact forest land were identified. These are potential areas of groundwater recharge resulting from enhancement of infiltration due to the abundance of roots and root channels which promote infiltration pathways in the subsurface. We recommend preserving as much of this land as possible to protect groundwater values.

The impact of high-density housing and development can be mitigated by incorporating simple “green” building features into development design that keep hydrologic principles in mind. Development design components, such as natural stormwater infiltration systems, whereby eaves troughs are fed into the ground rather than into a storm water pipe system will help to maintain the hydrologic integrity of local groundwater recharge regimes. Retaining trees and green spaces will also maintain groundwater recharge processes, but are only effective where the soils and surficial materials are well-drained. Inclusion of bioswales and storm-water detention ponds should be considered on a site-specific basis, where there is sufficient site drainage to facilitate infiltration. A combination of high-density development together with undisturbed natural areas can have a net overall effect lower than total coverage with low-density development, but this requires careful planning.

Areas of imperfect or poor drainage due to groundwater seepage are areas of recharge and can be considered as natural bioswales and ponds. Including greenspaces or increasing designated parkland will also assist in protecting groundwater recharge processes in the study.

5.7 Climate

The nearest Environment Canada Station, Surrey Municipal Hall (EC, 2009) is located approximately 8 km southeast of the study area at an elevation of 76 m above sea level. Climatic records are available for the 30 year period between 1971 and 2000.

Average annual precipitation is 1370 mm, with 71% of that occurring during the six month period from October to March. Average annual snowfall is 51 cm. The total annual precipitation is probably average for most of metropolitan Vancouver, more than the 1199 mm annual average precipitation for Vancouver International Airport in Richmond, but less that the north shore mountains (2043 mm for North Vancouver).

Daily mean temperatures range from 2.7°C to 17.5°C with an annual average temperature of 10°C. This is one of the highest mean temperatures recorded in Canada, but representative of lower elevations in southwestern BC.

Using Climate BC[1], a web-based climate model that interpolates data between established stations, estimated annual precipitation and snowfall at the upper elevations (60 m) of the Anniedale-Tynehead NCP Area are 1627 mm and 82 mm (water equivalent), respectively. These totals are 119% and 161% greater, respectively, than those at Surrey Municipal Hall.

6.0 VEGETATION AND ECOSYSTEMS

The study area is located within the Coastal Western Hemlock very dry maritime (CWHxm) biogeoclimatic (BEC) subzone. The CWHxm subzone is restricted to low elevations along southeast Vancouver Island, along the Sunshine coast, and on the mainland up the south side of the Fraser River above the Coastal Douglas-fir zone (Green and Klinka, 1994). The CWHxm is characterized by warm, dry summers and moist, mild winters with long growing seasons (Green and Klinka, 1994).

6.1 Introduction

We mapped the ecosystems and vegetation communities of the Anniedale-Tynehead NCP Area using a modified "Terrestrial Ecosystem Mapping" (TEM) methodology.

[1]Wang, et al.. 2006 ClimateBC. Available at: http://genetics.forestry.ubc.ca/cfgc/ClimateBC/Default.aspx. Accessed August 5, 2009

The ecosystem classification we used is based mainly on forested sites; however, the study area contains a number of non-forested anthropogenic and sparsely vegetated units. In the TEM methodology, we delineated areas of homogenous vegetation into polygons (or map areas) with associated ecosystem labels that reflect the current ecosystems, structural stages and stand composition.

At the site or local level, forested ecosystems are classified by site series following the Biogeoclimatic Ecosystem Classification (BEC) system. Site series are numerical identifiers that represent ecologically similar units across the landscape. Site series are ecosystems that correspond to vegetation assemblages and available nutrients and moisture at a site, specific to each BEC zone. Soil moisture, slope and aspect, and nutrient availability affect the vegetation that can occur at a site and subsequently different site series can be applied to a variety of ecological conditions.

The BEC classification system is intended to provide a framework for organizing ecological information and describing forest ecosystems within a standardized format for managers to prescribe and monitor site-specific treatments (Green and Klinka, 1994).

An ecosystem (or site series) is derived from a dynamic assortment of vegetation, soil types, and climate. Changes over time following disturbance is referred to as, succession. The system for describing ecosystems is developed from vegetation at later successional stages, in other words, ecosystems in BC are defined by the vegetation at their climax succession or late succession phases. The structure of the ecosystem in its present form can be described by their structural stage, placing a particular ecosystem within general age categories and vegetation development.

Furthermore, nutrient availability and moisture regimes affect the vegetation communities found at a site. For instance, a "zonal" site (site series 01; mapcode 'HK'), would be located mid-slope, be well-drained, have moderately rich soils, and have "typical" plant species. This zonal ecosystem can be present in early succession or later successional stages depending on the last disturbance. Therefore, a zonal ecosystem can be found with a variety of vegetation species with a range of forest structures, but will possess similar ecological conditions.

6.2 Objective

The main objective of the vegetation mapping was to create a base map delineating all ecosystems or vegetation communities within the study area using a combination of ecological features such as moisture, nutrient, slope position, soil type, and vegetation structure. A secondary objective was to identify vegetated corridors with significant ecosystem values including fisheries habitat and wildlife suitability.

6.3 Vegetation Mapping Methodology[2]

We mapped ecosystems and vegetation communities in the study area using a modified ecosystem mapping approach based on standardized TEM methods. Bioterrain features were not mapped for this project, instead soil moisture and nutrient status were interpreted from site series vegetation descriptions and associated edatopic grids from the Land Management Handbook No.#28 (Green and Klinka, 1994). Bioterrain mapping can help to correlate ecosystem types with terrain features; however, since the project area has been considerably modified by residential development and agricultural practices; bioterrain attributes would not add value to the mapping product and would increase field and production costs dramatically.

Polygons were drawn on the hard copy ortho-photography and digitized in an ArcGIS® software package. We separated areas of similar vegetation composition and structure from residential areas and development, such as large patches of forest, fields, or riparian areas.

Each polygon was labeled using TEM standard labels following provincial standards provided in the Resource Inventory Standards Council *Standard for Terrestrial Ecosystem Mapping in British Columbia* (RISC, 1998).

6.3.1 Mapping

We delineated vegetation communities and ecosystems by using interpretations of tone, texture, colour, shape, shadow, size, and pattern of vegetation (open, closed, layered, clumped).

Field staff used preliminary mapping to determine their position on the ground and to relate the ecosystem information to other areas of vegetation or forest stands.

[2] Adapted from: Resources Inventory Standards Committee. 1998. Standard for Terrestrial Ecosystem Mapping in British Columbia.

We marked plot positions on the map when plot data was collected and refined the vegetation mapping through notes and line changes. We attempted to delineate as many vegetated areas as possible; however, very small areas, such as hedgerows and residential trees, have been included with residential footprints (map code: RW).

6.3.2 Map Labeling

The vegetation and ecosystem mapping provides descriptions in the form of structural stages and map codes. Up to three map codes can be applied to each ecosystem polygon with applicable modifiers to describe the structure and ecosystem types found within. These interpretations seek to present each polygon area with the dominant ecosystem and vegetation structure.

For example, the zonal forested ecosystem is represented by the map code 'HK' and exhibits a range of structural stages from 3 – 6. See Appendix I A for a description of ecosystem map codes and associated modifiers. More information on map codes, modifiers and field methods can be found in the Resource Inventory Committee Standards "Standard for Terrestrial Ecosystem Mapping in British Columbia" (RISC, 1998).

Ecosystems, with the exception of wetlands, were coded using two upper case letters indicated in the provincially correlated TEM code list (MoE, 2006), including anthropogenic (human altered) units. We classified wetlands following the Wetland and Riparian Ecosystem Classification system (WREC) which is based on the BEC system (Mackenzie & Moran, 2004). They were assigned a four character code, the first two characters are letters indicating the wetland type (the first letter uppercase, and the second lower) while the second two characters are numbers that represent the site association.

We determined the structure of the vegetation by vegetation features and age criteria. See Appendix I. B for structural stage descriptions.

Structural stage 3, without additional substages, are used for regenerating forest communities undergoing normal succession toward climax forest. Cultivated fields and grass-dominated communities were attributed with a Stage 2b structural stage. Shrub dominated ecosystems including old fields, wetlands, or riparian areas that are dominated by low or tall shrubs were labeled with Stages 3a and 3b, respectively.

Structural stages 4 – 7 are typically estimated from a combination of attributes based on field inventory results and/or aerial photography interpretation. We observed no structural stage 7 (old forests) during the field visits, and only three polygons displayed mature forest structure (structural stage 6).

Three possible stand composition codes were applied to the structural stage modifiers indicating whether forested stands were coniferous, broadleaf or mixed. We applied stand composition modifiers to pole/sapling, young and mature forests (structural stages 4 – 6). Coniferous stands are comprised of greater than 75% coverage of conifer trees. Mixed stands have neither coniferous nor broadleaf dominating (<75%) the total tree cover.

6.3.3 Field Work

Fieldwork was undertaken to describe and verify the vegetation types and site conditions in the study area.

Field visits were focused on capturing the range of potential ecosystems, such as coniferous, broadleaf and mixed forests, seasonally flooded agricultural fields, and possible wetland and riparian areas which all have important wildlife habitat value.

During the field work we also recorded information on plant species densities, average tree heights, vegetation structure, coarse woody debris abundance, invasive species presence, wildlife habitat observations and any signs of disturbance.

6.4 Results

Vegetation mapping was interpreted at 1:5,000 scale or better from a high resolution orthophoto (10 cm pixel). The average polygon size is 2 hectares, with the largest polygon representing 9.25 ha and the smallest about 0.16 ha. The road surface network amounted to nearly 18 ha.

Site series and ecosystem types were determined for each polygon that was visited. Our field checking was conducted at a level 5 intensity, corresponding to 5% to 14% of polygons checked (RISC, 1998a). We delineated a total of 200 polygons and compiled a total of 26 vegetation or wildlife inspections in the field, resulting in about 10% polygons field-checked. The site inspections were concentrated in areas with high potential for wildlife and vegetation value, rather than in fields or rural areas.

Forested ecosystems in the study area consist primarily of second-growth stands. Regenerating forests range from tall shrub to dense young deciduous stands and maturing forests. Rural areas, urbanization and some industrialization have contributed to vegetation loss throughout the study area. The past and current history of land clearing for logging and agricultural practices has contributed to changes in vegetation structure and composition.

The young forest patches in the study area are dominated by a number of broadleaf deciduous tree species such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), bitter cherry (*Prunus emarginata*), western flowering dogwood (*Cornus nuttallii*), paper birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*). Maturing forests contain a mix of conifer and broadleaf trees. The coastal variety of Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) is most common with co-dominant coniferous trees like western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*).

The understory vegetation in upland forests is characterized by salal (*Gaultheria shallon*), trailing blackberry (*Rubus ursinus*), thimbleberry (*Rubus parviflorus*), sword fern (*Polystichum munitum*), Oregon-grape (*Mahonia* spp.) and feathermosses.

On drier sites Douglas-fir trees are joined by shrubs like Baldhip rose (*Rosa gymnocarpa*), common snowberry (*Symphoricarpos albus*), hazelnut (*Corylus cornuta*), and oceanspray (*Holodiscus discolor*).

Forests on lower slopes with moist soils typically contain more western redcedar, grand fir, red alder, and bigleaf maple in the canopy, with salmonberry (*Rubus spectabilis*), willow species (*Salix* sp.), red elderberry (*Sambucus racemosa*), Indian-plum (*Oemleria cerasiformis*), vine maple (*Acer circinatum*), ladyfern (*Athyrium filix-femina*), spiny wood fern (*Dryopteris expansa*), western trillium (*Trillium ovatum*), skunk cabbage (*Lysichiton americanum*), and leafy mosses in the understory.

6.4.1 Mapped Ecosystems

Zonal forests, rural residences and agricultural map units comprise the majority of the Anniedale-Tynehead NCP Area, with forested areas covering 152 ha and anthropogenic sites making up over 260 ha of the 415 ha.

Table 3 presents the total area of site series and vegetation units broken down by map code. We mapped a total of fifteen vegetation communities in the study area, including five forested site series, two wetland ecosystems and eight anthropogenic units. See Appendix I and III for descriptions of map codes.

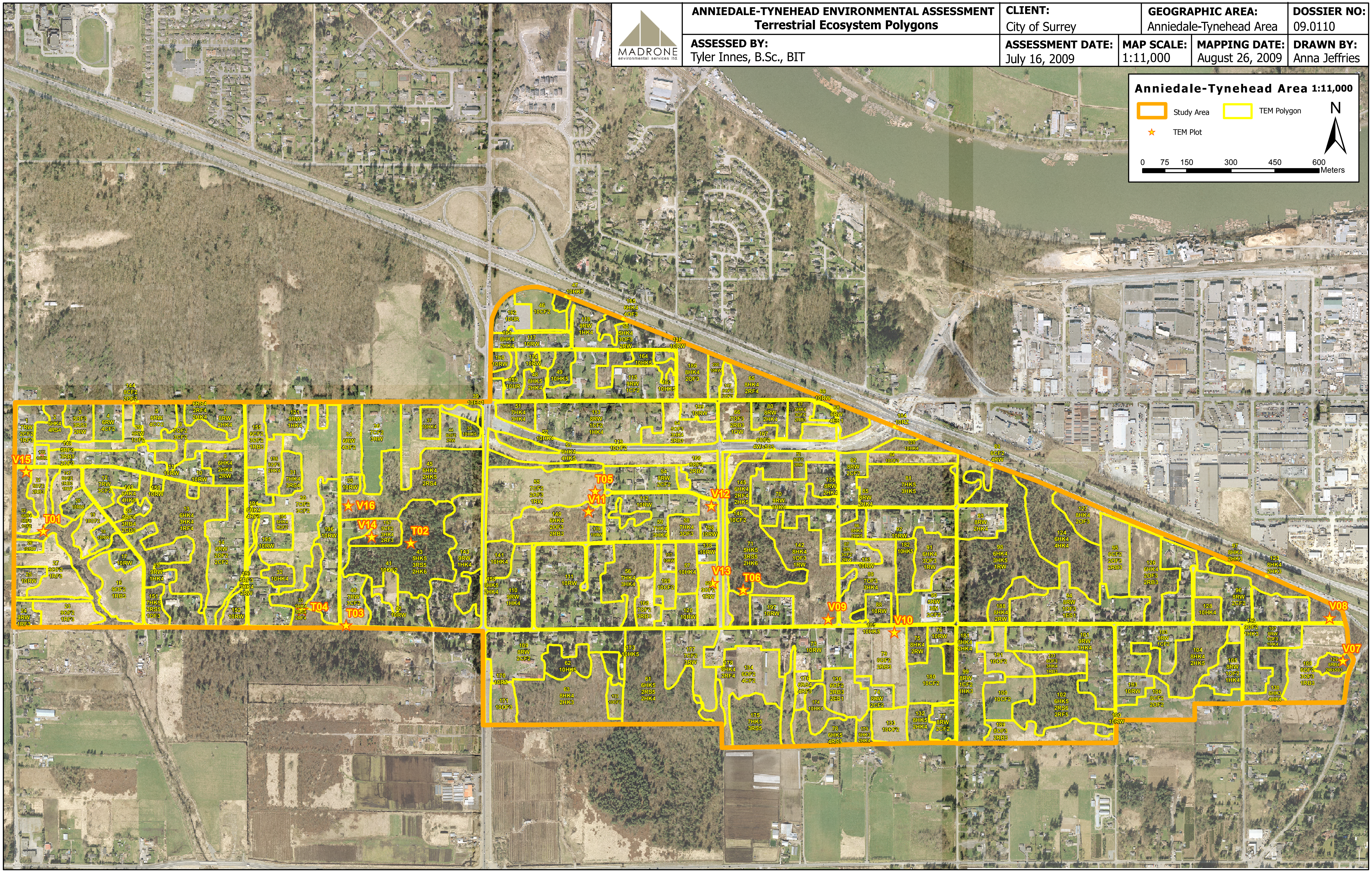
Table 3. Ecosystem Areas and Study Area Percentages

Map code	Site Series	Ecosystem name	Area (ha)	Area (%)
HK	01	Western hemlock/Douglas-fir–Oregon beaked moss	123	30
RS	05	Western redcedar–swordfern	13	3.2
RF	07	Western redcedar–foamflower	6.5	1.6
CD	09	Black cottonwood–red-osier dogwood	0.63	0.15
RB	13	Western redcedar–salmonberry	8.9	2.2
Total Forested			152	37
Forested site series				
Wetland Ecosystems				
Ws50		Pink spirea-Sitka sedge Swamp	0.4	0.1
OW		Shallow Open Water	0.2	0.05
Total wetlands			0.6	0.15
Anthropogenic Units				
CF		Cultivated Field	39.2	9.5
CO		Cultivated Orchard	0.62	0.15
ES		Exposed Soil	1.7	0.4
IN		Industrial	1.3	0.3
OF		Old Field	62.3	15
RW		Rural (includes Hedge Rows and Lawns)	137	33
RZ		Road Surface	18	4.4
UR		Urban	2.0	0.5
Total anthropogenic			262	63
Total Area			415	100

The study area consists primarily of forested ecosystems (36.7%), rural residences (33%) and cultivated or old fields (25.4%) with less than 0.2% wetlands. Figure 6 graphically represents the distribution of ecosystems and anthropogenic units found in the study area.

Western hemlock/Douglas-fir–Oregon beaked moss ecosystems (mapcode HK) occupied nearly 30% of the mapped area. The site conditions fit the moderate regimes of nutrient and moisture availability expressing the zonal ecosystem in the CWHxm; however, these forests have been modified by logging and urbanization, resulting in mixed broadleaf and coniferous forests between 20 and 100 years old.

Anthropogenic units are represented mainly by cultivated fields, old fields and rural areas with lesser amounts of road surfaces, industrial parks and urban locales. Cultivated fields, old fields, and much of the rural map units are vegetated with varying degrees of grasses, shrubs, and landscaped trees. In some cases, old fields can support a variety of wildlife species that may use grass and shrub vegetation for feeding and nesting habitat.



MADRONE environmental services ltd.
ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Terrestrial Ecosystem Polygons
CLIENT: City of Surrey
GEOGRAPHIC AREA: Anniedale-Tynehead Area
DOSSIER NO: 09.0110
ASSESSED BY: Tyler Innes, B.Sc., BIT
ASSESSMENT DATE: July 16, 2009
MAP SCALE: 1:11,000
MAPPING DATE: August 26, 2009
DRAWN BY: Anna Jeffries
Anniedale-Tynehead Area 1:11,000
Study Area
TEM Polygon
TEM Plot
N
0 75 150 300 450 600 Meters
V15
T01
V16
V14
T02
T04
T03
T05
V11
V12
V13
T06
V09
V10
V08
V07

6.4.2 Structural Stage

Structural stage modifiers reflect the age and vegetation structure of the landscape. Seven classes are recognized from Stage 1 (bare ground) to Stage 7 (eg: old-growth conifer forest). See Appendix I.B. for a description of structural stages. We didn't assign a structural stage to polygons that are dominated by rural areas because they represent a mix of buildings, roads and landscaped vegetation. Some rural lots did contain a variety of young and mature tree and shrub species that provide ecological and social value to the community.

The structural stages of the forested vegetation communities were mainly in the 20 to 80 year-old categories. The structure of an ecosystem depends on the development stages of the vegetation and time since disturbance.

Pole-sapling forests (structural stage 4) make up the majority of forest ecosystems, covering over 90 ha (22.5%) of the study area. Pole forests have a combination of regenerating tree species like big-leaf maple, red alder, and Douglas-fir, usually younger than 40 years. Young forests (structural stage 5) occupied 58 ha or about 14% of the landscape. Young forests are generally 40 to 80 years old with the forest canopy starting to differentiate into distinct layers through self-thinning.

Cultivated fields (map code: CF) are composed of actively mowed agronomic grass species covering almost 10% of the study area. Similar – but unmanaged - areas were identified as old fields (map code: OF); however, these communities usually contain older and more diverse herbaceous vegetation as well as various amounts of shrub and tree structure that likely support other ecological and wildlife features in the area, especially when they are located adjacent to forested ecosystems. Old fields, as their name implies, are older and usually represent abandoned fields that once were farmed.

Mature forests (structural stage 6) only covered about 3 ha of the area. Three polygons (43, 71, and 102) contained mature forest stands, one in the east central portion another in the west central area (Polygon 71); and in the southeast (Polygon 102). Portions of these areas contain tree species older than 80 years with a second cycle of shade-tolerant trees developing in the understory.

Table 4 shows the structural stage results in the mapped area.

Table 4. Structural Stage Area Summary

Structural Stage	1 Sparse	2 Herb	3 Shrub	4 Pole Sapling	5 Young Forest	6 Mature Forest	Not Applic.	Total
Hectares	1.7	82.0	34.3	93.4	58.8	3.2	141	415
Percentage	0.4%	19.8%	8.3%	22.5%	14.2%	0.8%	34%	100%

6.4.3 Stand Composition

Stand composition refers to the make-up of the forested areas according to their dominant tree type. We applied modifiers to the map codes to describe coniferous, broadleaf or mixed forest stands. Non-forested areas, such as cultivated fields and rural areas, constitute the majority of the landscape at over 270 ha. Table 5 depicts the stand composition results of the vegetation mapping.

Broadleaf forests are the most common forest stands in the study area comprising more than 70 ha. Mixed broadleaf and coniferous forests cover almost 60 ha of the landscape. Several mature broadleaf stands 60 to 80 years old occur in the Anniedale-Tynehead NCP Area, but are generally younger than coniferous stands belonging to the same structural stage. Forests with more than 75% coniferous tree species are not frequent in the study area, but small patches occupy about 8 ha of land in seven polygons in three main areas (Polygons 43, 47, 49, 102, 164, 173, and 185).

Table 5. Stand Composition Area Summary and Percentages

Stand Composition	Coniferous	Broadleaf	Mixed	Non-Forested Anthropogenic	Total
Composition in Hectares	8.1	71.1	58.7	277	415
Composition as a Percentage	1.9%	17.2%	14.2%	66.7%	100%

Several old deciduous broadleaf tree species were encountered during the field visits, including a bitter cherry tree in plot T06 that measured 47.3 cm in diameter and over 15 m tall (one of the largest native cherries we have seen).

Our native deciduous tree species, such as red alder, bigleaf maple, paper birch and bitter cherry are relatively short-lived and start to decline after 40 to 80 years. Black cottonwood on the other hand remains vigorous to as much as 120 years. After deciduous trees die, they tend to decompose quickly typically within 10 to 20 years.

On the other hand, conifers such as Douglas-fir and western redcedar are extremely long-lived with lifespans (barring blowdown or disease) over 1000 years. After death they take significantly longer to decay and therefore contribute to coarse woody debris (Fenger *et al.*, 2006).

6.4.4 Rare Plant Species

The study area within the CWHxm subzone has the potential to contain at least 26 rare plant species (Appendix IV); however, the Anniedale-Tynehead NCP Area contains no occurrences of species of conservation concern (BC Species and Ecosystem Explorer [CDC], 2008). Despite a careful survey, we observed no rare plants during the TEM fieldwork; however, this does not conclusively rule out their occurrence.

A more detailed vegetation survey would be required to ensure that rare plants are not present.

6.4.5 Rare Ecosystems

All of the forested ecosystems mapped in the study area are considered at-risk in BC, including three red-listed and two blue-listed site series (Table 6). These ecosystems are threatened or of special concern due to development and harvesting pressures on the coast. Over 150 ha of forested rare ecosystems occur in the study area, occupying over 36% of the land base. The majority of these forests are immature and are dominated by broadleaf trees or a mix of broadleaf and coniferous trees. Although they will likely develop into mature conifer forests with time (in some cases centuries) they are still classed as red or blue-listed ecosystems.

A list of potential rare ecosystems for the CWHxm subzone can be found in Appendix V. See Appendix II for definitions of rare elements.

Table 6.Rare Ecosystems Mapped in the Study Area

English Name	Prov Rank	BC Status	BGC	Ecosystem Group
western hemlock - Douglas-fir / Oregon beaked-moss	S2	Red	CWHxm/01	Forest
western redcedar / three-leaved foamflower	S2	Red	CWHxm/07	Forest
western redcedar / salmonberry	S1S2	Red	CWHxm/13	Forest, Riparian
western redcedar / sword fern	S2S3	Blue	CWHxm/05	Forest
black cottonwood - red alder / salmonberry	S3	Blue	CWHxm/09	Riparian, Forest

6.4.6 Weeds and Introduced Vegetation

A number of introduced weedy plant species and escaped ornamental vegetation were observed during the field visits, mainly along roadside ditches, old fields, rural residences and forest clearings. Introduced plant species include Himalayan blackberry (*Rubus discolor*), Canada thistle (*Cirsium arvense*), scotch broom (*Cytisus scoparius*), tansy ragwort (*Senecio jacobaea*), Policeman's helmet (*Impatiens glandulifera*), small touch-me-not (*Impatiens parviflora*), clovers (*Trifolium* spp.), field bindweed (*Convolvulus arvensis*), Japanese knotweed (*Polygonum cuspidatum*), English ivy (*Hedera helix*), and English holly (*Ilex aquifolium*). On abandoned fields we noted well-established, introduced grass species, especially canary reed grass (*Phalaris arundinacea*).

Weeds are considered unwanted plants. Some weeds are noxious or invasive; others are less of a problem. Noxious weeds are typically non-native plants that have been introduced to British Columbia without the insect predators and plant pathogens that help keep them in check in their native habitats. For this reason and because of their aggressive growth, these alien plants can be highly destructive, competitive and difficult to control.

The B.C. Weed Control Act imposes a duty on all land occupiers to control designated noxious plants. The purpose for the Act is to protect our natural resources and industry from the negative impacts of foreign weeds (Ministry of Agriculture and Lands, 2007); however, it is up to the City and property owners to decide how far the introduced vegetation needs to be managed. Some weeds may be tolerated for the long-term, but some will need continuous management to prevent potential changes to native vegetation communities.

A detailed invasive plant survey would need to be carried out in order to assess the threats and potential management recommendations.

Canada thistle is listed as a noxious weed on the BC Weed Control Act (Ministry of Agriculture and Lands, 2007) and reproduces aggressively by seed and is difficult to eradicate because of spreading roots. Tansy ragwort is also on the noxious weed list because it is a toxic to cattle, but it is only present in small numbers in the study area.

6.5 Vegetation and Ecosystem Ranking

In order to address the needs of the City and provide guidance on important vegetated areas, we developed a ranking system to identify ecosystem polygons with special importance to the study area. This ranking system is based on the objectives of the project as well as from the objectives found within the BC Ministry of Environment's document *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia* (MoE, 2006). The objectives are important principles that MoE will use when reporting on compliance by the development community and approval authorities. In addition, this ranking system is consistent with the methods used for the Grandview Heights Ecological Assessment project (Madrone, 2008).

The main planning and design guidelines listed in the Environmentally Valuable Resources (Section 4) of the *Develop with Care* document focuses on:

- Protecting environmentally valuable resources
- Protecting specialized habitats
- Protecting aquatic and riparian ecosystems
- Retaining and enhancing wildlife travel corridors

Environmental planning at the community level (Section 2 of the *Develop with Care* series), suggests guidelines for protecting species and ecosystems. The following ecological principles for protecting ecosystems and are designed to avoid or minimize impacts during land development:

- Larger sites provide a greater variety of habitats. A 40-ha site will tend to support a greater diversity of species and habitats than a 10-ha site.

- Diversity is better. Greater ecosystem diversity tends to support greater species diversity. Maintaining a diversity of ecosystems helps ensure a variety of food sources and cover and preferred breeding and rearing areas is maintained.

- Linkages help. There is a better chance of preventing fragmentation effects if individuals or whole populations can safely move from one area to the next.

- Redundancy helps ensure sustainability. If there is only one remaining population of a species, the chances of extirpation are very high. Having several populations in different locations increases overall species' survival.

- Small habitats can be critical to species' survival. The collective influences of many small habitats can be as great as a single larger park. These small habitats are critical areas for many urban species, and some may contain remnant populations of rare or endangered species.

- Buffers help protect core areas. The impacts of human activity and other ecosystem stressors, such as invasispecies, tend to be greatest at the edges of ecosystems. A buffer area helps protect core areas from these impacts.

Therefore, four elements were considered when ranking ecosystem polygons for potential for vegetation value and to help protect ecosystems and species in the project area. Ranking took into account the value of:

- Critical habitat for significant wildlife species and for support of biodiversity (Ecosystem label element).

- Significant and valuable tree stands or specimens, including tree species and areas with a high potential for retention (structural stage element).

- Watercourses, watersheds and groundwater recharge areas (including associated features such as wetlands and riparian zones) (Riparian features element).

- Natural areas with potential to provide habitat corridors or greenways linking to other green spaces within and beyond the study area (Polygon size element).

For each polygon, the four elements were given a value of 1 to 6; a value of 1 is the highest rating.

Then each ecosystem element value was weighted for their relative importance in determining the value of the vegetation resources. The weighted average of the four elements was used to arrive at a final weighted vegetation value rank that ranges from 1 to 6. Table 7 outlines the ranking matrix for the potential for vegetation values for each polygon.

Table 7. Vegetation Mapping Element and Ranking Matrix

← POTENTIAL FOR VEGETATION VALUE

Element / Weighting	1 High	2 Moderately High	3 Moderate	4 Low	5 Very Low	6 Nil
Ecosystem label / (50%)	CD (09) Swamp(Ws 50) OW (open water)	RF (07) RB (13)	HK (01) RS (05) OF	CF CO	RW	UR IN RZ ES
Structural stage / 25%	6	5	4	3	2	N/A
Riparian features / 20%	Permanent	Ephemeral	Surface water	Ditches	None	N/A
Polygon size (ha) / 5%	10+	5-10	1.1-4.9	0.6-1	0.2-0.59	N/A

The ecosystem element was given a weighting of 50% due to the importance of habitat use and ecosystems at-risk. Riparian ecosystems and Mature forests were ranked high and moderately high, while cultivated fields, old fields and rural areas were ranked low and very low, respectively.

Structural stage is also an important vegetation description element for determining forest ages, specific habitat features, and significant trees, therefore this category was given a weighting of 25%.

Riparian and potential for riparian features are important for wildlife habitat, and thus we applied a 20% weighting to polygons containing a watercourse.

A 5% weight was applied to each polygon based on size because it is assumed that larger tracts of forests or fields provide greater potential for wildlife use and old forest recruitment. Modifications were made to the vegetation value ranks depending on connectivity and proximity to adjacent polygon ranks.

Ecologically significant areas, such as rare vegetation types or known occurrences of red- or blue-listed species or ecosystems were not used for ranking vegetation polygons because ecosystem and structural stage criteria better reflect the vegetation value to wildlife and biodiversity maintenance.

No rare plant occurrences are known in the study area and none were located during the field inspections.

The ranking of polygons for vegetation value resulted in a themed map that represents higher values in darker green and less valuable vegetation polygons in lighter green. Vegetated polygons that are large, mature, with rich site conditions and high habitat value contribute to current and long-term biodiversity values. These areas tend to be grouped together and show a general corridor from the south to the northwest portion of the study area. See Figure 7 for the themed vegetation and biodiversity rankings.

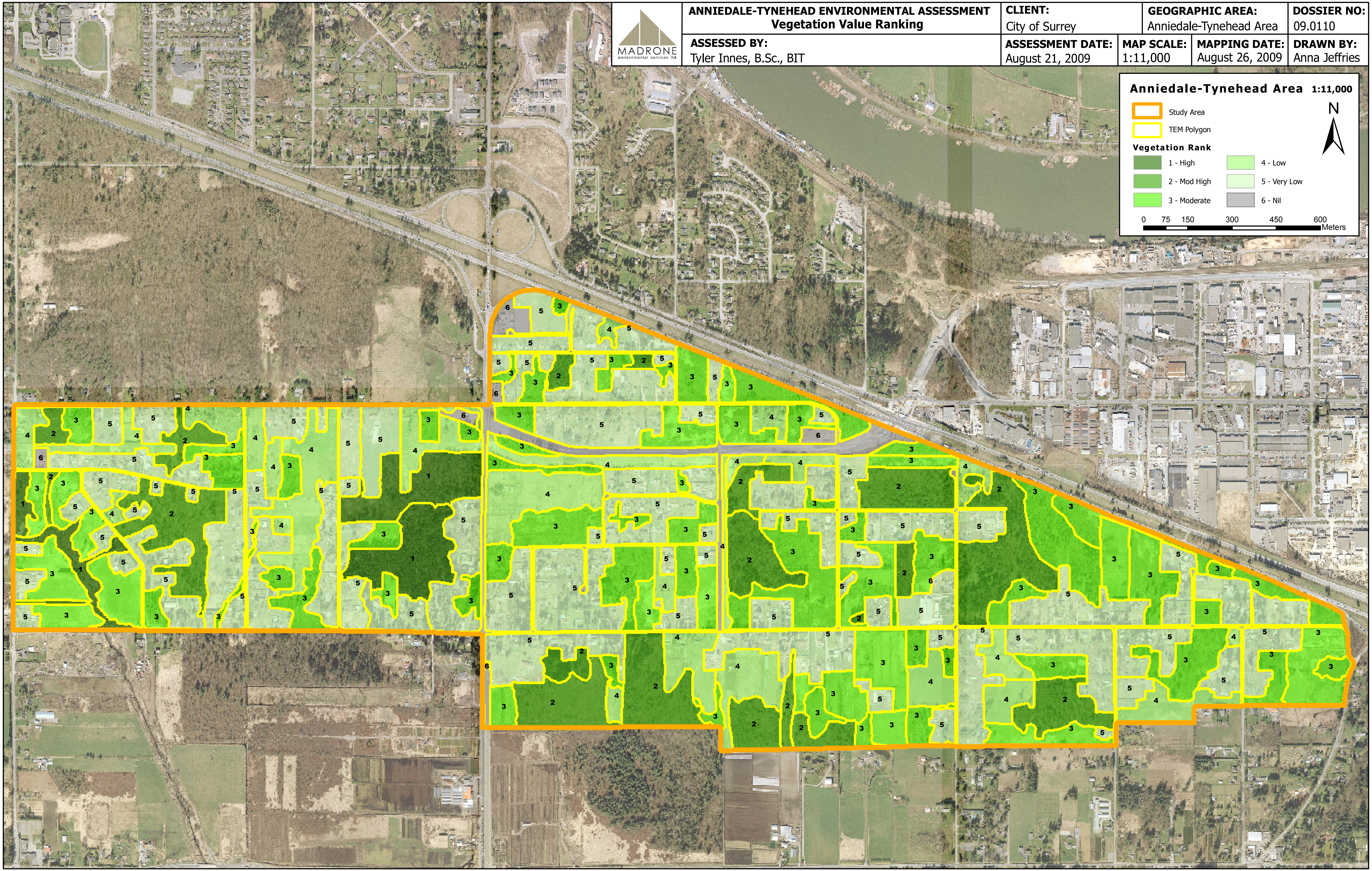
Polygons with no vegetation or biodiversity value are represented by a grey colour theme and depict commercial or industrial areas.

6.5.1 Limitations

We based our interpretations of structural stage on 2008 orthophotos; accordingly changes in cover since that time will not be recorded on our mapping. The aerial photos appear to have been taken in late autumn because broadleaf deciduous trees are not leafed-out. The lack of leaves makes interpretations a little more difficult to discern structure, but it did assist in differentiating conifer trees from broadleaf.

Our ecosystem and vegetation mapping was conducted at 1:5000 or better; however, at this level of mapping, polygon size is limited to about 0.2 of a hectare. At the mapping scale, ditches and microhabitats cannot be separated from the adjacent vegetation unit.

MADRONE environmental services ltd.	ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT Vegetation Value Ranking	CLIENT: City of Surrey		GEOGRAPHIC AREA: Anniedale-Tynehead Area	DOSSIER NO: 09.0110
	ASSESSED BY: Tyler Innes, B.Sc., BIT	ASSESSMENT DATE: August 21, 2009	MAP SCALE: 1:11,000	MAPPING DATE: August 26, 2009	DRAWN BY: Anna Jeffries



6.6 Summary and Conclusions

Significant ecosystems, forest stands and habitats that contribute to species-level and landscape-level biodiversity were themed from the vegetation mapping results. Vegetation and ecosystem polygons formed the basis for analyzing the current and potential vegetation value of the Anniedale-Tynehead NCP Area as well as for wildlife.

We consider the young forests and mature stands (structural stage 5 and 6) that occur in the study area to be of moderately high value, due to their ages and retention potential, and contribute to biodiversity maintenance. These forests, if protected, will very likely form the old forests in the future. Currently, these forests provide high habitat value for many birds, mammals and other wildlife. The forest is used in many ways by numerous species and in many different life stages; for example bats or nuthatches may nest behind loose bark on dead or dying trees.

Even-aged, second-growth conifer stands (especially structural stage 5) offer relatively low habitat values due to the closed canopy and lack of understory diversity and richness; however, habitat richness increases as these forests develop through structural stage 6 (typically beyond 60 years). Gradually the canopy differentiates, some trees die, creating gaps, dead standing trees and coarse woody debris. These processes create more diversity that will support a wider range of wildlife species. The value of second-growth forests is not so much for their present value, but that they will continue to gain value for habitat as they develop.

Conservation of biological diversity can be improved when forest reserves are protected and managed to reduce the effects of fragmentation and to provide connectivity between developed lands (Fenger *et al.*, 2006).

There are important natural or areas near to the study area. These have an effect on the conservation priorities. In particular, the western portion of the study area connects to large tracts of forested land to the north and south. We note the presence of the large Tynehead Regional Park (283 ha) immediately to the northwest of the study area. Due west is Bothwell Park, a mix of young deciduous and recreational areas (24.2 ha). Although not abutting the study area, the large Surrey Bend Park, at 428 ha) is one of the largest natural areas in the Lower Mainland, and is a short distance to the north.

The Ecosystem Management Study, (2009) in assessing a potential green infrastructure network, identified a number of "hubs" and corridors in the region containing the Anniedale-Tynehead NCP Area. Tynehead and Bothwell, already mentioned, constitute hubs outside the study area to the west and north. Additional hubs in the study area are Serpentine Heights East (17.9 ha), Anniedale-Tynehead (39.2 ha, straddling the southern boundary), Anniedale-Tynehead Northwest, and Anniedale-Tynehead North (16.7 ha). These are primarily wooded areas and correspond to our ecosystem polygons containing broadleaf or mixed forest with structural stages 4 and 5. Along the southern boundary and in the Serpentine floodplain, the study identified several hubs consisting of agricultural land.

The Serpentine River ecosystems and surrounding forests and fields in the east provide a general corridor of mixed tree species, open field habitat and forested ecosystems that offer moderately high vegetation values for habitat and recreational use. The central and eastern portions in Anniedale-Tynehead NCP Area are bound by Highway 1 to the north, but connect to fields and forests to the south.

Rural residence polygons contain some vegetation and habitat value from hedgerows and landscaped trees. Many of these trees are remnants of the second-growth forests that developed naturally after early logging or farming, or were planted for aesthetic reasons. Large trees are disproportionately valuable for habitat, aesthetics, and vegetation values.

6.7 Environmentally Sensitive Areas

The General Land Use for Anniedale-Tynehead NCP Area (Phoenix, 2004), identified five environmental sensitive areas from their report; however, ESA #1 is completely out of the current study area. A large portion of ESA #2 and ESA #3 are also out of the current study area.

The Serpentine River watershed in the west was identified as ESA #5 from the Phoenix report. This riparian area connects to forests to the north into Tynehead Park and south along the Serpentine River system. Polygons 2, 3, 6, 13, 15, 16, 19, 21, 22, 23, 27, and 28 are rated as moderate to high conservation value.

The large forested polygons in the west central region of the study area are referred to as ESA #4 (Polygons 43, 44, and 157). These polygons have a total size of nearly 12 ha.

ESA #3 is made up of deciduous and conifer forests and associated drainages from Lakiotis Creek watershed (Polygons 61, 62, 63, 78, 79, 171, 172, 173, 174, 175, 176 and 178). This is a large, relatively undeveloped area that has older agricultural fields and mixed forests.

Polygons 102, 131, and 189 comprise the moderate to high value vegetated areas around Sawmill Creek (ESA #2). Polygon 102 is rated as having high vegetation value that is an excellent candidate for conservation because of the drainage and connectivity to the forests to the south.

7.0 RIPARIAN AREAS AND FISH HABITAT

7.1 Introduction

Setbacks are designed to maintain the biological function of riparian ecosystems by protecting riparian vegetation which contributes to fish and wildlife values. Riparian vegetation plays a number of key roles and provides important inputs to fish habitat such as: shading to regulate water temperature; leaf litter for nutrient input into the water; insect-drop into the water (serves as a potential source of food for fish); and Large Woody Debris (LWD), which provides security habitat for fish and also provides bank stabilization, which decreases erosion and sediment input into the water. Consequently, when development takes place near any water body, it is important to ensure the provision of an adequate setback.

To help ensure the adequate protection of riparian areas and associated fish habitat, the City of Surrey has adopted the Land Development Guidelines developed by the Habitat Management Division of Fisheries and Oceans Canada (DFO) and the Integrated Management Branch of the Ministry of Environment (MoE). Watercourses have been assessed and classified based on habitat attributes and connectivity to fish habitat. The classification system is comprised of four classes of creeks (A, AO, B and C). Class A watercourses are inhabited by salmonids year-round, or are potentially inhabited year round; Class AO watercourses are inhabited by salmonids primarily during the overwintering period or potentially inhabited during the overwintering period with access enhancement; Class B watercourses do not support fish, but offer significant food/nutrient value to connected fish habitat; and Class C watercourses do not support fish and offer insignificant food/nutrient value.

The width of riparian setbacks adjacent to watercourses located in the City of Surrey is dependent upon the classification (i.e. fish value) and the proposed density of development adjacent to the watercourse.

If less than six units per acre are proposed adjacent to a Class A, AO or B watercourse, the setback is 15 m; if more than 6 units per acre are proposed, the setback becomes 30 m.

All commercial developments result in a setback of 30 m. Riparian setbacks are not required for Class C watercourses but riparian areas must be managed in a way that maintains the conveyance of water.

Individual property owners also have the option of using the standards set out in the provincial Riparian Areas Regulation, should variances be requested to the default City of Surrey riparian setback areas. Watercourses are managed by the City of Surrey with the continued involvement of the DFO (Steve Godwin, Environmental Coordinator, City of Surrey, pers. comm.).

Due to the stream classification work carried out by the City of Surrey and the default riparian setbacks, we did not, in our riparian and fisheries assessment, focus on the establishment of recommended riparian buffers. Our main objectives of the riparian and fish habitat assessment were to:

- Describe the general distribution of fish and fish habitat throughout the study area;
- Describe the biological function of existing riparian vegetation adjacent to fish habitat;
- Identify candidate areas for fish habitat enhancement; and
- Assess the accuracy of the existing stream classification mapping provided by the City of Surrey.

7.2 Pre-Field Research

Prior to field assessments, we accessed the Habitat Wizard website (Habitat Wizard, 2009) to determine the location of any known fish habitat and to ascertain documented fish presence. A detailed stream classification mapping layer (provided by the City of Surrey) was used as a base map for the riparian and fish habitat assessment. Previous reports produced by Phoenix Environmental Services Ltd. were also studied, as these were directly related to the study area. Of particular relevance was the report entitled *Anniedale "A" Neighbourhood Concept Plan. Anniedale-Tynehead NCP Area. Prepared for City of Surrey, by Phoenix Environmental Services Ltd. June 2007.*

7.3 Field Assessments

During field surveys, we placed a priority on visiting currently mapped Class B, C or unclassified drainages in proximity to either Class A or Class AO creeks to check for potential fish presence or the existence of fish habitat. We also focused on known fish habitat (e.g. the Serpentine River watershed) in order to help develop potential prescriptions for habitat improvement. Where feasible (*i.e.* considering access onto private property and the scope of the assessment), the accuracy of the existing City of Surrey stream classification map was assessed. It should be noted that, at this overview level, not all existing drainage classifications were checked for accuracy. Classification updates may occur when development occurs on a lot by lot basis, given the more focused level of detail.

Where discrepancies were observed between mapped drainages and drainages in the field, the drainage was traversed using a hand-held GPS unit for inclusion onto the updated riparian map. Throughout the field assessment, we made general notes regarding the extent of riparian vegetation and the surrounding land use.

7.4 Riparian and Fish Habitat Assessment Results

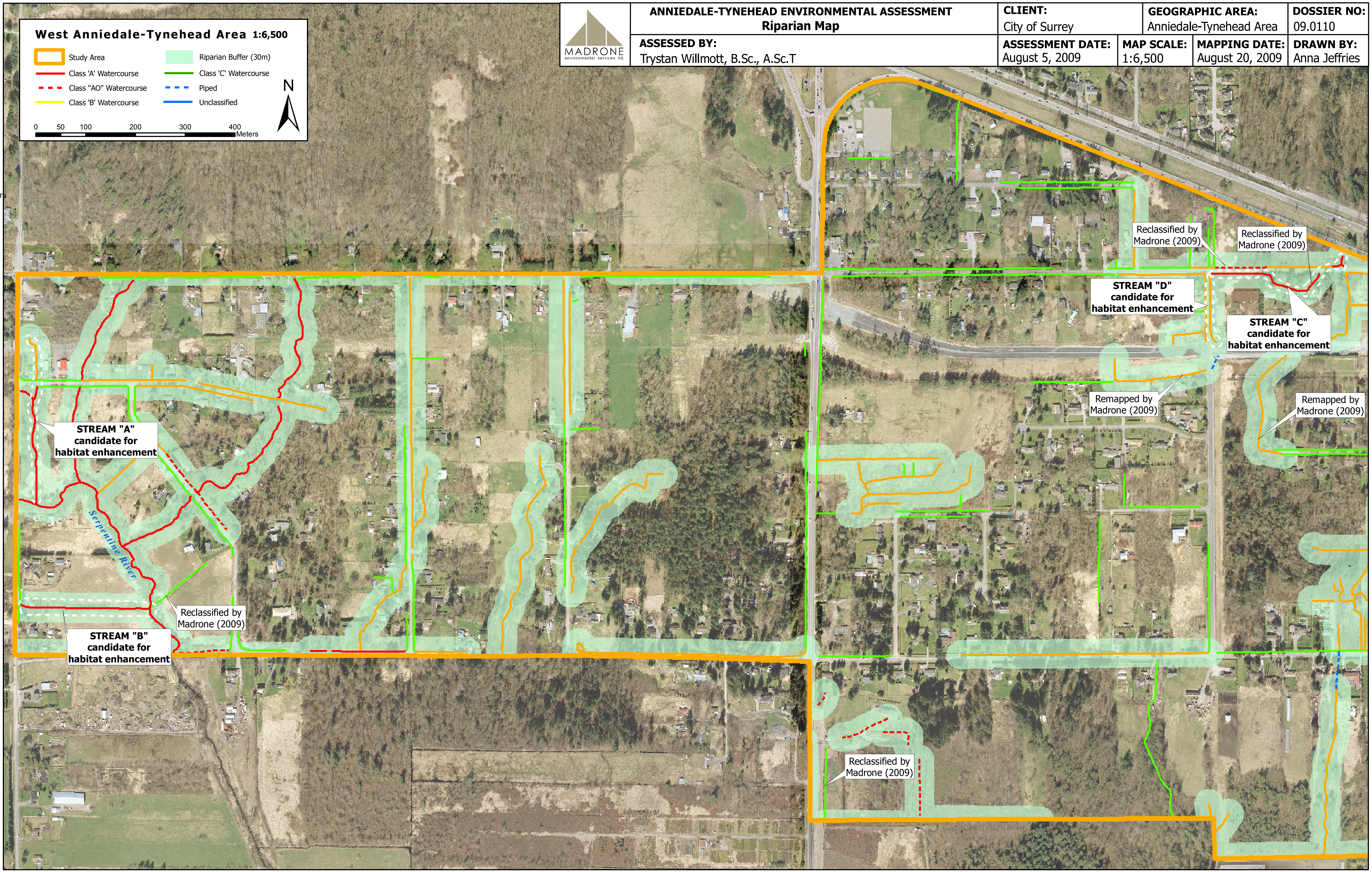
Figures 8 and 9 display the distribution of drainages and drainage classification based on existing City of Surrey mapping. The maps also show classification updates, re-mapped drainages and potential habitat enhancement/restoration areas. Riparian setbacks have been added as per the existing protocol used by the City of Surrey. As future development densities are unknown at present, all Class A, AO and B drainages have been associated with the maximum 30 m riparian buffer.

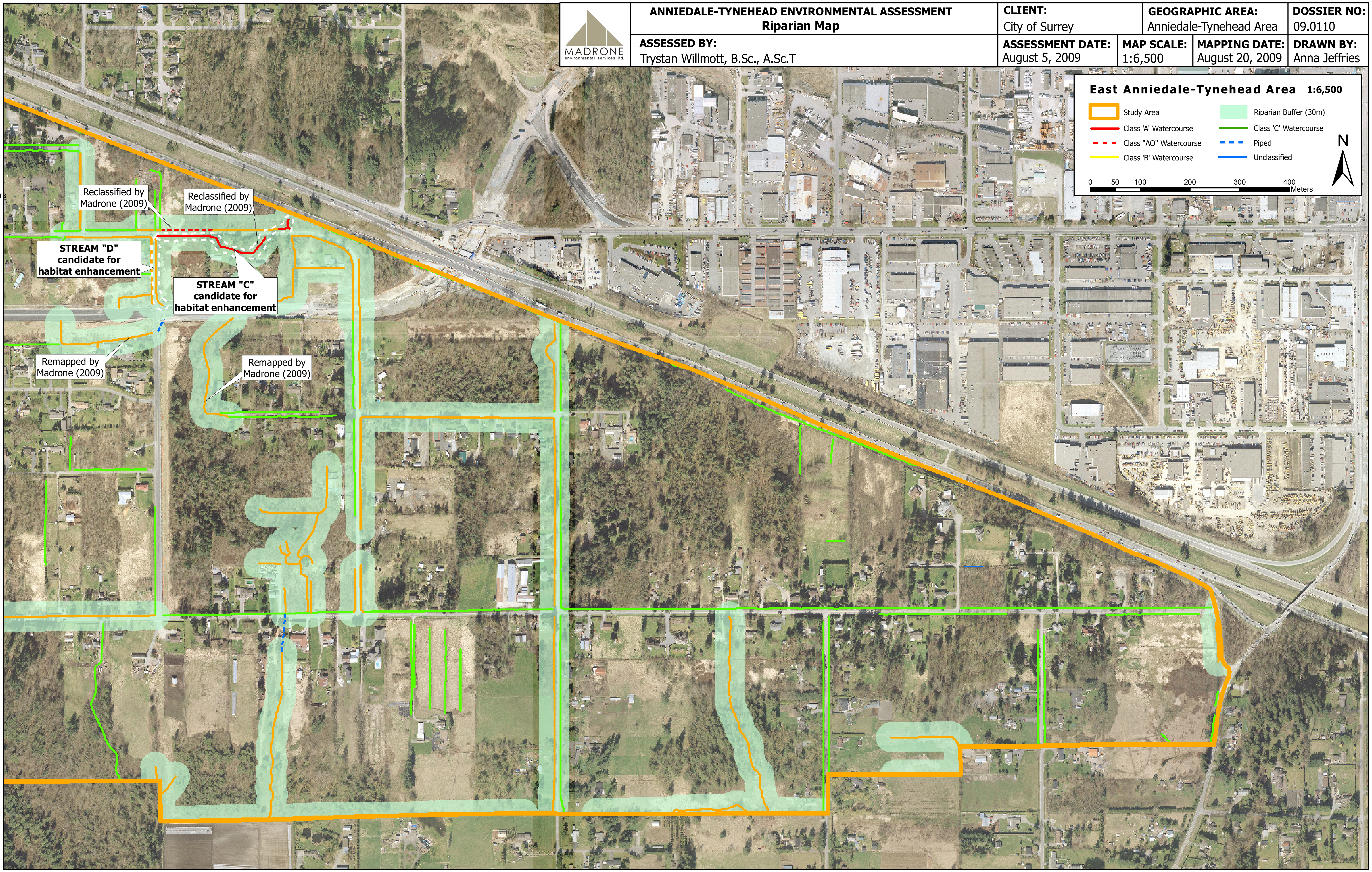
7.5 Fish Habitat and Fish Distribution

Fish habitat is generally limited throughout the study area, at least partly due to negative anthropogenic influences. Land development, mainly as a result of roads, extensive ditching and agriculture, has restricted the natural distribution of fish and fish habitat throughout the study area. Fish are present only in three separate river systems within the study area and adjacent areas.

7.5.1 The Serpentine River

The Serpentine River (Watershed Code 900-00500) is a 29.6 km 5^{th} order stream (Habitat Wizard 2009), part of which flows from north to south through the western portion of the study area.


ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Riparian Map
MADRONE environmental services ltd.
CLIENT:
City of Surrey
GEOGRAPHIC AREA:
Anniedale-Tynehead Area
DOSSIER NO:
09.0110
ASSESSED BY:
Trystan Willmott, B.Sc., A.Sc.T
ASSESSMENT DATE:
August 5, 2009
MAP SCALE:
1:6,500
MAPPING DATE:
August 20, 2009
DRAWN BY:
Anna Jeffries
West Anniedale-Tynehead Area 1:6,500
Study Area
Riparian Buffer (30m)
Class 'A' Watercourse
Class 'C' Watercourse
Class "AO" Watercourse
Piped
Class 'B' Watercourse
Unclassified
N
0 50 100 200 300 400 Meters
STREAM "A" candidate for habitat enhancement
STREAM "B" candidate for habitat enhancement
STREAM "C" candidate for habitat enhancement
STREAM "D" candidate for habitat enhancement
Serpentine River
Reclassified by Madrone (2009)
Reclassified by Madrone (2009)
Reclassified by Madrone (2009)
Reclassified by Madrone (2009)
Remapped by Madrone (2009)
Remapped by Madrone (2009)


MADRONE environmental services ltd
ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Riparian Map
CLIENT:
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East Anniedale-Tynehead Area 1:6,500
Study Area
Class 'A' Watercourse
Class "AO" Watercourse
Class 'B' Watercourse
Riparian Buffer (30m)
Class 'C' Watercourse
Piped
Unclassified
N
0 50 100 200 300 400
Meters
Reclassified by Madrone (2009)
Reclassified by Madrone (2009)
STREAM "D" candidate for habitat enhancement
STREAM "C" candidate for habitat enhancement
Remapped by Madrone (2009)
Remapped by Madrone (2009)

The Serpentine River is known to support a range of fish species (as per the species list in Habitat Wizard 2009), including chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), chum salmon (*O. keta*), steelhead (*O. mykiss*), westslope cutthroat trout (*O. clarki lewisi*), coastal cutthroat trout (*O. clarki clarki*), including anadromous form, rainbow trout (*O. mykiss*), redside shiner (*Richardsonius balteatus*), prickly sculpin (*Cottus asper*), three-spined stickleback (*Gasterosteus aculeatus*), peamouth chub (*Mylocheilus caurinus*), brown catfish (*Ameiurus nebulosus*), carp (*Cyprinus* sp.), pumpkinseed fish (*Lepomis gibbosus*) and yellow perch (*Perca flavescens*).

During the field assessment, we observed fish both in the mainstem Serpentine River and connected tributaries (including ditches). The majority of the fish we observed were rearing juvenile coho salmon fry. The mainstem river exhibits a perennial flow regime and offers relatively diverse habitat where it flows through the study area. Deep pools for cover and security are well represented, as are riffles with adequate gravel for spawning. Large woody debris (LWD) is generally lacking in the river, due to the historical clearance of riparian vegetation and subsequent lack of potential LWD recruitment trees (Photos 1-3).

Photo 1. Looking east (downstream) along the Serpentine River from the point where it crosses underneath 168th Street. Note overhanging riparian vegetation, providing litter input and insect drop to fish habitat. Juvenile coho salmon were observed at this location.

Photo 2. Looking northwest (upstream) along the Serpentine River in the Bothwell Drive area. Note dense shrub cover (Himalayan blackberry dominant) in the riparian zone.

Photo 3. Looking southeast (downstream) along the Serpentine River in the Bothwell Drive area. Note riffle/pool habitat type and presence of gravel deposits providing spawning habitat for a range of salmonid fish. Also note the small diameter of the deciduous LWD.

7.5.2 Latimer Creek

Latimer Creek flows from the northeast to the southwest beyond the eastern study area boundary. One Class B drainage flows from the study area into the creek. Latimer Creek (Watershed Code 900-005500-68900) is a 3rd order, 6.32 km long stream (Habitat Wizard 2009). The creek is known to contain a range of fish species, including chinook salmon, coho salmon, pink salmon (*Oncorhynchus gorbuscha*), sockeye salmon, steelhead, coastal cutthroat trout, kokanee (*O. nerka*), Dolly Varden (*Salvelinus malma*), redside shiner, three-spined stickleback and white sturgeon (*Acipenser transmontanus*) – Habitat Wizard 2009. We did not conduct habitat descriptions for Latimer Creek, as it is located beyond the study area boundaries.

7.5.3 Leoran Brook

The headwaters of Leoran brook, which occurs in the central northern portion of the property, is the final fish-bearing system located inside the study area boundaries. The existence of coastal cutthroat trout was confirmed in drainages located in the study area during fish sampling exercises carried out by Phoenix Environmental Services Ltd. in 2007. Observations of salmonid fish were made by Madrone in late July 2009 while carrying out the fish habitat/riparian assessments, further confirming the presence of fish in this system. The observations were of resident trout (likely coastal cutthroat trout). The fish were located in pool habitat units immediately upstream of the Highway 1 crossing and in the roadside ditch paralleling the northern side of 96th Avenue.

Fish habitat is spatially limited in the Leoran brook drainages, given the constrictions imposed by Highway 1 and 96th Avenue, which includes associated culverts and resultant restrictions to natural fish movement. Between 96th Avenue and Highway 1, a short section of riffle-pool habitat exists, which is inhabited by resident trout. The deep pool created at the outlet of the first culvert under 96th Avenue also provides confirmed habitat for resident fish. Substrate in the short reach between 96th Avenue and Highway 1 will provide potential spawning opportunities for resident fish (Photo 4).

Photo 4. Looking south (upstream) along the reclassified Class A Leoran brook drainage located between 96th Avenue and Highway 1. First culvert underneath 96th Avenue can be seen in the centre of the photograph. Resident salmonids (likely cutthroat trout) were observed in the pool immediately downstream of the culvert outlet.

The first culvert underneath 96th Avenue upstream of Highway 1 on the Leoran brook drainage appears to be too steep to allow the upstream movement of fish (Photo 5). It should be noted; however, that the habitat located on the southern side of 96th Avenue (upstream of the culvert inflow) is marginal, with a seasonal flow regime. Perennial flow occurs to the west of the first culvert outlet. Resident salmonids (likely coastal cutthroat trout) were observed below the second culvert crossing under 96th Avenue and in the ditched portion of the drainage parallel to the northern side of 96th Avenue.

Photo 5. Looking upstream (south) at the first culvert encountered on the reclassified Class A Leoran brook drainage located between 96th Avenue and Highway 1. This culvert drains Class B seasonal streams on the southern side of the road. The culvert is set at a steep angle, which will likely present a barrier to upstream fish movement. Note that the reclassified perennial Class A drainage continues to the west of the culvert outlet.

Upstream of the second culvert (Photo 6), which likely impedes upstream fish migration, habitat diversity increases where the Leoran brook drainage flows through private property on the southern side of 96th Avenue. The drainage is no longer ditched through this section, providing potential spawning habitat in riffle habitat units and cover/security habitat in pools (Photo 7). It is important that the second culvert crossing point allows the unimpeded movement of fish, as potential fish habitat continues upstream of the inlet. Potential fish habitat (albeit on a marginal basis) also exists throughout the remainder of the ditches to the east of 180th Street on both sides of 96th Avenue.

Photo 6. Outflow of second culvert under 96th Avenue on the reclassified Class A Leoran brook drainage. This culvert (at the very least) likely impedes upstream movement of fish and may limit access to potential fish habitat located on the southern side of 96th Avenue.

Photo 7. Looking downstream (southeast) along the reclassified Class A Leoran brook drainage at the point where it flows onto private property on the southern side of 96th Avenue. Note relatively diverse fish habitat attributes, including pools/undercut banks for cover, available spawning habitat and perennial flow.

7.6 Biological Function of Existing Riparian Vegetation

Despite the historical anthropogenic influences, the study area supports a relatively large area of green space in comparison to areas to the north of Highway 1. While existing riparian vegetation is limited in extent and function, site potential is high. Riparian vegetation adjacent to the majority of drainages is represented by relatively dense shrub coverage and narrow early seral-stage stands of deciduous trees. More detailed descriptions were made of riparian vegetation adjacent to the more significant fish habitat systems in the study area (namely the Serpentine River and the Leoran brook drainages).

Where it flows through the study area, the Serpentine River is generally bounded by open, grassy fields with a limited extent of treed riparian vegetation. Riparian vegetation (i.e. within 30 m of the river's edge) consists largely of a narrow strip (5 m-10 m) of deciduous-dominated tree coverage, with young red alder and black cottonwood dominating. The tree layer generally does not exceed 20 m in height. The shrub layer is generally dense in the immediate riparian zone (5 m-10 m from the river's edge), with Indian plum, willow, salmonberry (*Rubus spectabilis*) and Himalayan blackberry (*Rubus discolor*) the most common species (Photo 8).

Photo 8. Looking southwest from Bothwell Drive towards the riparian zone adjacent to the Serpentine River. Indicates the typically narrow treed riparian vegetation adjacent to open fields. Note the considerable site potential for developing an improved riparian area.

Regarding biological function of riparian vegetation on the Serpentine River, existing overhanging vegetation is providing litter fall and insect drop over the adjacent fluvial habitat, providing food for fish and nutrient inputs to the system. Temperature regulation of the water (including provision of shade in the summer and insulation during winter) is limited, based on the dominant deciduous component (lack of insulation during the winter months) and the minimal width of tree coverage. The narrow riparian treed area is providing bank stability, although the dominant deciduous component provides an inferior source of LWD in comparison with LWD from a coniferous source. LWD from red alder and black cottonwood (the dominant riparian species adjacent to the Serpentine River) tends to break down quickly in freshwater and does not create a lasting habitat feature.

Riparian vegetation adjacent to the Leoran brook drainages is also limited in extent and function. The ditched portion of the drainage adjacent to 96th Avenue has limited riparian vegetation, due to the function of the watercourse as a roadside ditch. The portion of the drainage between Highway 1 and 96th Avenue is well shaded with dense shrub vegetation, consisting mainly of red alder and willow. This vegetation is providing litter input and insect drop directly over fish habitat and shading during the summer months. The provision of insulating vegetation is limited in the winter months due to the deciduous nature of the riparian vegetation.

7.7 Recommendations

7.7.1 Candidate Areas for Habitat Restoration and Enhancement

Restoration and/or enhancement of fish habitat would be most beneficial in areas that are known to currently support fish, or in immediately adjacent areas with sufficient potential (e.g. adequate water availability). To attempt to restore or enhance the majority of any of the Class B and Class C drainages on site (non fish-bearing systems) would be expensive and likely prone to failure. Marginal habitat that currently supports fish can be improved in several locations, which would result in increased fish productivity. Figures 8 and 9 display the four candidate areas (labeled “A” to “D”) that were identified as having the most potential for habitat restoration and enhancement. In all cases, the habitat enhancement/restoration that is described represents suggested measures that would require detailed design prior to implementation.

7.7.2 Candidate Stream A

This drainage originates to the north of 94A Avenue as a non fish-bearing, Class B stream. Fish habitat attributes are limited upstream of 94A Avenue, with no real potential for fish to occur (hence the Class B classification). The head of the drainage is represented by a seasonally wet depression dominated by a dense cover of hardhack (*Spiraea douglasii*) in the hydro/gas right-of-way (ROW). Immediately downstream of the ROW, a poorly defined channel/swale identifies the drainage through an open lawn area (private property). Where the drainage exits the private property, it becomes more defined before entering a culvert under 94A Avenue. At the intake of the culvert, a freshwater crayfish (*Astacus fluviatilis*) was observed during the field assessment (Photo 9).

Photo 9. Freshwater crayfish observed at the inflow of the culvert draining "Stream A" underneath 94A Avenue.

Downstream of the road crossing, the drainage is classified as a Class A system. The drainage widens to approximately 2 m-3 m (bankfull width) and begins to exhibit improved (albeit marginal) fish habitat attributes. Pool habitat units contained juvenile coho salmon during the field assessment. Substrate is dominated by organic material, with limited alluvial deposits. Riparian vegetation consists of dense shrub cover, with Indian plum, red alder and hawthorn (*Crataegus* sp.) dominating.

Habitat diversity is generally lacking throughout the length of the system, but the direct connectivity to the Serpentine River and the perennial flow regime allow the drainage to support fish. The drainage parallels 168th Street for approximately 150 m before discharging into the Serpentine River. River (Photos 10-13).

Photo 10. Looking southwest over the poorly defined swale portion of "Stream A" (highlighted) where it flows through private property. This area could potentially be enhanced to provide viable fish habitat.

Photo 11. Looking upstream (north) along the Class B drainage ("Stream A") at the point where it flows off the private property shown in Photo 9. Note perennial water flow, allowing for potential fish habitat enhancement opportunities (drainage is currently connected directly to confirmed fish habitat).

Photo 12. Looking downstream (south) along the Class A drainage ("Stream A") immediately downstream of the culvert under 94A Avenue. Note general lack of fish habitat attributes (lack of cover/security habitat, LWD and gravel for spawning).

Photo 13. Looking upstream (north) along "Stream A" immediately downstream of the culvert under 94A Avenue. Juvenile salmonids (likely coho salmon) were observed in pool habitat units (highlighted).

The primary function of the drainage as rearing/security habitat could be improved using habitat modifications and additions. The upper portion of the drainage (currently Class B) upstream of the culvert underneath 94A Avenue could be defined (widened and deepened), although this portion of the drainage currently flows through private property (lawn area) – Photo 10. Hydrophytic vegetation and surface water in this area suggest that a constructed channel/pool would fill with water and be recharged throughout the year, offering perennial habitat. Fish passage into this area would need to be assured, which would necessitate potential modifications to the culvert under 94A Avenue. In particular, the conveyance of juvenile fish (including upstream and downstream movement) would be necessary, as the habitat would most likely be used as rearing habitat by juvenile salmonids. Year-round connectivity by surface flow to the Serpentine River would be important, to allow fish to naturally move between summer and winter rearing areas (*i.e.* to prevent potential stranding/isolation of fish during the summer). Detailed designs would be required to determine the exact amount of available water and recharge rates.

The constructed channel/pool would need to be complexed with security habitat, which would involve the placement of lengths of coniferous LWD and coniferous root wads. Riparian planting would also be required around the edges of the constructed wetted area to create a functioning riparian zone.

To improve on existing, known fish habitat throughout the remainder of the drainage downstream of 94A Avenue, LWD (currently lacking) could be added to the system. The addition of both root wads and lengths of coniferous LWD would increase cover/security habitat for rearing juvenile salmonids. LWD would also increase bank stability. Strategically placed LWD would also favour the development of pool habitat units by increasing scour downstream of the LWD structure. The biological function of the riparian zone could be enhanced by introducing a coniferous vegetation component, which would help accelerate the transition of the existing young seral vegetation to a more advanced seral stage.

7.7.3 Candidate Stream B

This perennial Class A stream enters the southwestern corner of the study area via a culvert underneath 168th Street. The drainage is extremely straight, as it likely functions as a field drain or ditch. The drainage flows east and connects directly to the Serpentine River. Concentrations of juvenile salmonids (appeared to be coho salmon) were observed in the scour pool immediately downstream of the culvert outflow.

Existing fish habitat lacks diversity, given the lack of natural sinuosity and cover/security habitat (e.g. deeper pools and LWD). Functioning riparian vegetation is minimal in terms of vertical and lateral extent and is dominated by young red alder and black cottonwood (Photos 14-15).

Photo 14. Looking upstream (west) towards the culvert draining "Stream B" under 168th Street. Juvenile salmonids were observed in the pool habitat unit shown.

Photo 15. Looking east (downstream) along "Stream B" from a point immediately downstream of the culvert under 168th Street. Note sparse treed riparian zone on the north side of the drainage. The red alder and black cottonwood treed zone on the southern side is more complete, but narrow (approximately 5 m-10 m wide).

To increase the productivity of this drainage, habitat complexity would need to be improved. At the very least, the strategic placement of coniferous LWD would help to encourage the development of pools and natural sinuosity over the long term. The addition of LWD would also improve security habitat for rearing fish over the short term. Large scale excavations could be undertaken to expedite the development of habitat complexity such as pools and meanders.

The construction of connecting side channels would also increase the diversity and overall area of available habitat. Side channels would likely be a viable option, given the perennial availability of water. Side channels would need to be complexed with LWD to increase the value of the constructed habitat. Planting riparian vegetation around the edges of the constructed channels would also be required to create functioning riparian habitat. The introduction of appropriate coniferous species and increasing the existing (minimal) width of riparian vegetation are also viable habitat improvement options for this drainage.

7.7.4 Candidate Stream C

This system represents the headwaters of Leoran Brook, which is a Class A drainage that flows from south to north on the northern side of Highway 1. Refer back to Photos 4-7 for a visual representation of the drainage.

The first culvert underneath 96th Avenue south of Highway 1 is likely a barrier to the upstream movement of fish, as it is set at a steep angle. Replacing or modifying this culvert could potentially open up the Class B drainages on the southern side of 96A Avenue to fish. It is worth noting; however, that the Class B drainages currently have limited fish value and flow on a seasonal basis only. If the culvert were to be modified to allow fish passage, the precise value of the habitat gained upstream would need to be determined. In addition, it is possible that fish entering the seasonal Class B drainages could become stranded in unsuitable or drying habitat during the summer. The Class B drainages may need considerable habitat improvements to allow viable seasonal fish use.

The second culvert underneath 96th Avenue connects perennial, known fish habitat (salmonids) downstream of the culvert outflow with perennial habitat on the southern side of the road. The drainage on the southern side of 96th Avenue contains habitat attributes suitable for fish, including perennial flow, pool habitat units for cover and riffles containing adequate spawning substrate.

Fish presence (coastal cutthroat trout) was confirmed in this section of the drainage during sampling procedures carried out by Phoenix Environmental Services Ltd. (Phoenix 2007). Fish (salmonid) presence was also confirmed downstream of the second culvert under 96th Avenue during field assessments by Madrone (2009).

It is important to ensure that the second culvert allows passage for fish, as it connects year-round confirmed fish habitat on both sides of 96th Avenue. Preventing or constraining access through the culvert would reduce the potential exploitation of the higher quality habitat located on private property on the southern side of 96th Avenue. If the culvert is found to limit fish access, it should be modified to allow the increased use of suitable fish habitat.

The known fish habitat between Highway 1 and 96th Avenue could be improved with the strategic placement of LWD (*i.e.* in pool habitat units to increase habitat diversity). Enhancement of the riparian vegetation would also be beneficial, using a mix of appropriate tree species. Similar enhancement could also be applied to the natural drainage on the southern side of 96th Avenue (located on private property).

Upstream of the third culvert under 96th Avenue and in a short section downstream of the first culvert, the drainage essentially functions as a roadside ditch. Fish presence has been confirmed in the ditch paralleling the northern side of 96th Avenue downstream of the first culvert (Madrone 2009) and in the ditch above the third culvert on the southern side of the road up to 180th Street (Phoenix 2007).

Habitat enhancements are limited within the ditched portion of the drainage, as alterations may interfere with the function of the ditch to carry run off from the road. Introducing riparian vegetation to increase cover, shading, litter fall and insect drop would be beneficial along the ditch lines, although introducing vegetation along the road edge may interfere with the road right of way and introduce safety concerns.

Due to the proximity of the road and the potential for contaminants to enter the ditch from the road, it would be beneficial to install catch basins to treat road surface run off. Oil and grease separators would help reduce the potential contamination of adjacent fish habitat.

7.7.5 Candidate Stream D

This drainage is currently mapped as a Class B drainage and it flows as an open roadside ditch along the eastern edge of 180th Street. It connects to the western edge of the reclassified Class A ditch line paralleling the southern side of 96th Avenue (described above). The ditch is entirely straight and does not currently provide viable fish habitat. The ditch exhibits a perennial flow regime and could conceivably be used by fish if habitat conditions were improved (Photo 16).

Photo 16. Looking upstream (south) along "Stream D" where it parallels the northern section of 180th Street. The intersection of 180th Street and Golden Ears Way can be seen in the background. Note general lack of fish habitat attributes in the ditch line. Given the perennial flow regime and connectivity to known fish habitat, the drainage has the potential for enhancement. Relatively wide zone between the ditch and the road base allows potential for riparian planting.

Habitat complexity would need to be added to "Stream D" to allow it to provide viable habitat for fish. The ditch flows through a relatively wide area and is set back from the road, which means it could potentially be enhanced without interfering with the road right of way. Deepening the ditch and creating pool habitat units complexed with LWD would allow for potential fish use. Any enhancement operations would need to take into account the potential risk of flooding of the road due to habitat modifications. Riparian vegetation would also need to be added, as the watercourse is currently very exposed with no overhanging vegetation.

Treatment of water from the adjacent road surface using catch basins and oil/grease separators would also be a viable option (if not already in place).

The source of fish that could potentially use this ditch is from the Leoran brook headwater drainages. Prior to any enhancement on the ditch line, fish passage needs to be assured upstream of the 2nd culvert underneath 96th Avenue (described above) and along the ditch paralleling the southern side of 96th Avenue. It is likely that if the ditch was enhanced, it would be used on a seasonal basis (during the winter), when higher flows allow passage of fish along the shallow ditch line on the southern side of 96th Avenue. It would be important to ensure that fish had unrestricted access throughout the connected system to prevent stranding of fish in unsuitable habitat (e.g. warm water with low dissolved oxygen) during the summer months.

7.8 General Opportunities for Fish Habitat Improvements

It is likely that habitat enhancement opportunities occur throughout areas of existing fish habitat (e.g. the mainstem Serpentine River). Instream modifications would lead to increased habitat diversity and an associated increase in fish productivity. Instream habitat enhancement projects that would be of benefit include (but are not limited to): log bank cover construction, rock/log weir construction, strategic instream boulder placement, gravel catchment/placement, installing wing/flow deflectors, LWD placement and off channel habitat development.

Riparian planting (including planting to increase bank stabilization) would be a habitat improvement option adjacent to existing fish habitat. For example, where it flows through the study area, the Serpentine River is currently associated with a riparian zone that offers limited biological function, largely due to the narrow treed riparian strip. The existing green space adjacent to the treed riparian zone of the Serpentine River results in the potential for improvement and the establishment of a wider functioning riparian zone.

7.9 Updates to the Existing City of Surrey Stream Classification Map

The existing City of Surrey stream mapping represents a relatively accurate portrayal of the drainage network throughout the study area. During the field assessment, stream locations were field checked where feasible. Figures 8 and 9 display the updates that were made to the current City of Surrey stream classification map.

The combination of salmonid observations and habitat assessments (including habitat connectivity) made by Madrone and the capture of coastal cutthroat trout by Phoenix Environmental Services Ltd. (2007) resulted in the updated classification of drainages located in the Leoran brook area. The currently mapped Class B drainage running parallel to the southern side of 96th Avenue and the section between 96th Avenue and Highway 1 should be reclassified as a Class A system. Due to potential seasonal (winter) use by salmonid fish, a section of ditch downstream of the intersection of 180th Street and 96th Avenue on the north side of 96th Avenue should be reclassified as an "AO" drainage.

A currently unclassified drainage near the southern end of Bothwell Drive should be reclassified as a Class C drainage. This drainage will supply food/nutrients to the Serpentine River, but any inputs will be minimal. It was not classified as a Class B system, due to the fact that the lower section is hard to define and connectivity with the Serpentine River likely only occurs during high flow events. The upper section is easily defined, with portions of alluvial deposits (Photos 17-18).

Photo 17. Looking upstream (northeast) along the reclassified Class C drainage near the southern end of Bothwell Drive. Hydrophytic vegetation defines the ditch line through the easily defined upper section.

Photo 18. Looking downstream (southwest) along the lower section of the Class C drainage near the southern end of Bothwell Drive. The drainage becomes difficult to define in this location and connectivity with the Serpentine River was difficult to identify. The dense grass is reed canarygrass.

A currently unclassified ditch flowing along the eastern side of Highway 15 near the southern study area boundary should be reclassified as a Class C drainage. Although the drainage is functioning as a roadside ditch, it connects with a larger (potentially fish-bearing) system beyond the southern property boundary. It does not represent a significant source or transportation medium of food or nutrients.

The Class B drainage originating at the western end of 94th Avenue is shown in an incorrect location on the current City of Surrey stream map. The stream was followed using a hand held GPS unit to more accurately portray its location. It should be noted that the lower section of this drainage immediately to the south of Golden Ears Way was difficult to follow, based on the fact that it spreads out into a low gradient area with dense hardhack coverage. This area likely ponds water during the winter months and there is no real defined channel through the low gradient area (Photo 19). Water from the ponded area drains underneath Golden Ears Way by means of a culvert.

Photo 19. Looking southwest from Golden Ears Way towards the lower section of the remapped Class B drainage originating from the western end of 94th Avenue. Note dense hardhack coverage, low gradient and resultant lack of a defined channel.

Part of the Class B drainage on the southern side of Golden Ears Way to the west of 180th Street was also remapped (as per Figures 8 and 9). Alterations to this drainage in the form of culverts and re-alignments likely occurred when the new roadway (Golden Ears Way) was installed.

7.10 Riparian Setbacks

Under the existing City of Surrey bylaws, the degree of protection afforded to drainages is dependent on stream classification and the density of proposed development. The maximum 30 m buffers are indicated in Figures 8 and 9, due to the fact that current development densities are unknown. For the most part, the City of Surrey methodology for the protection of riparian areas is sufficient.

It is reasonable to assume; however, that if the density of development adjacent to more significant fish habitat (e.g. the Serpentine River) is less than 6 units per hectare, that the river would receive a riparian setback of 15 metres, as per current City of Surrey bylaws. Due to the sensitivity of the habitat and the considerable site potential for the development of riparian habitat, the setback should be no less than 30 m for the Serpentine River regardless of the proposed density of development.

7.11 Stormwater Management

The majority of the study area consists of green space and, therefore, permeable substrate. Development activities tend to increase the surface area of impermeable coverings, such as concrete driveways, roads and roof tops. Any developments in the study area will likely lead to an increase in stormwater run off, which will increase the frequency and intensity of short duration high flow events in the drainage network. Natural infiltration of water will also be reduced, which will likely reduce the retention period of water within drainages (*i.e.* summer time low flows will be exacerbated). An increase in winter extreme flows and summer time low flows will negatively impact the morphology of the watercourses and will also impact negatively upon fish and fish habitat. Prior to any development plan being developed for the study area, a detailed stormwater management strategy should be developed.

When development densities are determined in the future, setbacks will range from 15 m to 30 m adjacent to Class A, AO and B streams. The provincial Riparian Areas Regulation (RAR) methodology could potentially be used by individual developers as a means of further delineating the riparian setback area after the default 15 m or 30 m setback has been applied.

For the most part, the application of the Land Development Guidelines will adequately protect the integrity and biological function of riparian areas. For larger, more significant drainages such as the Serpentine River; however, a 30 m setback would be more appropriate, regardless of the proposed density of development.

7.12 Conclusions and Recommendations

Regarding habitat enhancement, it would be more beneficial to concentrate on existing known fish-bearing watercourses which currently contain marginal habitat. Trying to enhance or create habitat in the majority of Class B or C streams would likely be very expensive and prone to failure.

Four main areas were identified for fish habitat enhancement; two are located in the Serpentine watershed and two are located in the headwaters of Leoran Brook (Figures 8 and 9). The identified areas either contain salmonids and exhibit a perennial flow regime, or are connected directly to salmonid habitat and exhibit a perennial flow regime.

Recommended habitat enhancement in the identified areas would involve culvert replacements and/or modification and increasing habitat diversity through Large Woody Debris (LWD) placement, increasing channel sinuosity and riparian planting. In addition to the four focused enhancement areas, broad-scale riparian planting would be beneficial adjacent to the more significant drainages, such as the Serpentine River. Riparian vegetation is currently limited in extent and biological function throughout the study area given the historical anthropogenic impacts.

Minor changes were made to the existing City of Surrey watercourse classification map during the field assessment. Two unclassified drainage ditches were upgraded to "Class C" drainages, due to direct connectivity to larger, fish bearing systems. The majority of the Leoran Brook headwater streams were upgraded from "Class B" drainages to either "Class A" or "AO" drainages, based on direct observations of salmonids during the field assessments and available habitat attributes. Modifications to the drainage network adjacent to the newly installed "Golden Ears Way" were also made, due to inaccurately mapped drainage locations (Figures 8 and 9).

A significant portion of any development proposal should be the proper design and implementation of a stormwater management plan. Stormwater management should ensure that the quality of stormwater is maintained or improved and that there is no net increase in stormwater flow. An appropriately qualified professional must be employed to help design and implement a long-term strategy for stormwater management. Fish and fish habitat could be negatively impacted by an increase in stormwater if not properly managed.

8.0 WILDLIFE ASSESSMENT

8.1 Introduction

The main objective of this assessment was to identify suitable habitat in the study area for species-at -risk, as defined under the federal Species-at-Risk Act, and provincially designated red or blue-listed species.

Other species of importance, such as Bald Eagles, black bear and deer are included to address additional habitat requirements like nest trees, or large areas of contiguous habitat. The wildlife assessment identifies environmentally sensitive areas and key habitat features, such as wildlife trees, travel corridors (game trails), and burrows.

The assessment recognizes the importance of incorporating urban wildlife values into the Neighbourhood Concept Plan at the early planning stages. Recommendations are based on current best management practices (BMPs) and are made for the retention of important wildlife areas, or hubs, that will serve as reserves of natural habitat among a landscape of development.

Wildlife travel corridors are also recommended to serve as safe travel routes for large and small wildlife in and beyond the Anniedale-Tynehead NCP Area. Travel corridors are fundamental to sustain wildlife populations in the hubs and are necessary to protect linkages between populations to ensure dispersal routes and the continued mixing of genetic material amongst them.

Species-at-risk and their associated habitats are protected from harm by the federal Species-at-Risk Act and the provincial Wildlife Act. Species-at-risk and their habitat potentially occur within the study area and therefore their life history requirements must be considered. It is important to determine the potential for, and needs of, species-at-risk and other urban wildlife in early planning stages to mitigate the inherent pressure of development and to protect the future viability of biodiversity in Anniedale-Tynehead NCP Area.

The Anniedale-Tynehead NCP Area is in the Coastal Western Hemlock (CWH) zone. Before European colonization the area was presumably covered by mature forests of Douglas-fir, western redcedar, western hemlock. Theses forests began to be modified by Europeans in the nineteenth century. Relatively low human density in the area has permitted remnant patches of forest habitat to re-establish, in addition, agricultural use of the land appears to be in decline and many former fields are changing to meadow-like habitats. As such, the potential for urban wildlife to occur throughout and beyond the boundaries of the study area is highly likely.

8.2 Habitat Assessment

8.2.1 Methods

Prior to fieldwork, a list of significant focal species that potentially occur in and near the study area was determined based on the location of the site and current red and blue listed species tracking lists from the Conservation Data Centre of BC and the priority species list of the South Coast Conservation Program (SCCP). Table 8 presents a list of significant focal species. For background on the provincial and federal species listing requirements and BC Wildlife Act Section 34, see Appendix II.

Table 8. Selected Focal Species and Status

Common Name	Scientific Name	Provincial Status	Federal Status
MAMMALS			
Pacific Water Shrew	Sorex bendirii	Red	Endangered (April 2006)
Snowshoe Hare *washingtonii*	Lepus americanus washingtonii	Red	Not listed
Trowbridge Shrew	Sorex trowbridgii	Red	Not listed
BATS			
Townsends Big Eared Bat	Corynorhinus townsendii	Blue	Not listed
Keen's Long Eared Myotis	Myotis keenii	Unknown	Data Deficient ((Nov 2003)
AMPHIBIANS & SNAILS			
Red-legged Frog	Rana aurora	Blue	Special Concern (Nov 2004)
Oregon Forestsnail	Allogona townsendiana	Red	Endangered (Nov 2002)
Pacific Sideband	Monadenia fidelis	Blue	Not Listed
BIRDS			
Band -Tailed Pigeon	Patagioenas fasciata	Blue	Status pending
Great Blue Heron *fannini*	Ardea herodias fannini	Blue	Special Concern (May 1997)
Western Screech-owl *kennicottii*	Megascops kennicottii kennicottii	Blue	Special Concern (May 2002)
Barn Owl	Tyto alba	Blue	Special Concern (Nov 2001)
Barn Swallow	Hirundo rustica	Blue	Not Listed

This list represents wildlife species which are identified as being at risk or that have specific habitat requirements, and that have the potential for occurring in the area. Appendix III outlines life history and habitat requirements for the focal species in Table 8.

In addition to the focal species listed in Table 8, habitat suitability for three regionally significant species was conducted as well as a general survey for wildlife trees. These species are black-tailed deer, Bald Eagle, and black bear.

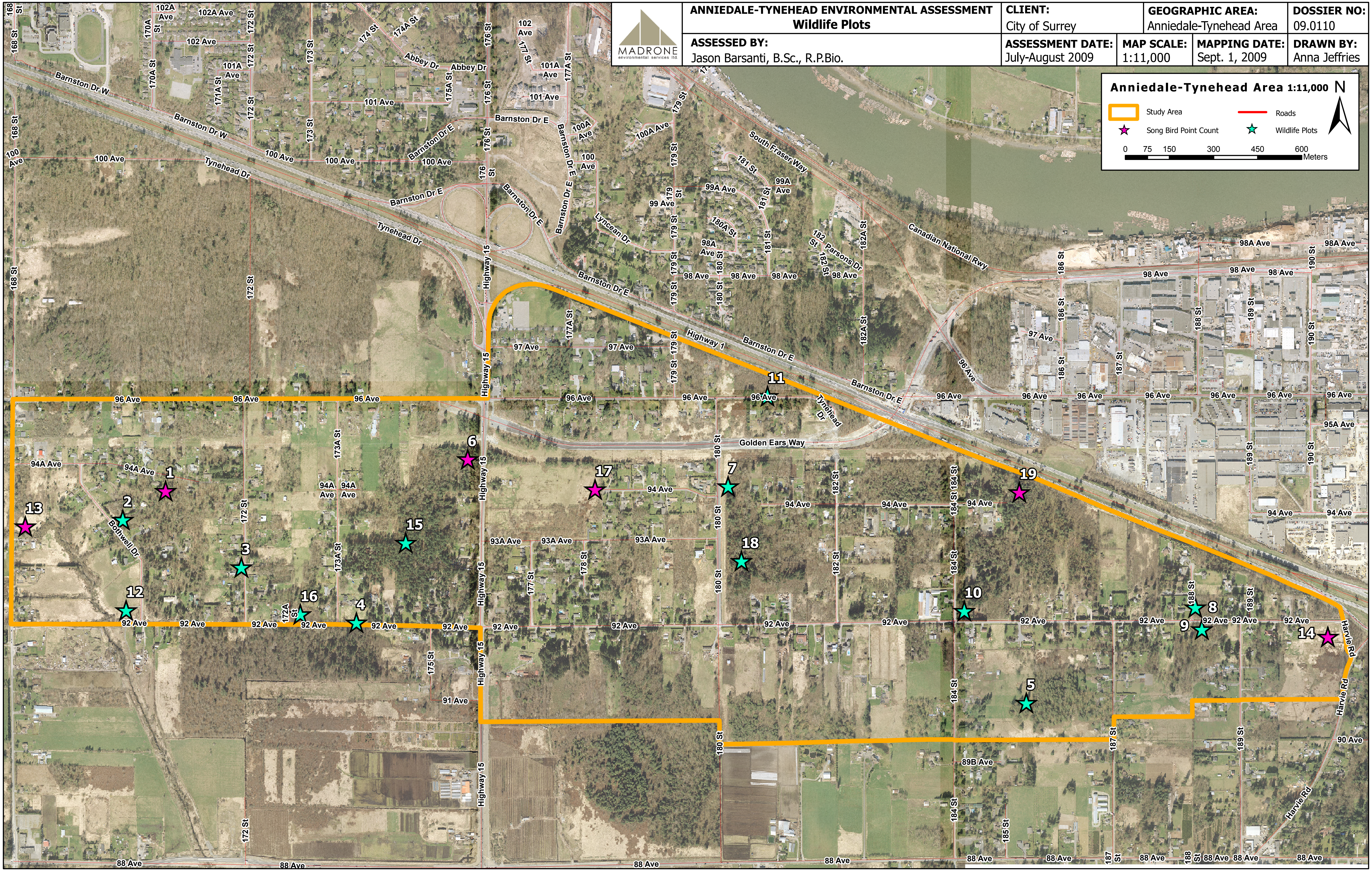
8.2.2 Fieldwork

We conducted fieldwork in July and August 2009. Survey plot locations were selected with the aid of air photo analysis and based on forest patch size and connectivity. At each survey plot, photos were taken to document representative habitat as well as notes describing wildlife observations.

At each plot, we ranked habitat suitability for each of the significant species. We assessed habitat for each focal species and ranked it on a scale from 1 – 4 for species with little available information on habitat requirements, or from 1 – 6 for species whose habitat requirements are well-known and studied. A score of 1 represents no potential for the species to occur and a score of 4 or 6 representing a very high potential for the species to occur.

8.3 Results

Detailed habitat suitability summaries for each of the focal species listed can be found in Appendix VI. Figure 10 illustrates the plot locations that were assessed. We also conducted an informal assessment of the habitat suitability forested patches straddling the boundary of the study area.


MADRONE environmental services ltd.
ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Wildlife Plots
CLIENT:
City of Surrey
GEOGRAPHIC AREA:
Anniedale-Tynehead Area
DOSSIER NO:
09.0110
ASSESSED BY:
Jason Barsanti, B.Sc., R.P.Bio.
ASSESSMENT DATE:
July-August 2009
MAP SCALE:
1:11,000
MAPPING DATE:
Sept. 1, 2009
DRAWN BY:
Anna Jeffries
Anniedale-Tynehead Area 1:11,000
N
Study Area
Roads
Song Bird Point Count
Wildlife Plots
0 75 150 300 450 600 Meters

8.4 Focal Species Habitat Suitability Assessment

8.4.1 Birds and Owls

8.4.1.1 Western Screech-owl *kennicotii* subspecies

The potential for the Western Screech-owl to occur within the study area is rated moderate mainly due to the presence of some large diameter trees (>50 cm) with large cavities along with the sighting of Pileated Woodpecker (*Dryocopus pileatus*) and its abandoned cavities. Suitable trees were observed in polygons rated moderately high or high for vegetation value and are rated moderate for nesting potential.

8.4.1.2 Barn Owl

Overall potential for barn owls to occur in the study area is moderate to high. Non-breeding habitat includes open country associated with agricultural areas, riparian woods, and edges of mixed woodlands (Campbell *et al.* 1990). Breeding most often occurs in association with agricultural areas in man-made structures though nests are occasionally found in tree cavities. (Campbell *et al.* 1990). A resident on 184th Street in the study informed us that he has knowledge of Barn Owls present on and around his property.

8.4.1.3 Great Blue Heron *fannini* subspecies

Potential for Great Blue Herons to occur in the study area is low for nesting but high for foraging. Great Blue Herons are often observed foraging in flooded agricultural fields and occasionally in wet ditches. We observed no heron rookeries observed; however, there are abundant foraging opportunities available throughout the study area and a significant number of maturing black cottonwood trees available for perching.

8.4.1.4 Band-tailed Pigeon

When non-breeding, Band-tailed Pigeons are found in farmland and near railway yards where they feed on grain spillage and in open areas bordered by trees suitable for roosting (Campbell *et al.* 1990). They are also found in open mixed deciduous/coniferous forests with abundant berry-producing shrubs.

Breeding occurs in openings in mature forests of all kinds, city parks, open shrubs, and golf courses (Campbell *et al.* 1990). Most nests are found in coniferous trees but about a quarter are found in deciduous trees (Campbell *et al.* 1990). Potential for this species to occur is moderate throughout the study area in which there are abundant salmonberry, huckleberry shrubs, Himalayan blackberry thickets and nearby berry farms.

8.4.1.5 Barn Swallow

The Barn Swallow utilizes open field habitats, typically near water and would be found nesting in barns, or other buildings and under bridges and is known to reuse the same nesting area in successive years (AOU 1983, Turner and Rose 1989).

Barn Swallows were observed foraging in numerous open fields throughout the study area as habitat suitability is high.

8.4.2 Small Mammals and Bats

A number of small mammals are known or expected to reside within the Anniedale-Tynehead NCP Area. Some of these are sensitive to habitat loss and have very specific habitat requirements.

8.4.2.1 Pacific Water Shrew

The Pacific water shrew is a riparian dependent species. No specimen has been recorded more than 350 m from a watercourse and virtually every other recorded capture of Pacific water shrew has been within 50 m (BC CDC, 2008). The study area is in the core of the Pacific water shrew range in BC which stretches from Squamish to Chilliwack. The CDC tracking list states an adult Pacific water shrew was collected in Fraser Heights from a forested slough – storm sewer outflow in a residential neighbourhood[3].

We did not observe any shrews in our fieldwork; however, given the presence of numerous watercourses and riparian areas within the study area, along with evidence from recent collections, virtually every watercourse could be considered suitable habitat for the Pacific water shrew. This is significant due to the extreme rarity of this species, Habitat suitability on the watercourses in the study varies from low to high.

8.4.2.2 Bats: Keen's Long-eared Myotis and Townsend's Big-eared Bat

Cavity nests are used by many small mammal species including bats like Keen's Long-eared Myotis and Townsend's Big-eared Bat, both of which are on our focal species list.

Keen's long-eared myotis is generally associated with mature forests and relies on tree cavities, loose bark, rock crevices, and small caves for roosting sites.

[3] BC MoE. Species and Ecosystems Explorer. Generalized Locations - Sorex bendirii (Pacific Water Shrew). Accessed on August 13, 2009. >http://a100.gov.bc.ca/pub/eswp/eoMap.do?id=14200<

Little is known about the ecological requirements for Townsend's big-eared bat in BC but habitat criteria of Keen's long-eared myotis are commonly used for assessing its potential occurrence. Suitable wildlife trees were found in a few plots and no rock faces or caves were observed. The potential for the focal bat species to roost in the study area is generally low but potential foraging opportunities exist in the forest patches and fields.

8.4.2.3 Snowshoe Hare *washingtonii* subspecies

The snowshoe hare is found in coniferous and mixed forests with dense understorey vegetation, generally on low mountain slopes (Cannings *et al.* 1999) and occasionally occupying burrows associated with mountain beaver (*Aplodontia rufa*). The study area has minimal suitable habitat; burrows were rarely observed but were likely occupied by eastern cottontail (*Sylvilagus floridanus*) and mountain beaver is not present in Anniedale-Tynehead NCP Area. Overall the potential for snowshoe hare to occur in the study area is low.

8.4.2.4 Trowbridge's Shrew

Trowbridge's shrew is known from captures around the study area. It occupies forest habitat with significant ground litter on the fringe of riparian areas and these habitat qualities were observed in several polygons, therefore habitat suitability is ranked as moderate.

8.4.3 Amphibians and Snails

Amphibians, such as the blue-listed red-legged frog, require wetlands ponds, streams or lakes for the reproductive stage of their lifecycle. Snails also generally require rich, moist forests as they are at greater risk from desiccation in drier environments.

8.4.3.1 Red-legged Frog

Red-legged frogs prefer moist forest habitats, generally with standing water, and when adults will migrate long distances from breeding waterbodies to upland areas. They prefer cool, moist environments with abundant coarse woody debris.

Breeding habitat for the red-legged frog was located throughout the study area. In addition, highly suitable habitat exists in an extensive marsh-forest habitat patch on and south of the study area boundary at the junction of 173rd A Avenue and 92nd Avenue (Plots 4 and 17).

Three frogs were observed during the assessment (two in Plot 17 and 1 in Plot 1), one of which was captured and identified as a red-legged frog.

8.4.3.2 Oregon Forestsnail and Pacific Sideband

The Oregon Forestsnail is found in mixed-wood and deciduous forests, typically dominated by bigleaf maple. A dense cover of low herbaceous vegetation is usually present (COSEWIC 2002). This snail is most often found in areas with rich soils and extensive coarse woody debris and cool shade (Proulx *et al.* 2003). A strong habitat indicator is the presence of moist, rich soils, bigleaf maple and stinging nettle.

The range of Oregon Forestsnail is currently known to end just east of the Anniedale-Tynehead NCP Area; however, the rarity of this species and the paucity of knowledge of its distribution make a compelling reason to be cautious in assuming it does not occur. Although areas with stinging nettle and bigleaf maple were observed in several plots, the extent of this association is limited in the study area; and was generally in a degraded condition. The potential for this species to occur is low.

We assume, based on the limited amount of literature available for this species that the Pacific sideband occupies a similar habitat types as the Oregon forestsnail; however, the association with bigleaf maple and stinging nettle is not a habitat indicator and therefore habitat suitability in the study area is considered moderate.

8.4.4 Other Important Wildlife Species Habitat Suitability Assessment

8.4.4.1 Bald Eagle

There are many mature black cottonwood trees and large snags within the study area. These trees make ideal nest and/or perch trees for Bald Eagles and so the potential for Bald Eagle to occur within the study area is moderate to high. Though no eagle nests were observed within the study area, several eagle nests are present in the surrounding area and Surrey in general has a number of successful nests.

8.4.4.2 Raptors

Within the study area there are an abundance of forest edge ecosystems and agricultural fields, both old field and in production. In addition a BC Hydro/gas right-of-way (ROW) transects the north perimeter of the study area. These habitat conditions provide many perching and excellent foraging sites for raptors. Raptors were often seen soaring overhead.

Red-tail hawks were observed (by sight and sound) near Plot 14 though no raptor nests were observed in the study area.

8.4.4.3 Song Birds

The varied habitat throughout Anniedale-Tynehead NCP Area indicates there is likely a high diversity of bird species in the area. The study area is a composite of active and fallow farm fields interspersed with regenerating stands of mixed forest and riparian areas which provide a great diversity of nesting, foraging, and roosting habitats

A songbird point-count survey was conducted on July 25th, 2009. Six point-count stations were assessed in three distinct habitat types, including: forested, field and riparian. A total of 26 species of songbird were observed in the point-counts, in addition there were several incidental species observed outside of the point-count surveys. The complete list of species observations is listed in Appendix VII. We believe the actual species richness in Anniedale-Tynehead NCP Area to be much greater over the course of the breeding bird season. The breeding bird season extends from April 1 to July 31 and the number of species encountered may have been higher at the peak of the breeding bird season.

8.4.4.4 Bear

There is a moderate to high potential for black bear to occur within the study area. Bears are likely to follow fall salmon migrations into urban riparian areas to feed on salmon; and bears will often wander through rural areas connected to more suitable habitat. A recent Vancouver Sun[4] report stated a black bear was removed from an urban neighbourhood approximately 6 km northwest of the study area.

8.4.4.5 Deer

There is a high potential for deer to occur within the study area. Deer commonly bed down in tall grasses of agricultural fields and seek cover in forested areas. Both habitat types are common throughout the study area and signs of deer (game trails and browse) were observed in numerous plots.

8.4.5 Wildlife Trees

Dead and dying trees (snags) provide habitat for cavity nesting birds, small mammals and bats.

[4] Vancouver Sun. Rebecca Tebrake, August 26, 2009: Black bear removed from Surrey neighbourhood.

After they have fallen, the coarse woody debris provides security cover, travel pathways, and dens for small mammals in addition to recycling nutrients in the forest ecosystem. The most important tree species for cavity nesters are western redcedar, Douglas-fir and black cottonwood (Fenger *et. al*. 2006).

These species are important for their size and, in the case of Douglas-fir and redcedar, their longevity of their presence on the forest floor. Other important species are bigleaf maple, paper birch and red alder, but these decay much faster and persist a shorter time.

The forested patches in the study area are predominantly mixed woods but with a greater proportion of deciduous species. Many of the deciduous stands consist of alder, birch, maple and cherry in a mature to declining stage. Wildlife trees were observed in the mature forest patches where there is an abundance of snags in various stages of decomposition and thus conditions are generally favourable for cavity nesters. Survey plots in mature forest have visible evidence of standing snags, cavity nests, woodpecker foraging activity and plentiful coarse woody debris. Forest patches showing this type of evidence of wildlife activity are highly valued resources for biodiversity. The forested patches in the study area are highly suitable habitat for birds, small mammals and bats. Wildlife trees are a significant factor in the valuation of ecosystem health for wildlife.

8.5 Discussion

8.5.1 Wildlife Hubs and Corridors

A historical perspective is useful when considering the value of conservation areas. The Anniedale-Tynehead NCP Area represents a landscape that has, overtime, undergone a complete conversion from an intact coastal forest ecosystem to one that is a mixture of fragmented forest patches and old field habitat. Wildlife[5] that originally occupied the Fraser Lowlands had virtually no impediments to migration and dispersal (except of course the channels of the Fraser).

Today, in the Anniedale-Tynehead NCP Area, gradually maturing second-growth forest patches are distributed amongst lightly developed and old-field habitats. The current situation imposes relatively simple impediments to the dispersal opportunities for wildlife populations.

[5] In this section wildlife refers to wildlife and plants.

Unrestrained development that does not take into account wildlife refuges and corridors, will result in fragmented islands of solitary populations with heavily impacted dispersal opportunities and genetic isolation (MOE 2006, Bond 2003). Fragmentation may have a deleterious effect, particularly on species with limited mobility, such as amphibians and small mammals, (less so for highly mobile species such as birds.)

Delineation of wildlife corridors will mitigate the effects of fragmentation not just for focal species, or species-at-risk, but for the whole wildlife community in general.

8.5.2 Corridor Design

Wildlife corridors should be thought of as a transportation network for species in the fast lane and for species in the slow lane (McKenzie 1995). Medium to large mammals, such as deer, coyotes and skunks will use corridors to move directly between distinct refuge forest patches, such as the wildlife hubs. Other small mammals, invertebrates and amphibians could take generations to pass from one area to another; in essence occupation of the corridor is a kind of reproductive daisy-chain of genetic mixing (McKenzie 1995). The result; however, is an interwoven fabric, or a habitat matrix on the landscape where distinct meta-populations[6] have sustained genetic viability over the long term through protected dispersal and reproductive opportunities.

Ultimately, corridor size and placement are decisions for planners and politicians; however, the ecology underlying wildlife corridors must be taken into consideration so as to not nullify their utility. A corridor must at least provide the basic needs of wildlife, including: food, water and cover while accounting for potential impediments to survival, such as: invasive plants and animals, domestic animals, traffic, noise and human encroachment (Bond 2003).

A narrow corridor provides a basic travel pathway, useful for bold and versatile species; however, a narrow corridor is typically entirely edge habitat. Edge habitat has numerous drawbacks including: increased edge-specialist predation, greater impact of invasive plants in conservation areas and greater potential of human encroachment, and little to no benefit for species adapted to interior or 'core' habitat. A wide corridor maintains habitat viability for edge-specialist predators while providing most of the life requisites of core dwellers.

[6] A **metapopulation** consists of a group of spatially separated populations of the same species which interact at some level.

The Ecosystem Management Study (EMS) identified hubs, sites and corridors, as mentioned earlier. Corridors emanate out of the large Tynehead Regional Park to the north and northwest of the study area.

One of the best opportunities for corridor establishment is in the western portion of the study area. One of the key conservation priorities is likely to be the wooded complex of Polygons 43 and 45, east of 15th Avenue and north of 92nd Street. This area corresponds to Hub 14 (Serpentine Heights East) in the EMS. It is only 200 m from Tynehead East. Across 92nd Street to the south lies another hub (#15: Serpentine heights), which we identified as a poorly-drained swamp, represented a long-ago abandoned field. We show this potential corridor on Figure 11. Note that there is no existing protection for Hub 15; being on ALR land, it may be cleared for agriculture at any time.

A second potential corridor is along the extreme western side; following the Serpentine River, which traverses the study area in the southwest corner. Although largely disturbed, there is great potential for returning part of this area into a productive riparian ecosystem.

Several valuable ecosystems are presents in the eastern portion of the study area as well, although the lack of large natural areas outside the boundaries reduces the potential for regional corridors. The large wooded complex formed by Polygons 98 and 124, corresponding to Hub 17 (Anniedale-Tynehead North) although not ideal in composition (young broadleaf forest interspersed with shrub vegetation), the large area (11.8 ha in these two polygons) renders it of value. Several other wooded polygons are distributed throughout the area, but unfortunately the corridor potential is limited. A large industrial area lies to the north.

A polygon of high value (71) lies in the centre of the study area; it contains maturing mixed conifer forest and approximately corresponds to Hub 16 (Anniedale-Tynehead Northwest). It is partly surrounded by polygon 142 pole-stage mixed forest of moderate value.

Straddling the south boundary is Hub 15 (Serpentine Heights), which lies mostly outside the study area. There is a stand of maturing conifers south of the boundary; within the study area lies Polygons 61 and 63 consisting of mixed forest of structural stage 4 and 5 with some shrubby areas interspersed. Again the natural area south of the boundary is primarily (or completely) on ALR land and may be subject to conversion to field crops.

8.5.3 Wildlife Corridor Implementation

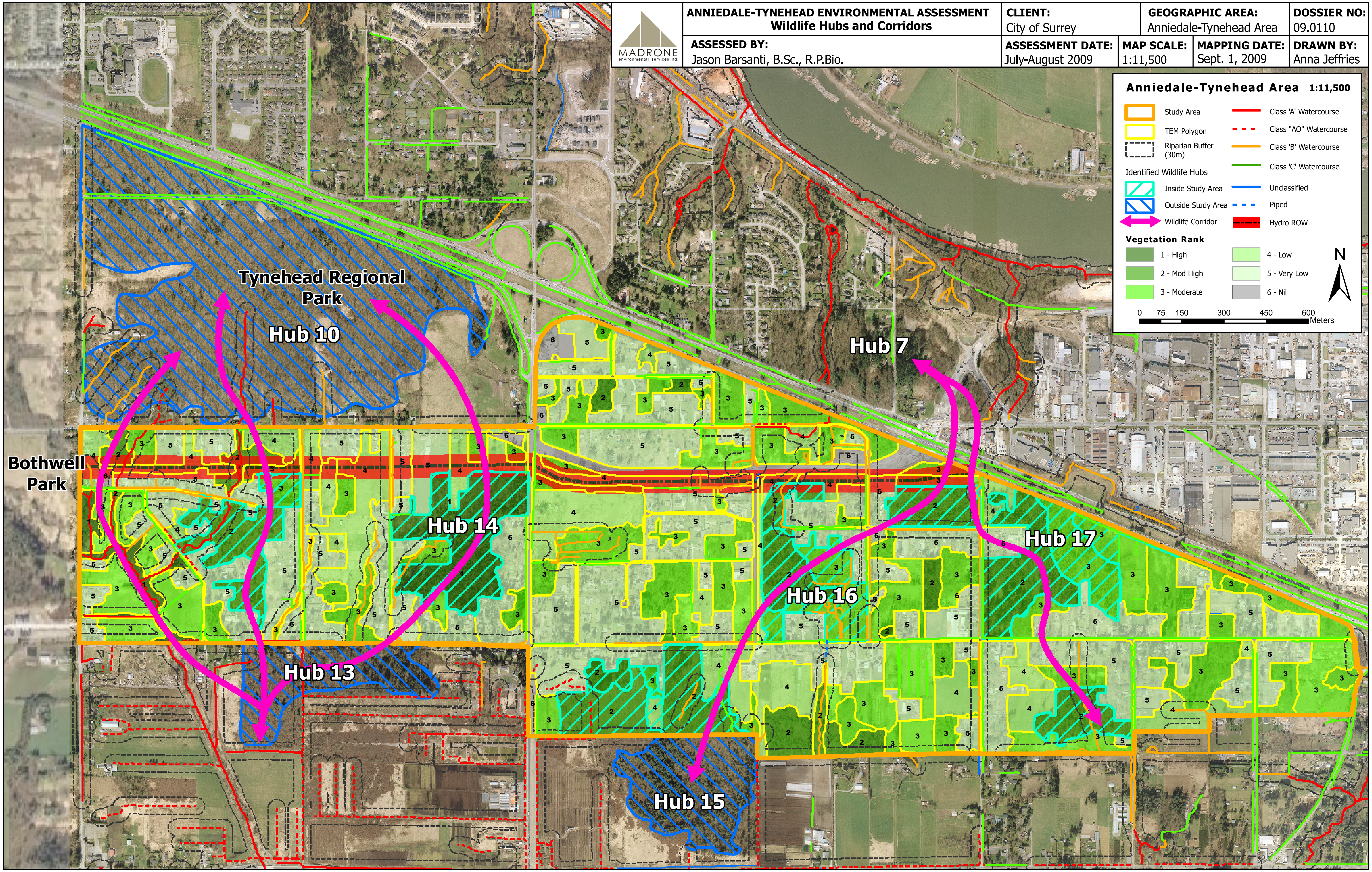
In urban settings capitalizing on existing legislation, such as laws protecting riparian areas, is useful for determining placement of corridors.

Riparian setbacks are a good tool for developing wildlife corridors in the study area as there is an extensive network of watercourses; however, more planning tools will have to be utilized to create a truly viable wildlife corridor network because wildlife hubs are not adequately connected by watercourses, and riparian setbacks on some watercourses can be as little as 10 m.

Bond (2003) suggests wildlife corridors should be as wide as possible. Ways to achieve this are to have conservation easements, or buffers, on development which occur adjacent to wildlife corridors and to enact strict lighting restrictions near corridors. Much wildlife activity occurs between dusk and dawn and increased lighting in wildlife reserve areas could impact safety and concealment of prey species. More suggestions from Bond include requiring only native vegetation in conservation easement buffer zones adjacent to corridors, and a landowner education program to help relieve the problem of invasive plants and domestic pets on natural wildlife habitat.

8.5.4 Recommendations for Wildlife Hubs and Corridors

Recommendations for wildlife hubs and corridors are built on the results of wildlife habitat suitability ratings in conjunction with the results from the vegetation and ecosystem ratings in this report. Figure 11 illustrates our recommendations for best potential wildlife hubs and travel corridors. This can be thought of, in effect, as a “fine filter” approach to habitat conservation. That is, if the life history needs of the focal species in this study are conserved then habitat will likely be available to a wide range of generalist species.


MADRONE environmental services ltd.
ANNIEDALE-TYNEHEAD ENVIRONMENTAL ASSESSMENT
Wildlife Hubs and Corridors
CLIENT: City of Surrey
GEOGRAPHIC AREA: Anniedale-Tynehead Area
DOSSIER NO: 09.0110
ASSESSED BY: Jason Barsanti, B.Sc., R.P.Bio.
ASSESSMENT DATE: July-August 2009
MAP SCALE: 1:11,500
MAPPING DATE: Sept. 1, 2009
DRAWN BY: Anna Jeffries
Anniedale-Tynehead Area 1:11,500
Study Area
TEM Polygon
Riparian Buffer (30m)
Class 'A' Watercourse
Class "AO" Watercourse
Class 'B' Watercourse
Class 'C' Watercourse
Identified Wildlife Hubs
Inside Study Area
Outside Study Area
Wildlife Corridor
Unclassified
Piped
Hydro ROW
Vegetation Rank
1 - High
2 - Mod High
3 - Moderate
4 - Low
5 - Very Low
6 - Nil
N
0 75 150 300 450 600 Meters
Tynehead Regional Park
Hub 10
Bothwell Park
Hub 7
Hub 14
Hub 17
Hub 16
Hub 13
Hub 15

A number of factors were used in selecting these areas. For instance, higher habitat suitability corresponds with higher vegetation value. A comprehensive system for rating vegetation polygons is described in the Vegetation and Ecosystems Resources section, the valuation system includes critical habitat for significant wildlife, forest patch size as well as riparian areas.

Critical wildlife values are integrated into high value vegetation polygons in three ways: the largest forest patches and forest patches with best habitat complexity received a higher ranking value. Patches with a water or riparian feature also have an increased value.

Rare ecosystems are discussed in the Vegetation and Ecosystems Resources section of this report. We note that some forested ecosystems occurring in the study area are considered rare in B.C.; therefore, retaining the largest patches of forest will not only conserve a bank of rare ecosystems, but also, retain the most valuable habitat for rare species. Wildlife hubs essentially co-occur with the largest patches of high vegetation value; however, any polygon with a moderately-high or high rank should be considered sensitive wildlife habitat.

The analysis for locating wildlife travel corridors was, by necessity, based solely on biological and ecosystem factors. Consideration of existing property ownership was purposefully ignored to avoid bias. The layout of wildlife corridors was made to provide the best linkage between high value ecosystem polygons.

Further, our analysis would be incomplete if we failed to consider high value habitat areas outside the study area. These are clearly important for delineating wildlife corridors. These include: Tynehead Park to the north, Bothwell Park to the west, Latimer Creek to the east, a large forest patch east of 176th Street and north of 88th Avenue and the forest patch south of 192nd Avenue in the area of 172nd Street and 173 A Street.

Riparian areas are discussed in the fisheries section of this report and recommendations are made for streamside setbacks in the 15 m to 30 m range. These are the parameters set by DFO and will have a net benefit as a travel corridor to most riparian dependent species; however, 30 m is below the recommendations for the Pacific water shrew. At least 50 m is the suggested setback for the Pacific water shrew. A 50 m setback is an ideal corridor width and while it may seem impractical at the site level, it should be a target in certain areas during planning at the community level.

The hydro/gas right-of-way (ROW) to the north of the study area is an excellent east-west corridor and Surrey should work with the owners to enhance the vegetation management on the ROW to manage for shrub and grassland ecosystem suitability.

Barriers to wildlife movement exist in several places. Highway 15 (176^{th} Street) essentially bisects the study area into two distinct zones. Wildlife underpasses were not included in its recent upgrade and this presents a barrier to virtually all species except for larger mammals.

This also applies to the new Golden Ears Parkway which essentially cuts off the triangle of land on the north perimeter of the study area.

Deer are common throughout north Surrey and migratory routes should be considered when planning future wildlife corridors. In establishing wildlife corridors, deer should be managed so as to maintain seasonal movement throughout North Surrey.

Bald Eagles, their eggs, and nests, whether occupied or not, are protected in British Columbia.

The black bear is a large charismatic mammal and human-bear encounters can be a potential risk. Wildlife trees provide shelter and rearing places for birds and mammals and are a significant factor in the valuation of ecosystem health for wildlife.

A detailed wildlife assessment on a site by site basis should be required prior to development approval.

Finally, though it is out of the study area, we are compelled to mention the forest patch south of 192^{nd} Avenue in the area of 172^{nd} Street and 173^{rd} A Street This patch represents a very significant wetland ecosystem that likely serves as a population source for many amphibian and riparian dependent species. This forest patch should be integrated into a landscape level conservation plan and be retained. The low volume of traffic on 192^{nd} Street permits excellent wildlife travel movement.

8.6 Recommendations for Development Planning

The rural nature of the study area will permit planners to utilize zoning regulations, conservation easements and covenants to provide for wildlife corridors amongst future development.

The following is a brief summary of important best management practices that should be integrated into development planning process when it is still at the community, or neighbourhood, planning stage. Enshrining long-range habitat protection measures is a necessary backstop for threatened species habitat protection and recovery. The following summary of better management practices pertinent to the study area is drawn from MoE's *Develop With Care* series and the guidelines should be considered at all stages of the land development process.

8.6.1 Pacific Water Shrew

The Pacific water shrew is a riparian habitat specialist that hunts in aquatic areas. It specializes in habitat near slow-moving water, and near swamps, marshes and wetlands either permanent or ephemeral, where it can pursue prey under water. The species is extremely rare and, due to the extent that its natural habitat has been compromised by development and conversion, it is now found in places generally considered to be of low habitat suitability. For that reason, current best management practices recommend testing for Pacific water shrew only in habitats of low habitat suitability and assuming it is present in areas of moderate to high habitat suitability.

The majority of occurrences most recently recorded were found within 60 m of a watercourse but dispersing individuals have been found over 1 km from a water feature. Existing fisheries legislation is beneficial for protecting travel corridors; however, retaining a 100 m buffer on riparian areas where moderate to high habitat suitability occurs (and adjacent low suitability) is an important way to protect Pacific water shrew home ranges. The greater buffer area is important for the Pacific water shrew because the forest strip on the outer edge of the buffer is necessary to protect the vital micro-climate conditions in the interior riparian zone and, protecting the connecting low suitability habitat will contribute to recovery strategies as that habitat matures into higher suitability habitat over time.

8.6.2 Raptors and Owls

Habitat requirements of raptors are quite variable depending on the species. There are a number of positive habitat elements for raptors in the study area and it is a better management practice to retain these.

Fortunately, most raptors and owls are generally tolerant of human development and with foresight and sensitive planning; their needs can be integrated into a community plan. Farm structures are utilized by Barn Owls for nesting, (and also by Barn Swallows); hedge rows and hydro/gas utility corridors are excellent foraging grounds for Red-Tail Hawks. The Western Screech-Owl requires snags and dying trees of large diameter in which to start a nest site, and interior habitat is preferred.

The Western Screech-Owl will benefit most from retaining large forested patches with access to riparian hunting grounds. Other species will benefit from the retention of old field habitat for foraging areas, (this also provides territory to small mammals).

Old field habitat could be left as riparian buffer strips. Standing dead and dying trees should be retained, preferably in patches for future nest locations and suitable woodpecker foraging grounds. In general, the greater the diversity of habitat, the greater the diversity of species that will use it.

8.6.3 Amphibians

Amphibians require a wet environment for at least one part of their lifecycle. Every wetland, stream and pond, whether it is seasonal or permanent, is important habitat for amphibians. Wetlands and wet areas provide the breeding and rearing grounds for amphibians as well as innumerable invertebrates that form the foundation of the 'web of life'. Wet areas should be protected from development and conversion. They should be buffered from human encroachment and treated as especially sensitive ecosystems.

There is very little legislative protection for wet areas that are unconnected to streams by surface flow; however, with proper planning wet areas can easily be protected and integrated into a community plan.

Many amphibians, the blue-listed red-legged frog, for example, disperse into upland terrestrial habitat in the adult stage. Protecting connectivity to upland habitats is vital to ensuring habitat is available for all life stages of amphibians.

8.7 Conclusion

Through our assessment, we have determined that there are many opportunities in the study area to plan for and preserve connectivity between the wildlife hubs. The relatively low impact of human development in the area is advantageous for reserving wildlife travel corridors in future development plans.

In the current arrangement – forested patches amongst agriculture and low density residential development – several viable routes exist and it is highly likely they are already being used by local wildlife.

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APPENDIX I

Vegetation and Ecosystem Mapcodes and Structural Stage Descriptions

Appendix I. Vegetation and Ecosystem Mapcodes and Structural Stage Descriptions

A. Vegetation and Ecosystem Mapcodes

Site Series	Map Code	Ecosystem Name	Assumed Situation	Assumed Modifiers	Typical Soil Moisture Regime	Structural Stage
01	HK	Western hemlock/Douglas-fir – Kindbergia	Gentle slope, deep, medium - textured soils.	d, j, m	submesic - mesic	3, 4, 5, 6
05	RS	Redcedar – swordfern	Gentle to significant slopes, moisture and nutrient receiving position, deep, medium - textured soils.	d, m	submesic - mesic	3, 4, 5, 6
07	RF	Redcedar – foamflower	Gentle slope, lower slope receiving position, deep medium - textured soil, richer nutrient regime.	d, j, m	subhygric - hygric	3, 4, 5
09	CD	Black cottonwood – red-osier-dogwood	Active floodplain, middle bench, deep medium - textured soil.	a, d, j, m	subhygric - hygric	3b
13	RB	Western redcedar – salmonberry	Strongly fluctuating water table, deep medium - textured mineral soil.	d, j, m	subhygric	3a, 3b, 4
	Ws50	Hardhack (pink spirea) - Sitka sedge	Swamp. These sites experience prolonged saturation and brief early season flooding and are common in basins, gullies, and margins of waterbodies and peatlands. Humisols and Gleysols are most common.		subhydric - hydric	3a
	OF	Old Field	A flat or gently rolling, non-forested, open area that is subject to past human agricultural practices. Old fields were differentiated from cultivated fields because of their more diverse vegetation structure.			2b, 3a
	CF	Cultivated Field	A flat or gently rolling, non-forested, open area that is subject to human agricultural practices (including plowing, fertilization and non-native crop production) which often result in long-term soil and vegetation changes.			2b

A. Vegetation and Ecosystem Mapcodes (continued)

Site Series	Map Code	Ecosystem Name	Assumed Situation	Assumed Modifiers	Typical Soil Moisture Regime	Structural Stage
	CO	Cultivated Orchard	An agricultural area composed of single or multiple tree species planted in rows. Pruning maintains low, bushy trees.			2b
	ES	Exposed Soil	Any area of exposed soil that is not included in any of the other definitions. It includes areas of recent disturbance, such as mud slides, debris torrents, avalanches, and human-made disturbances (e.g., pipeline rights-of-way) where vegetation cover is less than 5%.			1a
	IN	Industrial	An industrial area including mills and other industrial sites			not applicable
	OW	Shallow Open Water	A wetland composed of permanent shallow open water and lacking extensive emergent plant cover. The water is less than 2 m deep.			not applicable
	RZ	Road Surface	An area cleared and compacted for the purpose of transporting goods and services by vehicles.			not applicable
	RW	Rural	Any area in which residences and other human developments are scattered and intermingled with forest, range, farm land, and native vegetation or cultivated crops.			not applicable
	UR	Urban/ Suburban	An area in which residences and other human developments form an almost continuous covering of the landscape. These areas include cities and towns, subdivisions, commercial and industrial parks, and similar developments both inside and outside city limits.			not applicable

B. Structural Stage Description

Structural Stage	Description
1	**Sparse/Bryoid –** Initial stages of primary and secondary succession; bryophytes and lichens often dominant; time since disturbance < 20 years for normal forest succession, may be prolonged (50-100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover <20%; total tree cover <10%.
1a	**Sparse –** less than 10 % vegetation cover.
1b	**Bryoid –** bryophyte and lichen-dominated communities (>50% of total vegetation cover).
2	**Herb –** Early successional stage or herb communities maintained by environmental conditions or disturbance (e.g. snow fields, avalanche tracks, wetlands, flooding, grasslands, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree cover <10%, shrubs ≤20% or <33% of total disturbance <20 years for normal forest succession; many non-forested communities are perpetually maintained in this stage.
2a	**Forb-dominated –** includes non-graminoid herbs and ferns.
2b	**Graminoid-dominated –** includes grasses, sedges, reeds, and rushes.
2c	**Aquatic –** floating or submerged; does not include sedges growing in marshes with standing water (classed as 2b); or
2d	**Dwarf shrub-dominated –** dominated by dwarf woody species
3	**Shrub/herb –** Early successional stage or shrub communities maintained by environmental conditions or disturbance; dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree cover <10%, shrub cover >20% or ≥33% of total cover.
3a	**Low shrub –** dominated by shrubby vegetation <2 m tall; seedlings and advance regeneration may be abundant; time since disturbance <20 years for normal forest succession; may be perpetuated indefinitely by environmental conditions or disturbance.
3b	**Tall shrub –** dominated by shrubby vegetation that is 2 m-10 m tall; seedlings and advance regeneration may be abundant; time since disturbance <40 years for normal forest succession; may be perpetuated indefinitely.
4	**Pole sapling –** Trees >10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually >10-15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance < 40 years for normal forest succession; up to 100+ years for dense (5000-15000+ stems per ha) stagnant stands.
5	**Young forest –** Self-thinning has become evident and the forest canopy has begun to differentiate into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in Stage 4; begins as early as age 30 and extends to 50-80 years; time since disturbance generally 40-80 years, depending on tree species and ecological conditions.
6	**Mature forest –** Trees established after the last disturbance have matured; a second cycle of shad-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance generally 80-140 to 80-250 years.
7	**Old forest –** Old, structurally complex stands comprised mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition and patchy understories typical; understories may include tree species uncommon in the canopy because of inherent limitations in these species under the given conditions; time since disturbance generally >140-250 years.

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APPENDIX II

Legislative Background

Appendix II. Legislative Background

Prior to fieldwork, a list of species of interest was determined based on the location of the site, and current red and blue listed species tracking lists from the Conservation Data Centre of B.C. Red-listed species included Pacific Water Shrew (Sorex bendirii), Snowshoe Hare (Lepus americanus washingtonii), Trowbridge Shrew (Sorex trobridgii) and Keen's Long-Eared Myotis (Myotis keenii) and Oregon Forestsnail (Allogona townsendiana). Blue-listed species included Band-tailed Pigeon (Columba fasciata), Western Screech Owl (Megascops kennicottii), Townsend's Big-Eared Bat (Corynorhinus townsendii), and Red-legged Frog (Rana aurora), Pacific Sideband (Monadenia fidelis), Great Blue Heron (Ardea herodia fannini), Barn Owl (Tyto alba) and Barn Swallow (Hirundo rustica). Additional site assessments were made to determine if seasonal habitats within the study area were suitable for additional species of significance including Bald Eagle (Haliaeetus leucocephalus), and Black Bear (Ursus americanus).

Federal Ranking System

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the status of wild species in Canada. The application of ranking criteria by COSEWIC describes the relative condition of a particular species and gives some indication as to the likelihood of extinction. For example, a species that is "Endangered" faces imminent extirpation or extinction; a species that is "Threatened" is likely to become endangered if limiting factors are not reversed (Table 1). Species ranked as G1 are considered of greatest risk for global extinction, and are therefore of highest management priority.

Table 1. Federal Species at Risk Ranking and Definitions.

Rank	Description
X – Extinct	Species no longer exists.
XT - Extirpated	Species no longer exists in Canada, but it still occurs elsewhere.
E - Endangered	Species is facing imminent extirpation or extinction.
T - Threatened	Species is likely to become endangered if limiting factors are not reversed
SC - Special Concern	Species that are sensitive to human activities and natural events, but are not considered to be Endangered or Threatened.
DD - Data Deficient	Species with inadequate information to make direct / indirect assessment.
NAR - Not at Risk	Species that have been evaluated, but are considered not to be at risk.

Provincial Ranking System

Within BC, the Conservation Data Centre (CDC) is responsible for assigning provincial status of indigenous species. The CDC is a branch of the Ministry of Water, Land and Air Protection (MWLAP). The coding is by colour, with red indicating species at greatest risk (threatened and endangered species), and yellow indicating the lowest level of risk (Table 2).

Table 2. Provincial Ranking System and Definitions

Rank	Description
Yellow List	Indigenous species, subspecies and natural plant communities deemed not to currently be at risk in B.C.
Blue List	Indigenous species, subspecies and natural plant communities of Special Concern in B.C.
Red List	Indigenous species, subspecies and natural plant communities that are extirpated, endangered or threatened in B.C. These species either have, or are candidates for, official extirpated, endangered, or threatened status in B.C.

Section 34 of the *B.C. Wildlife Act* states:

- A person commits an offence if the person, except as provided by regulation, possesses, takes, injures, molests or destroys:

  (a) A bird or its egg,
  (b) The nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl, or the nest of a bird not referred to in paragraph (b) when the nest is occupied by a bird or its egg.

In this regard, "nest" is defined as “a structure, or part of a structure, prepared by or used by an animal of the class Aves to hold its eggs or offspring”.

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APPENDIX III

Mapcode Descriptions

Appendix III. Mapcode descriptions

Western hemlock/Douglas-fir – Oregon beaked moss

Mapcode HK: 01 site series

Western hemlock/Douglas-fir – beaked moss ecosystems represent the regional CWHxm climate. Typical site conditions for zonal HK forests are mid to upper slope positions and gentle topography. Soils are most often moderately-well to well drained and medium-textured loamy soils with less than 35% coarse fragments.

Zonal forests are dominated by Douglas-fir, in association with western hemlock. Forests are generally open with 30%-50% canopy closure; however, many stands contain big-leaf maple, red alder or cottonwood within mixed stands. Alder-dominated stands are common in the study area and have reached mature ages, some over 60 years.

The understory consists of salal, dull Oregon-grape, sword fern, and Oregon beaked moss. Less frequent species include oceanspray, red huckleberry, bracken fern, western hemlock, grand fir, step moss, and electrified cat's-tail moss.

Example of HK ecosystem

Western redcedar – swordfern

Mapcode RK: 05 site series

Western redcedar – Douglas-fir – Oregon beaked moss ecosystems have more available moisture than zonal sites (slightly dry to fresh), and are typically situated on lower gentle sloping (moisture receiving) sites. Soils are typically deep and often imperfectly to moderately-well drained. This unit is not common throughout the study area; however, it does occur in moisture receiving areas and near creek drainages.

Douglas-fir and western redcedar are typically the most abundant, but bigleaf maple, red alder and western hemlock can also occur in mixed stands. The shrub layer is dominated by salal and dull Oregon-grape, with trailing blackberry also occurring. Sword fern is dominant in the herb layer. Step moss and Oregon beaked moss are the major bryophytes (Madrone Environmental Services Ltd., 2008).

Example of RS ecosystem

Western redcedar – foamflower

Mapcode RF: 07 site series

Western redcedar – Grand fir - Foamflower ecosystems are found in similar terrain and slope positions to site series 05 (gentle lower slopes and moisture receiving sites), but soils tend to be deeper and richer, with a higher proportion of fines (e.g., loamy silt, silty clay loam).

Dominant tree species include western redcedar, Douglas-fir, bigleaf maple, red alder and grand fir. The canopy tends to have more complete closure and ingress of western redcedar, with few, shade-tolerant shrubs and herbs persisting in the understory – primarily sword fern, red huckleberry, salal and dull Oregon-grape. The RF unit is often found complexed with zonal (DS) forests and adjacent to creeks (Madrone Environmental Services Ltd., 2008).

Example of RF ecosystem

Black cottonwood – red-osier dogwood

Mapcode CD: 09 site series

These deciduous dominated floodplain ecosystems occupy medium bench active floodplains and are limited in occurrence to one polygon along the Serpentine River (Polygons 28). This shrub-dominated floodplain ecosystem is frequently inundated and supports species adapted to periodic flooding or high water tables.

This site series was recorded as occupying less than 1 hectare of the project area. The vegetation on mid bench floodplains are usually composed of black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), red alder, willows, red-osier dogwood and salmonberry. Herb species include piggy-back plant (*Tolmiea menziesii*), lady fern, and common horsetail (*Equisetum arvense*). It occurred adjacent to RF rich sites, RB fluctuating water tables and old fields.

Some non-native vegetation was observed at this site, including reed canary grass, policeman's helmet and Himalayan blackberry.

Example of CD ecosystem

Western redcedar - salmonberry

Mapcode RB: 13 site series

Western redcedar–salmonberry ecosystems occur around drainages or depressions that are imperfectly drained. These sites tend to be complexed with site series 07 and old fields, with the former in hollows and the latter adjacent to drainages.

Red alder dominates the open tree canopy with various co-dominants including western redcedar, western hemlock and black cottonwood. Dense thickets of salmonberry and tall willows were the dominant shrub component, with thimbleberry, red elderberry and red osier-dogwood (*Sambucus racemosa*). Herbs were variable, but few were apparent during the sampling period (largely in winter). Sword fern grew on hummocks and piggy-back plant, lady fern and Cooley's hedge-nettle were also common associates. Bryophytes were sparse to absent, except on decaying wood.

This ecosystem covers about 2% of the study area observed adjacent to the Serpentine River (Polygon 28) and scattered throughout old fields and adjacent to drainages.

Example of RB ecosystem along the Serpentine River

Mapcode Ws50: Hardhack-Sitka sedge swamp

Two hardhack-Sitka sedge swamp sites occur in the study in Polygon 129 and 167. The shrub layer is dominated by pink spirea with minor components of willows and red-osier dogwood. Sitka sedge may not always be present, depending on the density of spirea and amount of open water.

Example of Ws50 ecosystem

Mapcode OF: Old Field

Old fields usually contain more diverse herbaceous vegetation compared to cultivated fields. Old fields are dominated by reed canary grass, Himalayan blackberry, stinging nettle (*Urtica dioica*) and low shrub species. They contain various amounts of shrub and tree structure that likely support other ecological and wildlife features in the area, especially when they are located adjacent to forested ecosystems.

Example of old field (OF) mapcode

Mapcode CF: Cultivated Field

Example of cultivated field (CF) mapcode

Cultivated fields are non forested, open areas that are subject to agricultural practices including plowing, fertilization, and non native crop production which often result in long-term soil and vegetation changes. Cultivated fields are common throughout the study area. The typical structural stage for cultivated fields is 2b, graminoid-dominated.

Rural residential (RW) is also a very common association with cultivated fields. Although cultivated fields are typically agriculture based, CF was mapped for other green spaces as well. These included city parks, baseball fields, and residential lawns. This unit was often complexed with Rural (RW) units.

Mapcode CO: Cultivated Orchard

Agricultural areas are composed of single or multiple tree species planted in rows. Typically this would include, for example, apple orchards or mixed species orchards. Old homesteads are common in the study area and although many of them have become overgrown, these have been mapped as CO wherever possible. It also includes tree farms or any area where trees are planted in rows for commercial production. Cultivated orchard was mapped in Polygon 5.

Mapcode ES: Exposed Soil

Exposed soil is any area of exposed soil that is devoid of vegetation and is not bedrock but mineral soil. Exposed soil was only mapped once near an industrial area in the northeast portion of the study area and is associated with new developments or disturbance sites.

Mapcode IN: Industrial

Industrial sites were added as an anthropogenic unit due to the requirement to address sites that were dominated by industrial development namely, large commercial complexes. These units are characterized by a high degree of ground disturbance; concrete parking lots, large commercial buildings, work yards and other specialized industry infrastructure. IN was mapped in two polygons (87 and 90).

Mapcode OW: Open Water

Shallow open water is a wetland class composed of permanent, shallow (less than 2 m at midsummer levels), standing water that has less than 10% surface cover of emergent vegetation (plants rooted in the bottom). Open water with more than 10% surface cover of emergent vegetation is classified as marsh wetland. OW was mapped once (Polygon 66) representing a manmade pond used for irrigation.

Mapcode RW: Rural Residences

Example of rural (RW) mapcode

Rural areas are characterized by areas that have residences and other human development scattered and intermingled with forests, range, farm land, cultivated fields, lawns and native vegetation. Rural areas are very common in the study area and often form the dominant polygon component. Minor components include cultivated fields and zonal forests.

Mapcode RZ: Road Surface

Road surfaces are defined as areas cleared and compacted for the use of vehicles. Road surfaces are linear features that cross the landscape and occur in varying degrees. One large interconnected road polygon was mapped that includes small farm roads, two-lane residential paved roads, highways and main thoroughfares with a significant portion being two-lanes.

Mapcode UR: Urban/Suburban

Urban units are characterized by an almost continuous covering over the landscape by impervious development. UR was only mapped in three polygons (122, 159, and 162) for commercial buildings, two in the extreme north and in the extreme northwest portions of the study area.

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APPENDIX IV

Potential Rare Plants in the CWHxm subzone

Appendix IV. Potential Rare Plants in the CWHxm subzone

Scientific Name	English Name	Prov Rank	COSEWIC	BC Status	SARA
Anagallis minima	chaffweed	S3		Blue	
Carex interrupta	green-fruited sedge	S2		Red	
Carex scoparia	pointed broom sedge	S2S3		Blue	
Carex vulpinoidea	fox sedge	S2S3		Blue	
Claytonia washingtoniana	Washington springbeauty	S2		Red	
Eleocharis rostellata	beaked spike-rush	S2S3		Blue	
Epilobium ciliatum ssp. watsonii	purple-leaved willowherb	S2S3		Blue	
Epilobium leptocarpum	small-fruited willowherb	S2S3		Blue	
Fissidens pauperculus	poor pocket moss	S1	E (Nov 2001)	Red	1
Glyceria leptostachya	slender-spiked mannagrass	S2S3		Blue	
Helenium autumnale var. grandiflorum	mountain sneezeweed	S2S3		Blue	
Hypericum scouleri ssp. nortoniae	western St. John's-wort	S2S3		Blue	
Isoetes nuttallii	Nuttall's quillwort	S3		Blue	
Juncus oxymeris	pointed rush	S2S3		Blue	
Lindernia dubia var. anagallidea	false-pimpernel	S2S3		Blue	
Navarretia intertexta	needle-leaved navarretia	S2		Red	
Pleuropogon refractus	nodding semaphoregrass	S3		Blue	
Rubus nivalis	snow bramble	S3?		Blue	
Rupertia physodes	California-tea	S3		Blue	
Verbena hastata var. scabra	blue vervain	S2		Red	
Wolffia borealis	northern water-meal	S2		Red	

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APPENDIX V

Potential Rare Ecosystems in the CWHxm subzone

Appendix V. Potential Rare Ecosystems in the CWHxm subzone

Scientific Name	English Name	Prov Rank	BC Status	BGC	Ecosystem Group
Sidalcea hendersonii Tidal Marsh	Henderson's checker-mallow Tidal Marsh	S1	Red	CWHxm/00	Wetland, Estuarine, Herbaceous
Tsuga heterophylla - Pseudotsuga menziesii / Eurhynchium oreganum	western hemlock - Douglas-fir / Oregon beaked-moss	S2	Red	CWHxm/01	Forest
Pseudotsuga menziesii - Pinus contorta / Racomitrium canescens	Douglas-fir - lodgepole pine / grey rock-moss	S2	Red	CWHxm/02	Woodland, Forest
Pseudotsuga menziesii / Polystichum munitum	Douglas-fir / sword fern	S2	Red	CWHxm/04	Forest
Tsuga heterophylla - Thuja plicata / Blechnum spicant	western hemlock - western redcedar / deer fern	S2	Red	CWHxm/06	Forest
Thuja plicata / Tiarella trifoliata Very Dry Maritime	western redcedar / three-leaved foamflower Very Dry Maritime	S2	Red	CWHxm/07	Forest
Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	S2	Red	CWHxm/08	Riparian, Forest
Thuja plicata / Rubus spectabilis	western redcedar / salmonberry	S1S2	Red	CWHxm/13	Forest, Riparian
Thuja plicata / Lonicera involucrata	western redcedar / black twinberry	S2	Red	CWHxm/14	Forest
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	S2	Red	CWHxm/Wf52	Wetland, Shrub, Herbaceous
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	S2	Red	CWHxm/Wf53	Wetland, Herbaceous
Leymus mollis ssp. mollis - Lathyrus japonicus	dune wild rye - beach pea	S1S2	Red	CWHxm	Sparsely Vegetated, Herbaceous
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge	S2	Red	CWHxm/Wm51	Wetland, Herbaceous
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Dry Maritime	Douglas-fir - western hemlock / salal Dry Maritime	S2S3	Blue	CWHxm/03	Forest
Thuja plicata / Polystichum munitum Very Dry Maritime	western redcedar / sword fern Very Dry Maritime	S2S3	Blue	CWHxm/05	Forest
Populus balsamifera ssp. trichocarpa - Alnus rubra / Rubus spectabilis	black cottonwood - red alder / salmonberry	S3	Blue	CWHxm/09	Riparian, Forest

Scientific Name	English Name	Prov Rank	BC Status	BGC	Ecosystem Group
Populus balsamifera ssp. trichocarpa / Salix sitchensis	black cottonwood / Sitka willow	S2S3	Blue	CWHxm/10	Riparian, Forest
Pinus contorta / Sphagnum spp. Very Dry Maritime	lodgepole pine / peat-mosses Very Dry Maritime	S3	Blue	CWHxm/11	Forest, Wetland
Thuja plicata - Picea sitchensis / Lysichiton americanus	western redcedar - Sitka spruce / skunk cabbage	S3?	Blue	CWHxm/12	Wetland, Forest
Thuja plicata / Carex obnupta	western redcedar / slough sedge	S2S3	Blue	CWHxm/15	Wetland, Forest
Ledum groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador tea / western bog-laurel / peat-mosses	S3	Blue	CWHxm/Wb50	Wetland, Shrub
Typha latifolia Marsh	common cattail Marsh	S3	Blue	CWHxm/Wm05	Wetland, Herbaceous
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	S3	Blue	CWHxm1/Wm50	Wetland, Herbaceous

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APPENDIX VI

Species Habitat Suitability Summaries

Appendix VI. Species Habitat Suitability Summaries

MAMMALS

Pacific Water Shrew (Red-listed)

The Pacific Water Shrew depends upon large, structurally diverse riparian areas adjacent to permanent streams and lakes for all stages of its life cycle (Proulx et.al. 2003).

Snowshoe Hare (Red-listed)

The Snowshoe Hare is found in coniferous and mixed forests with dense understorey vegetation, generally on low mountain slopes (Cannings et al., 1999). They may rest during the day in Mountain Beaver burrows, and forage on berries, willow, grasses and green vegetation (Whitaker Jr., 1998). Approximately one quarter of the sites we surveys were ranked high for Snowshoe Hare potential.

Trowbridge's Shrew (Blue-listed)

This species lives in varied habitats throughout the Fraser Valley and Lower Mainland (Cannings *et al.* 1999). It prefers habitats with mature forests, loose soil, deep litter and abundant invertebrates (Cannings *et al.* 1999, Natureserve 2007).

Keen's Long-Eared Myotis bat (Red-listed)

Davis *et al.* (2000, *as cited in* Chatwin, 2004) indicated that caves >100 m in length and above 500 m elevation are known to be important winter hibernation sites for myotis bats. Rock faces and knolls with crevices that are solar or geothermally heated are important maternity roosts while tree cavities in wildlife trees and loose bark are important natural roost sites and may be limiting in some parts of their range. Insect-rich low elevation coastal forest and riparian areas are important foraging areas.

Townsend's Big-Eared Bat (Blue-listed)

The habitat requirements of Townsend's Big-Eared Bat essentially mirror those of Keen's Long-eared Myotis (BC MELP, 1998).

Black Bear (Yellow-listed)

Black bears den in or under large diameter trees, snags or stumps. Home ranges for adult males are usually 25 km^2 to 150 km^2 while females generally only occupy 5 km^2 to 25 km^2 (Blood 2001). Home ranges are composed of several feeding areas connected by travel routes. Home ranges are usually well forested area that provide cover for travel between feeding areas but feeding areas are varied and include; forests, wetlands, subalpine meadows and beaches (Blood 2001).

AMPHIBIANS AND SNAILS

Red-legged Frog (Blue-listed)

The life history of this species requires it have suitable heavily vegetated aquatic areas in which to breed, and to have the terrestrial component of its habitat dominated by tall shrubs, coarse woody debris and a relatively flat substrate (Maxcy, 2004).

Oregon Forestsnail (Red-listed)

The Oregon Forestsnail is found in mixed-wood and deciduous forests, typically dominated by bigleaf maple. A dense cover of low herbaceous vegetation is usually present (COSEWIC, 2002). This snail is most often found in areas with rich soils and extensive coarse woody debris and cool shade (Proulx et al., 2003).

Pacific Sideband (Blue Listed)

Deciduous, coniferous or mixed forests and open woods and grassy areas west of the Coast and Cascade mountains (Forsyth 2004).

BIRDS

Band-tailed Pigeon (Blue-listed)

In the US Pacific Northwest, this shy species is found primarily below 1,000 m in fir-hemlock-cedar-spruce stands (Keppie and Braun, 2000; Braun, 1994). Nesting occurs in virtually all habitat types. Areas that are rich in berry-producing shrubs and bud-producing deciduous trees serve as prime foraging areas.

Western Screech Owl (Blue-listed)

In the northern portion of its range, the Western Screech-Owl is generally found in lower elevation forested or treed environments, especially in riparian forests (Johnsgard, 1988). This species is a secondary cavity nester and is largely dependent on the excavations made by large woodpecker species.

Great Blue Heron (Blue-listed)

Nesting colonies are the critical habitat for this species. Mature forest needs to be close to foraging habitat (< 8 km away; most are within 3 km) (Proulx et.al. 2003).
Bald Eagle (Not listed)

Tall snags (>35 m) above the canopy may provide important winter roosting and may serve as perches throughout the year. The main requirement for nesting are large trees for nesting and perching adjacent to shallow aquatic habitats rich in fish or aquatic birds (Blood and Andweiler, 1994). Large trees (> 75 cm dbh) which protrude above the canopy are most important for nesting (Blood and Andweiler, 1994).

Barn Owl (Blue-listed)

Barn Owls generally nest and forage in agricultural areas (Fraser et al., 1999). Up to 85% of their prey is made up of Townsend's voles *(Microtus townsedii)*. The Fraser Valley represents the core of their breeding range in the Lower Mainland (Fraser et al., 1999).

Barn Swallow (Blue-listed)

This species generally forages over open fields (BNA 2008). Nesting habitat includes buildings with overhanging eaves or roofs within close proximity to a pond or lake with mud for nest building (BNA 2008).

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APPENDIX VII

Song Bird Point Count Survey Results

Appendix VII. Song Bird Point Count Survey Results

Plot	Alpha code	English Name	Latin Name	Assessment Plot Number	Habitat Type
1	RBNU BRCR CRCH WIMR AMRO	Red-breasted Nuthatch Brown Creeper Chestnut-backed Chickadee Winter Wren American Robin	Sitta canadensis Certhia americana Poecile rufescens Troglodytes troglodytes Turdus migratorius	Plot 1	Riparian Forest
2	NWCR SWTH CEWX WIFL EUST AMRO TRSW CEWX COYE WIFL BNSW	Northwestern Crow Swainson's Thrush Cedar Waxwing Willow Flycatcher European Starling American Robin Tree Swallow Cedar Waxwing Common Yellowthroat Willow Flycatcher Barn Swallow	Corvus caurinus Catharus ustulatus Bombycilla cedrorum Empidonax traillii Stumus vulgaris Turdus migratorius Tachycineta bicolor Bombycilla cedrorum Geothlypis trichas Empidonax traillii Hirundo rustica	Plot 13	Old- Field Riparian
3	BRCR NWCR AMRO NIWR BHGR CEWX STJA	Brown Creeper Northwestern Crow American Robin Winter Wren Blackheaded Grosbeak Cedar Waxwing Steller's Jay	Certhia americana Corvus caurinus Turdus migratorius Troglodytes troglodytes Pheucticus melanocephalus Bombycilla cedrorum Cyanocitta stelleri	Plot 6	Mature Forest
4	AMRO HOSP SWTH BRCR PSFL SPTO BRCR SOSP SPTO SPTO BCCH PISI WIWR AMRO	American Robin House Sparrow Swainson's Thrush Brown Creeper Pacific-slope Flycatcher Spotted Towhee Brown Creeper Song Sparrow Spotted Towhee Spotted Towhee Black-capped Chickadee Pine Siskin Winter Wren American Robin	Turdus migratorius Passer domesticus Catharus ustulatus Certhia americana Empidonas difficilis Pipilo maclatus Certhia americana Melospiza melodia Pipilo maclatus Pipilo maclatus Poecile atricapillus Spinus pinus Troglodytes troglodytes Turdus migratorius	Plot 17	Old Field
5	SOSP WIFL WIFL DEJU BNSW SPTO CBCH	Song Sparrow Willow Flycatcher Willow Flycatcher Dark-eyed Junco Barn Swallow Spotted Towhee Chestnut-backed Chickadee	Melospiza melodia Empidonax traillii Empidonax traillii Junco hyemalis Hirundo rustica Pipilo maclatus Poecile rufescens	Plot 14	Old Field

Plot	Alpha code	English Name	Latin Name	Assessment Plot Number	Habitat Type
6	BHGR BRCR SPTO WIWR AMRO CBCH CBCH WIWR PSFL CEWX NOFL	Blackheaded Grosbeak Brown Creeper Spotted Towhee Winter Wren American Robin Chestnut-backed Chickadee Chestnut-backed Chickadee Winter Wren Pacific-slope Flycatcher Cedar Waxwing Northern Flicker	Pheucticus melanocephalus Certhia americana Pipilo maclatus Troglodytes troglodytes Turdus migratorius Poecile rufescens Poecile rufescens Troglodytes troglodytes Empidonas difficilis Bombycilla cedrorum Colaptes auratus	Plot 19	Mature Forest

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APPENDIX VIII

Biogeoclimatic Zone

Appendix VIII. Biogeoclimatic Zone

BIOPHYSICAL SETTING

The BC Ecoregion Classification and the Biogeoclimatic Ecosystem Classification (BEC) systems offer a framework for describing the variation of vegetation, climate and topography in the study area. Ecoregions and biogeoclimatic zones represent the broad scale regional and climatic landscape units.

Ecoregion Classification

The Anniedale-Tynehead study area is situated in the City of Surrey within the Lower Mainland Ecoregion, which is divided into two Ecoprovinces. Anniedale-Tynehead is classified as occurring within the Georgia Depression Ecoprovince, which lies at the southern basin of the Coast Mountains. The southern parts of this Ecoprovince have the greatest annual amounts of sunshine in British Columbia. Temperatures throughout the area are modified by the ocean and the Strait of Georgia (Demarchi, 1996). Perhaps the most important factor affecting terrestrial ecology in this area is the summer moisture deficit, which arises from the relatively dry summers and moist, mild winters. Continuing down in the hierarchy, within this Ecoprovince, Anniedale-Tynehead Sound is contained in the Fraser Lowland (FRL) Ecosection (Demarchi, 1996). The Fraser Lowland consists of Fraser delta, estuary, lowlands, and associated uplands areas of low relief at the base of the Coast Ranges. The Fraser Lowland Ecosection is also classified into a series of biogeoclimatic zones.

Biogeoclimatic Ecosystem Classification

The Biogeoclimatic Ecosystem Classification (BEC) system is a framework that groups similar sets of landscapes into a site classification. Sites are classified on their potential to produce similar vegetation communities within similar environmental site conditions. Site series are representative ecosystems in each biogeoclimatic subzone in the Province. Site series are specific to a subzone and primarily correspond to forested ecosystems that repeat across each biogeoclimatic subzone. The typical site conditions, such as soil, terrain and climate combined with the interaction of vegetation, animals and insects make up the ecosystems / site series (Green & Klinka, 1994). Additional non-forested ecosystems, such as wetlands, are also based on the BEC system (Mackenzie & Moran, 2004).

The Anniedale-Tynehead study area is situated within the Coastal Western Hemlock (CWH) biogeoclimatic zone, which is subdivided into subzones and variants. Anniedale-Tynehead occupies one variant, called the Very Dry Maritime subzone variant (CWHxm1). The CWHxm1 (very dry maritime) subzone variant is located adjacent to the Coastal Douglas Fir (CDF) biogeoclimatic zone. The common tree species are Douglas-fir, western hemlock, and western redcedar; however, the location of the project, combined with the forest succession and disturbance factors, leads to a variety of vegetation and ecosystem types.

Elevation boundaries for the study area range from approximately 5 m to 55 m. The CWHxm1 variant is very common in southwestern BC, covering much of Vancouver Island and the mainland coast. The temperature and climate in the CWHxm1 is generally warm and dry in the summer months with moist, mild winters (Green & Klinka, 1994).