11.0 HYDROGEOLOGY OF WOODDALE ADA

11.1 General Description of Area

11.1.1 Location & Extent

The Wooddale ADA covers an area of approximately 4,620 hectares in north central Newfoundland, encompassing the community of Wooddale and located immediately north of the municipal limits of Bishop's Falls and approximately 8 km northeast of the community of Grand Falls. The boundary of the Wooddale ADA is shown on Drawing No. 1034406-11-1 in Appendix 11a.

The main access to the Wooddale ADA is provided by a secondary paved road, which starts at the Trans-Canada Highway (Route 1) approximately 5 km west of Bishops Falls and leads north to Wooddale and continues on to the New Bay Pond area. A network of graveled roads and ATV trails leading from this secondary road provide access to most areas within the ADA.

11.1.2 Physiography, Topography & Drainage

The Wooddale ADA is located within the physiographic region referred to as the Northeast Trough. This physiographic region is characterized by elevations ranging from sea level up to 150 m above sea level, except for local ridges, which rise up to 600 m above sea level. The Wooddale ADA is characterized by undulating to rolling terrain the trends northeast towards the coast, and has elevations ranging from 30 to 90 m above sea level. Maximum elevations of up to 570 m above sea level are present in the Hodges Hill area, located approximately 20 km west of the Wooddale ADA.

The Wooddale ADA encompasses a section of the upper course of the Peter's River system, which flows directly into the Bay of Exploits. The ADA is bordered to the north and south by small ridges that separate the Peter's River drainage system from adjacent river systems flowing northeast towards the Bay of Exploits, including the Northern Arm Brook drainage system, located approximately 6 km north of the site, and the much larger Exploits River drainage system located approximately 4 km south of the site. The headwaters of the Peter's River system are local and originate along a narrow ridge of high ground located approximately 7 km southwest of the ADA that separates surface drainage between Peter's River in the northeast and the Exploit's River in the southwest.

No Public Protected Water Supply Areas are present within the drainage catchment area of the Wooddale ADA.

11.1.3 Climate, Vegetation & Agricultural Land Use

The Wooddale ADA is located within the Central Newfoundland Ecoregion, which is the second largest ecoregion, covering approximately one-third of the central and northeastern portion of the island. The Wooddale ADA is located within the Northcentral Subregion, and is characterized by higher summer maximum temperatures, lower rainfall and higher fire frequency than anywhere else in Newfoundland. Climate data obtained from Environment Canada's Wooddale – Bishops Falls monitoring station dating back to 1971 was used to characterize climatic conditions in the ADA. The monthly mean temperature in the area is 4.3°C, ranging from a high of 17.1°C in July to a low of -8.3°C in February. Average

annual precipitation in the area is 1,068 mm, of which 75% falls as rainfall and 25% as snowfall. October is typically the wettest month, and April is typically the driest month (Environment Canada, 2008). In the ADA, there are an average of 1,379 growing degree days (base temperature 5^{o}C) for the year and 1,275 growing degree days for the vegetative season (i.e., May to September).

Vegetation in the vicinity of the Wooddale ADA consists of black spruce dominated forests and aspen stands broken by areas of domed bogs, and patches of sparsely forested heath covered barrens. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, approximately 553 hectares (i.e., 12% of the total landmass of the ADA) is currently utilized for agriculture, with forage, nursery, and vegetable crop land representing the most significant proportion of the ADA's agricultural land use.

11.2 Geology

11.2.1 Surficial Geology

The surficial geology of the Wooddale ADA is summarized in Drawing No. 1034406-11-2 in Appendix 11a, and is based on most recent 1:50,000 scale mapping of the area by Liverman and Taylor (2000a), as well as descriptions of surficial geology provided in Rickets (1987) and Liverman and Taylor (2000b). For the purposes of this study, surficial geological units on existing maps have been simplified into four (4) groups, including exposed bedrock, areas of bog, areas of till and areas of sand and gravel.

The central portion of the ADA is underlain by thick deposits of glacial outwash and fluvial sand and gravel that occur within the Peter's River valley as a relatively flat flood plain, with local areas of undulating raised terraces. The glaciofluvial deposits are locally eroded and dissected. A stony coarse textured glacial till derived predominantly from reddish sandstone with various amounts of granites, shale, slate and volcanic rocks borders the glaciofluvial sand and gravel deposits at higher elevations along the valley flanks and forms both thin discontinuous veneer (typically less than 2 m thick), and more extensive moraine deposits with local thicknesses up to 20 m. Along with glacial units, deposits of organic and peaty soils are common in the vicinity of ADA, overlying either till or bedrock. Local ridges and knobs of bedrock outcrop are exposed within the till and various other surficial deposits in the vicinity of the ADA, and typically occur as areas of high ground. Bedrock outcrops may be partially or fully concealed by thin mat vegetation and sparse forest. However, where exposed bedrock outcrops are commonly streamlined and display glacial striations that indicate northeastward directed flow. Available well logs indicate an average overburden thickness in the Wooddale ADA and surrounding area of approximately 10 m.

11.2.2 Bedrock & Structural Geology

The bedrock geology of the Wooddale ADA is summarized in Drawing No. 1034406-11-3 in Appendix 11a, and is based on the regional 1:250,000 scale compilation mapping by Colman-Sadd and Crisby-Whittle (2005), as well as a description of bedrock geology provided in Dickson (1999).

The Wooddale ADA lies within the Dunnage tectonostratigraphic zone and is underlain by early to late Silurian siliclastic sedimentary and volcanic rocks and Silurian intrusive rocks. The majority of the ADA is underlain by subaerial mafic and felsic volcanic and volcaniclastic rocks and shallow marine to subaerial sandstone, siltstone and conglomerate of the Botwood Group. In the northwestern portion of the ADA, the Botwood Group is in fault contact with the Charles Lake Sequence, which comprises

subaerial bimodal volcanic and volcaniclastic rocks, and minor sandstone and conglomerate. The Silurian Hodges Hill intrusive suite, comprising both gabbro and granite, intrudes both the Botwood Group and Charles Lake Sequence along the northern boundary of the ADA.

The Silurian volcanic and sedimentary rocks that underlie the ADA have undergone regional folding and faulting related to both Silurian Salinic and Devonian Acadian orogenies. Rocks in the area are generally folded into northeast-plunging open folds with steep limbs. Northeast-directed thrust faults and high angle faults with strike-slip offsets are also common, the most significant of which is the Northern Arm Fault, located along the northern boundary of the ADA, which separates the Botwood Group from the Hodges Hill Intrusive Suite and the Charles Lake sequence. In addition, various joint sets and fracture zones occur within rocks underlying the ADA related to deformation.

11.3 Hydrogeology

11.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the Wooddale ADA was assessed utilizing available records for water wells completed within each unit obtained from the NLDEC-Water Resources Management Division Drilled Water Well Database for wells drilled between 1950 and March, 2008. The data provided in the well records are organized by community and includes information on the well depth and yield, well casing depth and diameter, depths to water bearing zone(s), plus data on the quality and use of the water and the driller's description of the depth and lithology of the overburden and bedrock units encountered.

A total of 31 drilled bedrock wells and 2 drilled surficial wells from three (3) communities in the ADA and surrounding area had adequate well data to evaluate the groundwater potential of various surficial and bedrock strata in the ADA. Since lithologic information provided in the well records was of insufficient detail to define the bedrock encountered in each individual drilled well, the wells were assigned to their respective geologic units based on the community in which the wells were located and the corresponding underlying geologic unit, as shown on the bedrock geology map provided in Drawing No. 1034406-11-3 in Appendix 11a.

The groundwater potential of each geological unit was quantified by assessing the reported well yields and depths from the records of wells completed within each unit. Reported yields for drilled wells in the Wooddale ADA and surrounding area are based on airlift testing carried out by the driller at the time of well installation to obtain a rough estimate of well capacity, and does not necessarily represent the short or long term safe yield of the well, or the groundwater yield characteristics of the corresponding aquifer. To accurately determine such values, aquifer testing, including step drawdown and constant rate pump testing must be conducted, ideally with monitoring of groundwater levels in nearby observation wells. No aquifer testing has been carried out on any of the drilled wells in the ADA and surrounding area. Therefore, in the absence of this data, the groundwater potential of the various geological strata in the Wooddale ADA is defined based on the estimated well yields obtained from the driller's records.

11.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the Wooddale ADA have been subdivided into two broad hydrostratigraphic units, including one comprised of till deposits, and the other predominantly of sands and gravels. The

yield and depth characteristics of these units are summarized on Table 11.1. No water well information was available for the till deposits present in the ADA. Therefore groundwater potential within this overburden unit was inferred based on well records for similar overburden material in the St. John's ADA.

Till Deposits

A stony glacial till derived from reddish sandstone with various amounts of granites, shale, slate and volcanic rocks, and forming both thin discontinuous veneer and more extensive moraine deposits is locally present at higher elevations along the flanks of the Peters River Valley. There is no documented data on the groundwater potential of the till material in the Wooddlae ADA. However, based on records of water wells within similar till material in the St. John's ADA, the range of yields from wells within the till can be expected to vary from 10 to 70 L/min at depths of 9.5 to 35 m. The average yield is estimated to be approximately 40 L/min at 21 m depth. However, median yield and depth estimates of 34 L/min at 20 m depth are more likely representative of the typical groundwater potential of this unit.

Sand and Gravel Deposits

Sand and gravel deposits of glacial outwash and fluvial origin underlie the central portion of the ADA occurring within the Peter's River valley as a relatively flat flood plain. These deposits are potentially significant groundwater aquifers. Two (2) wells, including one each from the communities of Botwood and Wooddale, were available to characterize the groundwater potential of this unit in the ADA. Based on the two well records, the sand and gravel deposits are considered capable of providing wells with moderate yields, with the Botwood and Wooddale wells reporting yields of 90 L/min at 12 m depth, and 65 L/min at 22 m depth, respectively.

Table 11.1 Summary of Overburden Drilled Well Information for Wooddale ADA

Overburden Unit	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
			Mean (Median)	Range	Mean (Median)	Range
Till*	St. John's ADA	6	21.3 (19.6)	9.5 - 35	39.5 (33.5)	10 - 70
Sand & Gravel	Botwood Wooddale	2	-	12.2, 21.9	-	90, 65

* * Groundwater yield estimates for the till deposits based on well data from the St. John's ADA

11.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the combined Silurian bimodal volcanic and siliciclastic sedimentary rocks of the Botwood Group and Charles Lake sequence located within the ADA. The well yield and depth characteristics of these units are summarized in Table 11.2.

No water well information was available for the Silurian Hodges Hill intrusive suite, which intrudes both the Botwood Group and Charles Lake Sequence along the northern boundary of the ADA. Therefore groundwater potential within this unit was inferred based on well records for similar granitic rocks in the Terra Nova ADA.

Botwood Group and Charles Lake Sequence

A total of 31 well records from the communities of Botwood, Bishop Falls, and Wooddale were used to characterize the groundwater potential of the combined Botwood Group and the Charles Lake Sequence in the ADA. These units underlie the majority of the ADA. Based on well data, the combined

Botwood Group and the Charles Lake Sequence strata are considered capable of providing wells with low yields, having water yields ranging from 1 to 64 L/min at well depths of 17 to 91 m, and an average yield of 15 L/min at 52 m depth. However, median yield and depth estimates of 10 L/min at 51 m depth are more likely representative of the typical groundwater potential of these units.

Silurian Granite (Hodges Hill Intrusive Suite)

No documented data is available for the groundwater potential of the Silurian Hodges Hill intrusive suite rocks that occur in the northern portion of the ADA. However, based on records from two (2) water wells within similar granitic rocks in the Terra Nova ADA, this unit is considered capable of providing wells with low yields, reporting yields of 18 L/min at 73 m depth, and 20 L/min at 13 m depth, respectively.

Table 11.2 Summary of Bedrock Drilled Well Information for Wooddale ADA

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Botwood/ Charles Lake Sequence	Bimodal volcanic rocks; incl. siliciclastic sedimentary rocks	Botwood Bishop Falls Wooddale	31	52.1 (50.6)	17.4 – 90.8	14.6 (10)	1 - 64
Silurian Granite*	Granitoid intrusions, including unseparated mafic phases	Terra Nova ADA	2	-	13.4, 73.2	-	18, 20

*Groundwater yield estimates for granitic rocks based on well data from the Terra Nova ADA

11.3.2 Groundwater Flow System

The Wooddale ADA and surrounding areas are underlain by an unconfined aquifer system contained within the overburden material and underlying shallow bedrock. The movement of groundwater through the overburden material is controlled by primary porosity, while groundwater flow within the underlying bedrock can be expected to mainly occur within secondary openings, such as fractures and joints, and will be variable depending on the frequency and interconnection of these structural features.

Shallow groundwater flow within the ADAs is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along areas of high ground and discharging along the Peter's River system. It is expected that the shallow groundwater system in the ADA will be largely controlled by surface runoff and local recharge, while at moderate depths the flow system may be influenced by lateral inflow of groundwater from up-gradient areas to the northwest. Based on a review of water well records for the area, groundwater levels are generally assumed to be within 6 m of the ground surface and to be a subdued reflection of the topography.

11.4 Water Quality

11.4.1 Surface Water Quality

Surface water quality data for the Wooddale ADA was obtained from two sources, including:

1. Ambient water quality data collected as part of the Canada–Newfoundland Water Quality Monitoring Agreement, from one (1) water quality monitoring sites in the ADA and surrounding area –
    - Peter's River (NFS02YO0121, 2003-2007); and,
2. Water quality monitoring data collected by the NL Department of Environment - Water Resources Management Division from one (1) protected public surface water supplies in the ADA and surrounding area –
    - Wooddale, Northern Arm Lake (WS-S-0291, 1987-2007)

A summary of chemical data obtained from these surface water sources over their respective monitoring periods is provided in Tables 11.3 and 11.4 in Appendix 11b, and is compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007), as well as the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses (CWQG-AWU) (October, 2005).

Based on major ion chemistry, surface water in the ADA and surrounding area can be classified as a calcium-sodium-chloride-sulfate-bicarbonate ($Ca\text{-}Na\text{-}Cl\text{-}SO_4\text{-}HCO_3$), type water. Surface water in the area is soft, slightly acidic to slightly basic, and of low alkalinity. Classification of surface water according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron, manganese, and turbidity in surface water at the Peter's River ambient water monitoring site, and manganese, pH, turbidity and color in the Wooddale protected public water supply, concentrations of all other parameters tested meet CDWQG. The guidelines for iron, manganese, pH, turbidity and color are aesthetic objectives only and levels of these parameters detected at the surface water locations evaluated do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining in the case of iron, manganese, turbidity and color, and corrosion in the case of pH.

Concentrations of all parameters tested at the two surface water sites meet CCME CWQG-AWU for irrigation and/or livestock water use.

Based on chemical data, surface water quality within the ADA is generally considered excellent, returning average Canadian Water Quality Index (CWQI) values ranging from 95 to 100. However, a negative Langelier Index in the Wooddale public surface water supply indicates that water is unsaturated with calcium carbonate and it will tend to be corrosive, leading to potential leaks in the distribution system. Peter's River is not considered a potable water source, and would require treatment for disinfection, as well as to improve the aesthetic quality of the water.

11.4.2 Groundwater Quality

The groundwater quality data for the Wooddale ADA consists of analyses from two (2) private drilled wells from the communities of Woodale and Bishop's Falls collected by the NL Department of Environment - Water Resources Management Division. A summary of chemical data obtained from these water wells is provided in Table 11.5 in Appendix 5b, and is compared to the Canadian Drinking Water Quality Guidelines (CDWQG) (Health Canada, 2007).

Based on major ion chemistry, shallow groundwater in the ADA can be classified as a combination of calcium-sodium-bicarbonate-chloride-sulfate (Ca-Na-HCO_3-Cl-SO_4), and calcium-sodium-chloride-sulfate-bicarbonate- (Na-Ca-Cl-SO_4-HCO_3) type waters. Groundwater in the area ranges from slightly to moderately hard, neutral to slightly acidic, and of moderate alkalinity. Classification of groundwater according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of iron, manganese, and turbidity concentrations in the Wooddale well and iron concentrations in the Bishop Falls well, concentrations of all other parameters tested in the wells meet CDWQG. The guidelines for iron, manganese, and turbidity are aesthetic objectives only and levels of these parameters detected in the wells do not pose any health concerns, however problems may be experienced such as foul taste, deposition or staining.

In addition, concentrations of iron and manganese detected in the private water well in Wooddale exceeded CCME CWQG-AWU for irrigation water use.

Insufficient monitoring data was available to determine Canadian Water Quality Index (CWQI) values for groundwater in the ADA. However, available chemical data indicates that groundwater in the ADA and surrounding area is generally of good quality. Treatment might be considered to improve the aesthetic quality of the water. In addition, concentrations of iron and manganese that exceed CCME CWQG-AWU in the water well in Wooddale may limit usage of this groundwater source as a potential agricultural water supply without appropriate treatment.

11.5 Groundwater Recharge & Availability

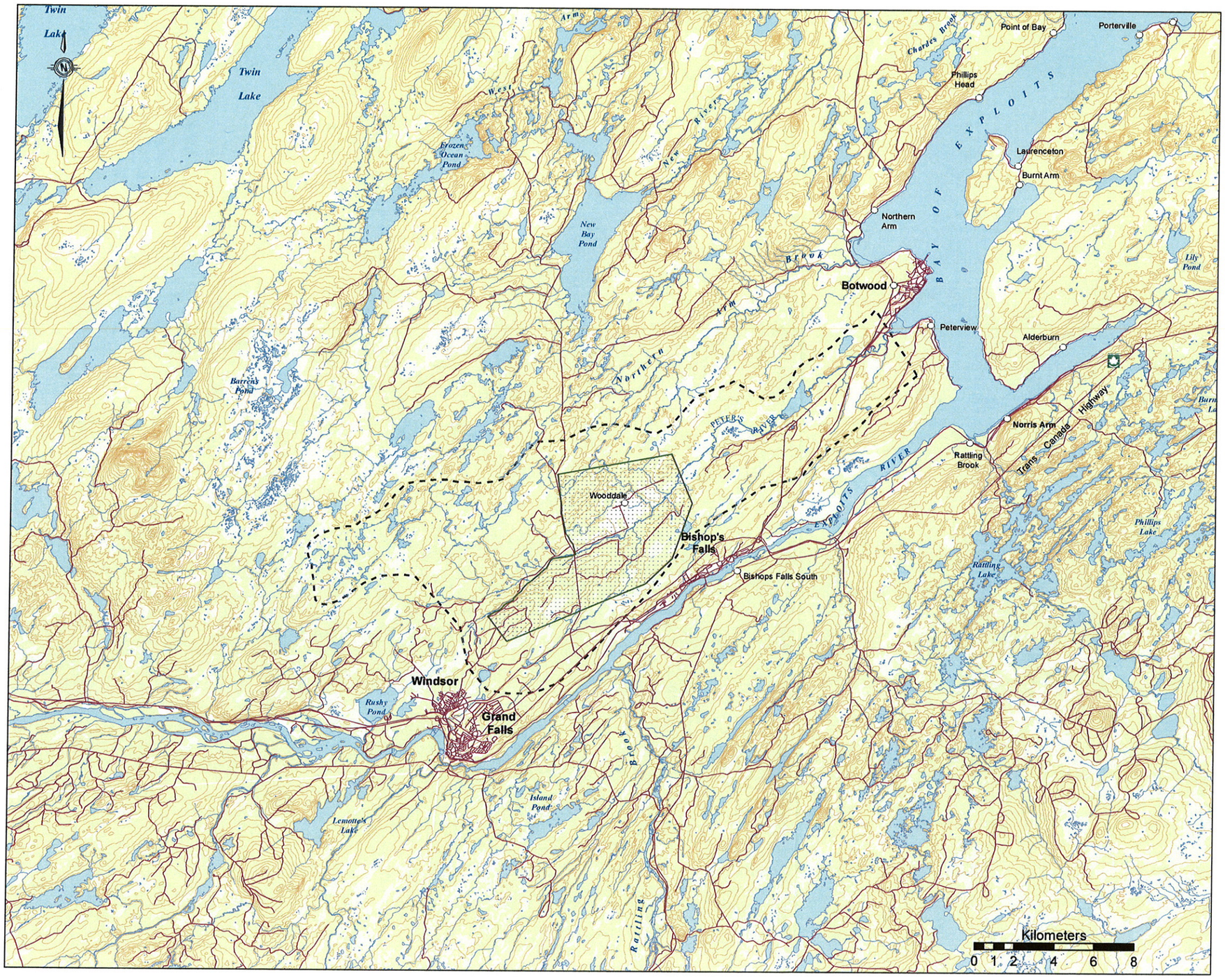
Recharge to the shallow groundwater system underlying the ADA is by direct infiltration of rainfall, after runoff and the requirements of evaporation and plant transpiration have been met, and is directly related to rainfall, infiltration characteristics and size of the recharge zone. A common practice in estimating the long term groundwater recharge for an area is to multiply the groundwater catchment area by the percent of precipitation estimated as able to infiltrate. The recharge to groundwater in the Wooddale ADA is estimated on the basis of a local groundwater catchment area equivalent to the area of the ADA of approximately 4,621 hectares, and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,068 mm, equivalent to 107 mm). Based on these values, the groundwater recharge to the Wooddale ADA is estimated at $4.9 \times 10^6 m^3$/year or 1,068 m^3/hectares/yr.

Groundwater use in the area is currently limited to minor individual domestic, commercial, and industrial wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the Wooddale ADA, thus preventing an accurate balance of groundwater supply and demand to be estimated, and making it difficult to evaluate groundwater supply potential for future agricultural development in the area. However, considering the current, overall under-utilization of groundwater in the area from other users, it is expected that an adequate supply of groundwater of

sufficient quality is available to meet and/or augment water supply requirements for various existing and future agricultural needs in the ADA.

APPENDIX 11a

Drawings



Transportation Route
Stream
Contour Line
Waterbody
Drainage Catchment Area
Agricultural Development Area
Wetland/String Bog
Vegetated Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

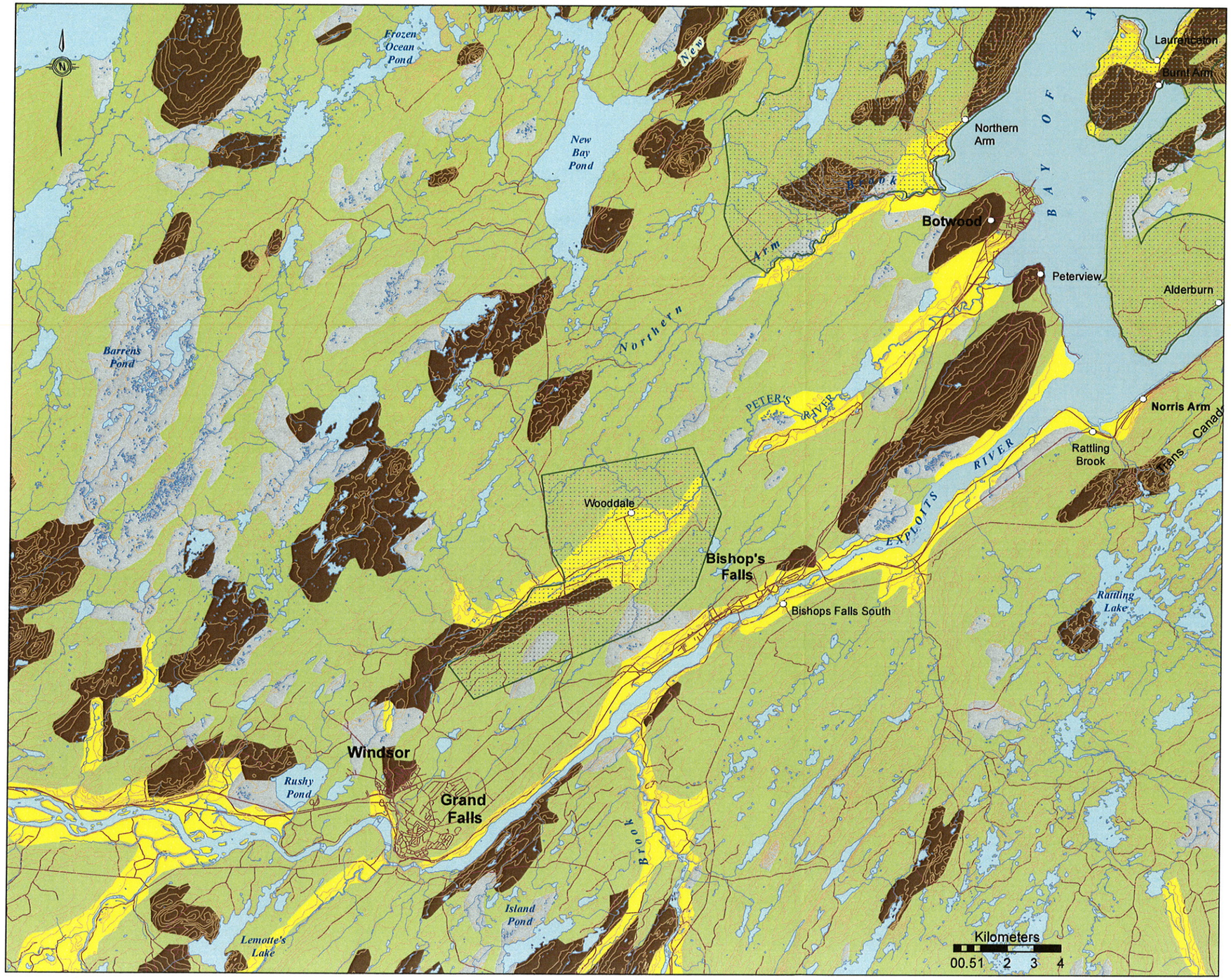
DRAWING TITLE:

WOODDALE ADA LOCATION AND DRAINAGE

Jacques Whitford

Jacques Whitford

SCALE: 1:200,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No.: 0
DRAWING No.: 1034406-11-1	
MAP FILE: 1034406-XX.MXD	



Surficial Geology Legend

- Bog: Poorly drained accumulations of peat, peat moss and other organic matter; developed in areas of poor drainage
- Sand & Gravel: Sands, gravels and silts of glaciofluvial, fluvial, lacustrine or marine terrace origin
- Glacial Till: Till veneer and moraine deposits of varying thickness overlying bedrock. Composed of diamicton (poorly sorted sediment containing a mixture of grain sizes from clay to boulders)
- Rock: Exposed Bedrock, includes areas concealed by vegetation, till veneer, as well as colluvium

- Stream
- Transportation Route
- Contour Line
- Waterbody
- Agricultural Development Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

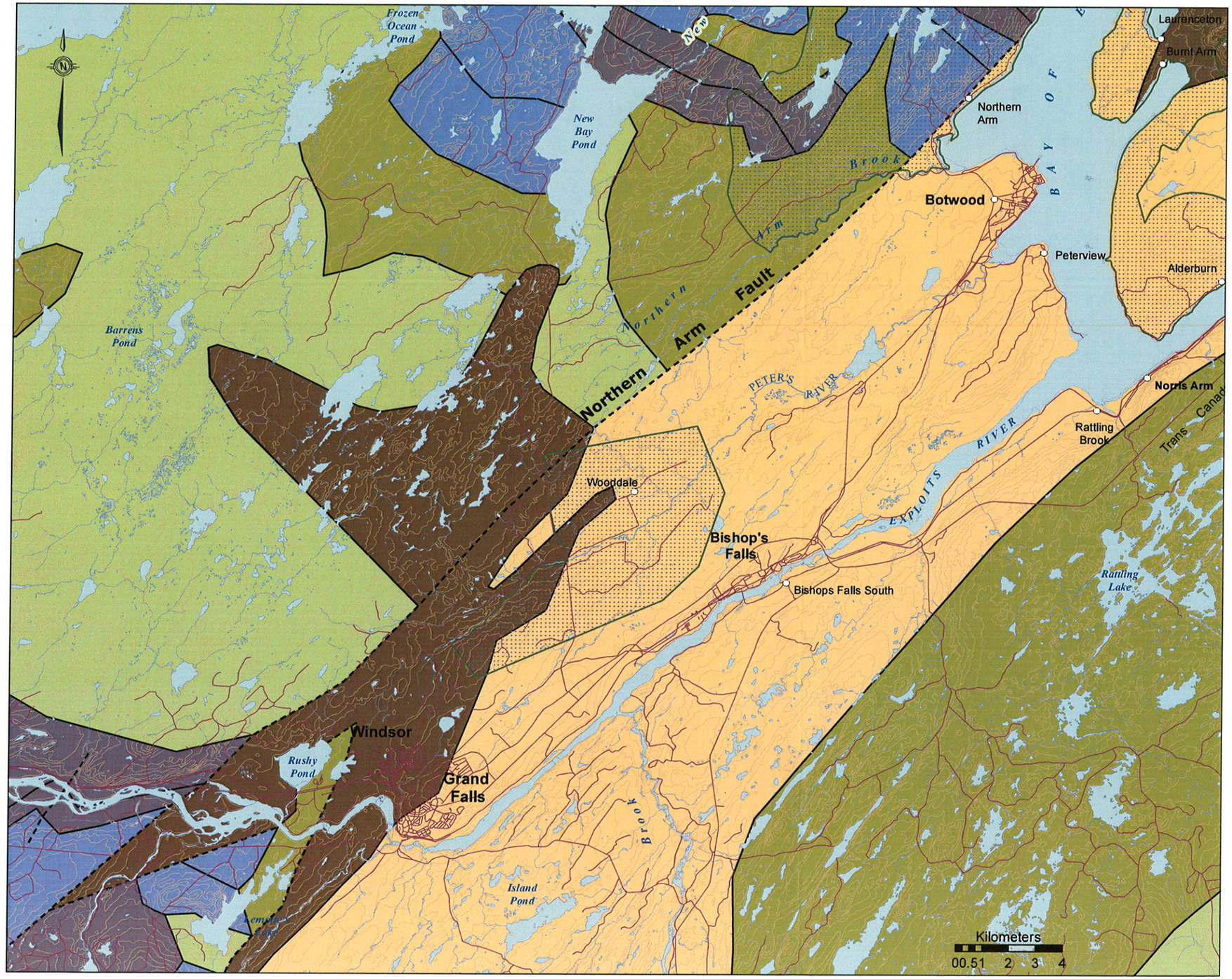
DRAWING TITLE:

WOODDALE ADA SURFICIAL GEOLOGY

Jacques Whitford

SCALE: 1:150,000	DATE: 03/06/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: MCH	REV. No. 0
DRAWING No.: 1034406-11-2	
MAP FILE: 1034406-XX.MXD	

DD/MM/YEAR



Generalized Bedrock Geology Legend

Post Ordovician Units Overlap Sequences

Silurian

- Bimodal volcanic rocks; includes siliciclastic sedimentary rocks (Charles Lake Sequence)
- Shallow marine and non-marine siliciclastic sedimentary rocks, including sandstone, shale and conglomerate (Botwood Group)

Dunnage Zone

Stratified Rocks

Middle Ordovician to Early Silurian

- Black shale, slate and argillite, including subordinate chert and greywacke and turbidites consisting of sandstone, shale and conglomerate; other marine sedimentary rocks

Cambrian to Middle Ordovician

- Marine siliciclastic sedimentary rocks, including slate, shale, argillite, siltstone, sandstone, conglomerate, and minor unseparated carbonate, volcanic and intrusive rocks, and schist, gneiss and migmatite

Intrusive Rocks

Cambrian to Ordovician

- Mafic intrusions, including unseparated granitoid rocks and ultramafic rocks of ophiolite complexes

POST ORDOVICIAN INTRUSIVE ROCKS

Devonian and Carbiniferous

- Granite and high silica granite (sensu stricto), and other granitoid intrusions that are posttectonic relative to mid-Paleozoic orogenies

Silurian and Devonian

- Gabbro and diorite intrusions, including ultramafic phases
- Granitoid suites, varying from pretechtonic to syntechtonic, relative to mid-Paleozoic orogenies

- Fault, Strike-Slip and High Angle
- Contact
- Fault, Thrust
- Transportation Route
- Contour Line
- Stream
- Waterbody
- Agricultural Development Area

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

WOODDALE ADA BEDROCK GEOLOGY

Jacques Whitford

SCALE: 1:150,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-11-3	
MAP FILE: 1034406-XX.MXD	

APPENDIX 11b

Water Chemistry Data

Table 11.3 Surface Water Chemistry, NL Ambient Water Quality Monitoring Sites, Wooddale ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Peter's River NF02YO0121 (2003-2007)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaCO_3$	na	na	na	8.5	33.2	21.8
Aluminum	mg/L	na	5	5	0.01	0.15	0.07
Ammonia	mg/L	na	na	na	-	-	-
Antimony	mg/L	0.006	na	na	-	-	-
Arsenic	mg/L	0.01	0.1	0.025	0.00032	0.0014	0.00082
Barium	mg/L	1	na	na	0.004	0.02	0.011
Beryllium	mg/L	na	0.1	0.1	0	0.00001	0.000005
Bicarbonate	mg/L $CaCO_3$	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	0.0018	0.008	0.0045
Bromide	mg/L	na	na	na	0	0.000051	0.00001
Cadmium	mg/L	0.005	0.005	0.08	-	-	-
Calcium	mg/L	na	na	na	-	-	-
Carbonate	mg/L $CaCO_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	1.75	4.14	3.09
Chromium	mg/L	0.05	na	na	0.0001	0.0003	0.0002
Copper	mg/L	1*	0.2 - 1	0.5-5	0.0001	0.001	0.0003
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-
Fluoride	mg/L	1.5	1	1 - 2	-	-	-
Hardness	mg/L $CaCO_3$	na	na	na	-	-	-
Iron	mg/L	0.3*	5	na	0.06	0.31	0.15
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-
Langelier Index	-	na	na	na	-	-	-
Lead	mg/L	0.01	0.2	0.1	0.000008	0.000105	0.000032
Magnesium	mg/L	na	na	na	-	-	-
Manganese	mg/L	0.05*	0.2	na	0.01	0.12	0.02
Mercury	mg/L	0.001	na	0.003	-	-	-
Nickel	mg/L	na	0.2	1	0.00003	0.0004	0.00016
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	-	-	-
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	6.73	7.91	7.28
Potassium	mg/L	na	na	na	-	-	-
Reactive Silica	mg/L SiO2	na	na	na	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0.00005	0.00103	0.00011
Silver	mg/L	na	na	na	0	0.000007	0.000002
Sodium	mg/L	200*	na	na	-	-	-
Specific Conductance	uS/cm	na	na	na	23.5	85.4	56.9
Sulphate	mg/L	500*	na	1,000	0.72	2.35	1.42
Sulphide	mg/L H2S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	0.000001	0.000021	0.000005
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	-	-	-
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	-	-	-
Total Suspended Solids	mg/L	na	na	na	-	-	-
True Color	TCU	15*	na	na	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.12	1.7	0.47
Uranium	mg/L	0.02	0.01	0.2	0.00002	0.0001	0.00004
Vanadium	mg/L	na	0.1	0.1	0.0002	0.000	0.0003
Canadian Water Quality Index	-	-	-	-	-	-	94.18
Zinc	mg/L	5*	1 - 5	50	0.0001	0.002	0.0005

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statisitics calculated using chemicial data obtained from the NL Deprtment of Environment - Water Resources Management Division Drinking Water Quality Database. Note in the data base, prior to March 31, 2004 analytical results less than the detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 11.4 Surface Water Chemistry, Public Water Supply, Wooddale ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Wooddale - Northern Arm Lake WS-S-0291 (1987-2007)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	0	16	4.5
Aluminum	mg/L	na	5	5	0.025	1.66	0.126
Ammonia	mg/L	na	na	na	0	0.1	0.02
Antimony	mg/L	0.006	na	na	0	0.001	0.0002
Arsenic	mg/L	0.01	0.1	0.025	0	0.005	0.001
Barium	mg/L	1	na	na	0	0.025	0.003
Beryllium	mg/L	na	0.1	0.1	-	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Boron	mg/L	5	0.5 - 6	5	0	0.03	0.01
Bromide	mg/L	na	na	na	0	0.03	0.02
Cadmium	mg/L	0.005	0.005	0.08	0	0.001	0.0002
Calcium	mg/L	na	na	na	0	6	2
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	1	4	1.7
Chromium	mg/L	0.05	na	na	0	0.005	0.001
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.12	0.01
Dissolved Organic Carbon	mg/L	na	na	na	0.5	8.3	4.8
Fluoride	mg/L	1.5	1	1 - 2	0	0.11	0.03
Hardness	mg/L $CaC0_3$	na	na	na	0	15	5
Iron	mg/L	0.3*	5	na	0.005	0.2	0.099
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-
Langelier Index	-	na	na	na	-3.87	-2.35	-3.13
Lead	mg/L	0.01	0.2	0.1	0	0.002	0.001
Magnesium	mg/L	na	na	na	0	1	0.3
Manganese	mg/L	0.05*	0.2	na	0	0.12	0.02
Mercury	mg/L	0.001	na	0.003	0	0.001	0.0001
Nickel	mg/L	na	0.2	1	0	0.005	0.002
Nitrate	mg/L N	45	na	na	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0	0.05	0.02
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	5.9	6.8	6.4
Potassium	mg/L	na	na	na	0	0.72	0.24
Reactive Silica	mg/L SiO2	na	na	na	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0.005	0.001
Silver	mg/L	na	na	na	-	-	-
Sodium	mg/L	200*	na	na	0	4	1
Specific Conductance	uS/cm	na	na	na	13	28.5	18.8
Sulphate	mg/L	500*	na	1,000	0	4	2
Sulphide	mg/L H2S	0.05*	na	na	-	-	-
Thallium	mg/L	na	na	na	-	-	-
Tin	mg/L	na	na	na	-	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	7	30	14
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.03	0.01
Total Suspended Solids	mg/L	na	na	na	1	2	1
True Color	TCU	15*	na	na	19	57	36
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.15	2.1	0.68
Uranium	mg/L	0.02	0.01	0.2	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-
Canadian Water Quality Index (CWQI)	-	-	-	-	95	100	97
Zinc	mg/L	5*	1 - 5	50	0	0.12	0.01

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Summary statisitics calculated using chemicial data obtained from the NL Deprtment of Environment - Water Resources Management Division Drinking Water Quality Database. Note in the data base, prior to March 31, 2004 analytical results less than the detection limit were reported as half of the detection limit, while after March 31, 2004 analytical results less than the detection limit were reported as zero.

na = No applicable criteria

* = Aesthetic objective

** = Operational guideline value based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

Bolded = Value does not meet CWQG-AWU for irrigation and/or livestock water

Table 11.5 Groundwater Chemistry, Private Drilled Wells, Wooddale ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Communities[1]	
					Wooddale	Bishop's Falls
			Irrigation Water	Livestock Water	12475	15286
Alkalinity	mg/L $CaC0_3$	na	na	na	22.6	70.5
Aluminum	mg/L	na	5	5	0.11	-
Ammonia	mg/L	na	na	na	0.01	0.02
Antimony	mg/L	0.006	na	na	0.001	-
Arsenic	mg/L	0.01	0.1	0.025	0.001	-
Barium	mg/L	1	na	na	0.05	-
Beryllium	mg/L	na	0.1	0.1	-	-
Bicarbonate	mg/L $CaC0_3$	na	na	na	-	-
Boron	mg/L	5	0.5 - 6	5	0.2	-
Bromide	mg/L	na	na	na	0	-
Cadmium	mg/L	0.005	0.005	0.08	0.0001	-
Calcium	mg/L	na	na	na	6.1	19
Carbonate	mg/L $CaC0_3$	na	na	na	-	-
Chloride	mg/L	250*	100 - 700	na	5	46
Chromium	mg/L	0.05	na	na	0.006	-
Copper	mg/L	1*	0.2 - 1	0.5-5	0.01	-
Dissolved Organic Carbon	mg/L	na	na	na	5.6	-
Fluoride	mg/L	1.5	1	1 - 2	0.1	0.05
Hardness	mg/L $CaC0_3$	na	na	na	19.3	67.6
Iron	mg/L	0.3*	5	na	**8.76**	0.92
Kjeldahl Nitrogen	mg/L	na	na	na	-	-
Langelier Index	-	na	na	na	-	-
Lead	mg/L	0.01	0.2	0.1	0.001	-
Magnesium	mg/L	na	na	na	1	4.9
Manganese	mg/L	0.05*	0.2	na	**0.21**	0.04
Mercury	mg/L	0.001	na	0.003	0.02	-
Nickel	mg/L	na	0.2	1	-	-
Nitrate	mg/L N	45	na	na	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0.05	1.1
Nitrite	mg/L	na	na	10	0.05	0.005
Orthophosphate	mg/L P	na	na	na	-	-
pH	Units	6.5-8.5*	na	na	6.5	7.09
Potassium	mg/L	na	na	na	0.26	1.26
Reactive Silica	mg/L SiO2	na	na	na	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	-	-
Silver	mg/L	na	na	na	-	-
Sodium	mg/L	200*	na	na	3.71	32
Specific Conductance	uS/cm	na	na	na	65	312
Sulphate	mg/L	500*	na	1,000	5	10
Sulphide	mg/L H2S	0.05*	na	na	-	-
Thallium	mg/L	na	na	na	0.001	-
Tin	mg/L	na	na	na	-	-
Total Dissolved Solids	mg/L	500*	500 - 3,500	3,000	50	209
Total Organic Carbon	mg/L	na	na	na	-	-
Total Phosphorus	mg/L	na	na	na	-	0.02
Total Suspended Solids	mg/L	na	na	na	15	-
True Color	TCU	15*	na	na	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	11.7	-
Uranium	mg/L	0.02	0.01	0.2	-	-
Vanadium	mg/L	na	0.1	0.1	-	-
Zinc	mg/L	5*	1 - 5	50	0.01	0.005

Notes:

CDWQG = Health Canada Canadian Drinking Water Quality Guidelines (March, 2007)

CWQG-AWU = CCME Canadian Water Quaility Guidelines for the Protection of Agricultural Water Uses (Irrigation and Livestock Water) (October, 2005)

1 = Chemicial data obtained from the NL Department of Environment - Water Resources Management Division Drinking Water Quality Database

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