4.0 HYDROGEOLOGY OF MARKLAND ADA

4.1 General Description of Area

4.1.1 Location & Extent

The Markland ADA is located in the central portion of the Avalon Peninsula, and includes two adjacent zones (i.e., Zone I and Zone II) that cover a combined area of approximately 38,685 hectares. Zone I forms the southern portion of the ADA, encompassing a stretch of coast at the head of St. Mary's Bay from North Harbour to Salmonier Arm, and extending approximately 16 km inland from the coast. Zone II is located immediately north of Zone I, and extends into the interior of the peninsula, encompassing the communities of Markland and Whitbourne. The boundary of the Markland ADA is shown on Drawing Nos. 1034406-4-1in Appendix 4a.

The Markland ADA overlaps the communities of Little Island Cove, Whitbourne, Markland, Placentia Junction, Colinet, John's Pond, North Harbour South, Harricott, Mitchells Brook, Mount Carmel, and St. Catherine's.

The main access to the ADA is provided by Provincial Highway Route 81 (Markland Road), a paved highway which leads south from the Trans Canada Highway near Whitbourne to Colinet. At Colinet, Provincial Highway Route 81 joins Provincial Highway Route 91 (Old Placentia Highway), and provides access to the eastern portion of Zone I. In addition, various paved and graveled secondary roads and ATV trails leading from Highway Routes 81 and 91 also provide access to some areas within the ADA.

4.1.2 Physiography, Topography & Drainage

The Markland ADA is located on the Avalon Peninsula, which forms the eastern extent of the physiographic region referred to as the Atlantic Uplands. This physiographic region is underlain by the remnants of an ancient peneplain that slopes in an easterly direction and is characterized by rugged bedrock-controlled ridges and northeast-southwest trending coastal bays and inlets. In general, the Avalon Peninsula comprises a highland area surrounding a central lowland, with the arms of the peninsula situated at relatively higher ground with respect to a large central lowland area located in the central part of the peninsula between Conception Bay and St. Mary's Bay, including in the vicinity of the Markland ADA. The Markland ADA is generally underlain by an irregular rolling topography, and is characterized by elevations less than 120 m above sea level. Maximum elevations ranging from 300 to 325 masl are present in upland areas surrounding the ADA. In addition, a narrow topographic ridge is present in the northern portion of Zone II of the ADA that acts as a drainage divide separating drainage in the lowlands between Trinity Bay in the north and St. Mary's Bay in the south. Coastal sections of Zone I have gentle slopes and are indented with long narrow bays and inlets.

Zone I of the Markland ADA encompasses the lower courses of several major stream and river drainage systems that drain into St. Mary's Bay, including Rocky River and Colinet River. Other smaller water courses are also present within Zone I that drain into St. Mary's Bay. In addition, Zone I of the ADA borders the lower course of Salmonier River along its eastern boundary. Zone II of the ADA encompasses the upper course of Rocky River (including its tributary Hodges River), as well as the

upper course of a number of other stream and river systems that drain into adjacent bays along the peninsula, the most significant of which is Northeast River, which drains into Placentia Bay, North River, which drains into Conception Bay, and Spread Eagle River, which drains into Trinity Bay. The headwaters of these stream and river systems originate in the upland regions east and west of the ADA. In addition, numerous small ponds are scattered throughout the drainage catchment area of the ADA.

With the exception of the boundaries of the Whitbourne – Hodges River Public Protected Water Supply Area, which overlaps Zone II of the Markland ADA, no other Public Protected Water Supply Areas are present in the ADA or its drainage catchment areas.

4.1.3 Climate, Vegetation & Agricultural Land Use

The Markland ADA is located within the Avalon Forest ecoregion. This ecoregion represents a sheltered outlier within the more open and exposed Maritime Barrens, and is characterized by a moist climate with frequent summer fog. Climate data obtained from Environment Canada's Colinet monitoring station dating back to 1971 was used to characterize climatic conditions in the ADA. The monthly mean temperature in the area is 4.9°C, ranging from a high of 15.2°C in August to a low of -4.9°C in February. Average annual precipitation in the area is 1,392 mm, of which 88% falls as rainfall and 12% 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 1,166 growing degree days (base temperature 5^{o}C) for the year and 1,032 growing degree days for the vegetative season (i.e., May to September).

The landscape in the vicinity of the Markland ADA is dominated by pure stands of Balsam Fir with a significant mixture of White Birch and Yellow Birch. Domed bogs are common in low-lying areas between ridges. Based on agricultural land use information provided by the NL Department of Natural Resources Agrifoods Division, approximately 672 hectares (i.e., 2% of the total landmass of the ADA) is currently utilized for agriculture, with forage land representing the most significant proportion of the ADA's agricultural land use.

4.2 Geology

4.2.1 Surficial Geology

The surficial geology of the Markland ADA is summarized in Drawing No. 1034406-4-2 in Appendix 4a, and is based on most recent 1:50,000 scale mapping of the area by Catto and Taylor (1998a, b, c & d), as well as a description of surficial geology provided in Heringa (1981), Batterson and Taylor (2003), Batterson and Taylor (2004), and Marich, *et al.* (2005). 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.

Till is present throughout the ADA occurring mainly as thin (typically less than 1.5 m thick) veneer cover over bedrock in the southern portions of the ADA underlying Zone I, but forming more extensive hummocky, ridged and ribbed moraine deposits in the northern portion of the ADA underlying Zone II, with local thicknesses up to 20 m. The veneer and moraine tills comprise a very stony, loamy sand derived from the underlying siltstone, slate and acid volcanic rocks. The veneer and moraine tills are locally eroded and dissected, particularly along stream and river channels. Only small isolated areas of

sand and gravel deposits of glacial outwash and fluvial origin are present within the ADA. Sand and gravel units shown in Drawing No. 1034406-4-2 in Appendix 4a also include un-subdivided marine terraces that contain various silt and clay deposits in addition to sands and gravels and occur locally along coastal areas of the ADA. Along with glacial units, deposits of organic and peaty soils are common throughout the ADA, overlying either till or bedrock. Bedrock outcrop is rare in the ADA and is limited to small scattered ridges and knobs that occur as high ground in Zone I of the ADA. Bedrock outcrops may be partially or fully concealed by thin mat vegetation and sparse forest, but where exposed are commonly streamlined and display glacial striations and grooves. Streamlined glacial features in the area indicate northeast-directed ice flow. Available well logs indicate an average overburden thickness in the Markland ADA and surrounding area of approximately 10 m.

4.2.2 Bedrock & Structural Geology

The bedrock geology of the Markland ADA is summarized in Drawing No. 1034406-4-3 in Appendix 4a, and is based on the regional 1:1,000,000 scale compilation mapping by Colman-Sadd, *et al.*, (1990), as well as descriptions of bedrock geology provided by King (1990).

The Markland ADA lies within the Avalon tectonostratigraphic zone and is underlain by late Precambrian and Cambrian sedimentary and volcanic rocks. The oldest rocks are present in the eastern portion of Zone I of the ADA and comprise a sequence of dominantly green to grey fine-grained siliceous sedimentary rocks, as well as minor volcaniclastic rocks of the Conception Group. Westward, the Conception Group is conformably overlain by a marine – deltaic sequence of dark grey shale and sandstone of the St. John's Group, followed by an shoaling-upward sequence of marine to terrestrial volcano-sedimentary rocks of the Musgravetown Group. Along the western boundary of Zone II of the ADA, the Musgravetown Group sequence is disconformably overlain by younger Cambrian sedimentary rocks, which comprise red and green carbonate-bearing mudstones overlain by dark grey to black shale, siltstone and sandstone.

The Precambrian and Cambrian sedimentary and volcanic rocks that underlie the ADA have undergone regional-scale folding and eastward-directed trusting related to the Devonian Acadian orogenesis. Rocks in the area are folded into open to locally tight north-northeast trending anticlines and synclines with near vertical axial surfaces and with associated doubly plunging parasitic folds. Several examples of large-scale folds in the area include the Stag Pond Syncline, Markland Anticline and Colinet Syncline. Numerous high-angle and eastward-directed thrust faults are also common, the most significant of which is the Spread Eagle Thrust, located along the western boundary of the ADA. In addition, numerous joint sets and fracture zones occur within rocks underlying the ADA related to deformation.

4.3 Hydrogeology

4.3.1 Hydrostratigraphy

The groundwater potential of the various geological units within the Markland 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 152 drilled bedrock wells and 2 drilled surficial wells from 9 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 maps provided in Drawing Nos. 1034406-4-3 in Appendix 4a.

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 Markland ADA and surrounding area is 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 Markland ADA is defined based on the estimated well yields obtained from the driller's records.

4.3.1.1 Surficial Hydrostratigraphic Units

The surficial deposits within the Markland 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 4.1

Till Deposits

The till deposits form both thin veneer and more extensive moraine deposits over much of the ADA and comprise a very stony, loamy sand. Only one (1) well from the community of Whitbourne was available to characterize the groundwater potential of this unit in the ADA. Based on limited data, wells within the till in the ADA can be expected to yield 35 L/min at a depth of 24 m.

Sand and Gravel Deposits

Only small isolated areas of sand and gravel deposits of glacial outwash and fluvial origin are present within the ADA. Marine-derived sand and gravel units also occur locally along coastal areas of the ADA. These deposits are potentially significant groundwater aquifers. Only one (1) well from the community of Harricott was available to characterize the groundwater potential of this unit in the ADA. Based on limited data, wells within the sand and gravel in the ADA can be expected to yield 91 L/min at a depth of 20 m.

Table 4.1 Summary of Overburden Drilled Well Information for Markland ADA

Overburden Unit	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
			Mean	Range	Mean	Range
Till	Whitbourne	1	-	24.4	-	35
Sand & Gravel*	Harricott	1	-	20		90.9

4.3.1.2 Bedrock Hydrostratigraphic Units

Well record information is available for the majority of bedrock units located within the ADA, including the Conception, St. John's, Musgravetown groups, and the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups. The well yield and depth characteristics of these various strata are summarized in Table 4.2.

Conception Group

A total of 37 well records from the communities of St. Catherine's, Mitchells Brook, and Mount Carmel were used to characterize the groundwater potential of the Conception Group in the ADA. This unit underlies the eastern portion of Zone I of the ADA. Based on well data, the Conception Group strata are considered capable of providing wells with low yields, having water yields ranging from 0.5 to 60 L/min at well depths of 15 to 183 m, and an average yield of 11 L/min at 70 m depth. However, median yield and depth estimates of 9 L/min at 62 m depth are more likely representative of the typical groundwater potential of this unit.

St. John's Group

A total of two (2) well records from the community of Harricott were used to characterize the groundwater potential of the St. John's Group in the ADA. This unit is present locally in the eastern portion of Zone I of the ADA. Based on the two well records, the St. John's Group strata are considered capable of providing wells with low yields, reporting a yield of 14 L/min in both wells at depths of approximately 30 m and 49 m, respectively.

Musgravetown Group

A total of 99 well records from the communities of Colinet, Markland, Placentia Junction, and Whitbourne were used to characterize the groundwater potential of the Musgravetown Group in the ADA. This unit underlies the western portion of Zone I and the majority of Zone II of the ADA. Based on well data, the Musgravetown Group strata are considered capable of providing wells with low yields, having water yields ranging from 0.5 to 225 L/min at well depths of 10 to 165 m, and an average yield of 17 L/min at 67 m depth. However, median yield and depth estimates of 9 L/min at 61 m depth are more likely representative of the typical groundwater potential of this unit.

Adeytown & Harcourt Groups

A total of 14 well records from the community of Chapel Arm were used to characterize the groundwater potential of the combined Cambrian sedimentary rocks of the Adeytown & Harcourt groups in the ADA. These units are present locally in the eastern portion of Zone II of the ADA. Based on well data, the Adeytown & Harcourt groups strata are considered capable of providing wells with low yields, having water yields ranging from 0.5 to 27 L/min at well depths of 39 to 162 m, and an average yield of 6 L/min at 102 m depth. However, median yield and depth estimates of 3 L/min at 105 m depth are more likely representative of the typical groundwater potential of this unit.

Table 4.2 Summary of Bedrock Drilled Well Information for Markland ADA

Rock Group	Rock Type	Communities	No. of Wells	Well Depth (m)		Well Yield (L/min)	
				Mean (Median)	Range	Mean (Median)	Range
Conception	Siliceous sandstone, shale and volcaniclastic rocks	St. Catherines Mitchells Brook Mount Carmel	37	69.8 (61.5)	15.2-182.9	10.9 (9)	0.5-60
St. John's	Shale and sandstone	Harricott	2	-	30-48.7	-	14
Musgravetown	Siliciclastic sedimentary rocks, and minor bimodal volcanic rocks	Colinet Markland Placentia Junction Whitbourne	99	67.5 (61)	9.8-164.6	17.3 (9)	0.56-225
Adeytown & Harcourt	Siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks	Chapel Arm	14	102.5 (105.2)	38.7-162	6.3 (2.8)	0.5-27.3

4.3.2 Groundwater Flow System

The Markland ADA and surrounding area is 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 ADA is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along areas of high ground and discharging in various wet lowland areas, ponds, lakes and rivers, as well as along the coast. 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 east and west. 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.

4.4 Water Quality

4.4.1 Surface Water Quality

Surface water quality data for the Markland ADA was limited to water quality monitoring data collected by the NL Department of Environment - Water Resources Management Division from the Whitbourne – Hodges River (WS-S-0779) protected public surface water over a monitoring period from 1987 to 2007. A summary of chemical data obtained from this surface water source over the monitoring period is provided in Table 4.3 in Appendix 4b, 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 combination of sodium-calcium-chloride-sulfate-bicarbonate (Na-Ca-Cl-SO_4-HCO_3) and calcium-

sodium-chloride-sulfate-bicarbonate (Ca-Na-Cl-SO_4-HCO_3) type waters. Surface water in the area is soft, slightly acidic, and of low alkalinity. Classification of surface water according to dissolved-solids and specific conductance indicates fresh conditions.

With the exception of manganese, pH, turbidity and color, concentrations of all other parameters tested meet CDWQG. The guidelines for 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 manganese, turbidity and color, and corrosion in the case of pH.

Concentrations of all parameters tested in the Whitbourne – Hodges River protected public surface water supply meet CCME CWQG-AWU for irrigation and/or livestock water use.

Based on chemical data, surface water quality within the ADA is considered good, returning an average Canadian Water Quality Index (CWQI) value of 85. However, a negative Langelier Index in the Whitbourne – Hodges River protected 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. Treatment would be required to improve the aesthetic quality of the water.

4.4.2 Groundwater Quality

The groundwater quality data for the Markland ADA consists of analyses from six (6) private drilled wells from the communities of Colinet, Whitbourne, and Chapel Arm 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 4.4 in Appendix 4b, 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, shallow groundwater in the ADA can be classified as calcium-sodium-bicarbonate-chloride-sulfate (Ca-Na-HCO_3-Cl-SO_4) type water. Groundwater in the area ranges from slightly to moderately hard, slightly acidic to slightly basic, 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 several of the private water wells in Colinet and Chapel Arm, 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 the case of iron, manganese, and turbidity, and corrosion in the case of pH.

Further, one private water well in Chapel Arm had a concentration of manganese that exceeds CCME CWQG-AWU for irrigation water use.

Insufficient monitoring data is available to determine Canadian Water Quality Index (CWQI) values for groundwater in the ADA. However, available chemical data indicates that shallow groundwater in the ADA and surrounding area is generally of good quality. However, treatment might be considered to improve the aesthetic quality of the water. Further, the elevated concentration of manganese that exceeded CCME CWQG-AWU in the water well at Chapel Arm may limit usage of this groundwater water source as a potential agricultural water supply without appropriate treatment.

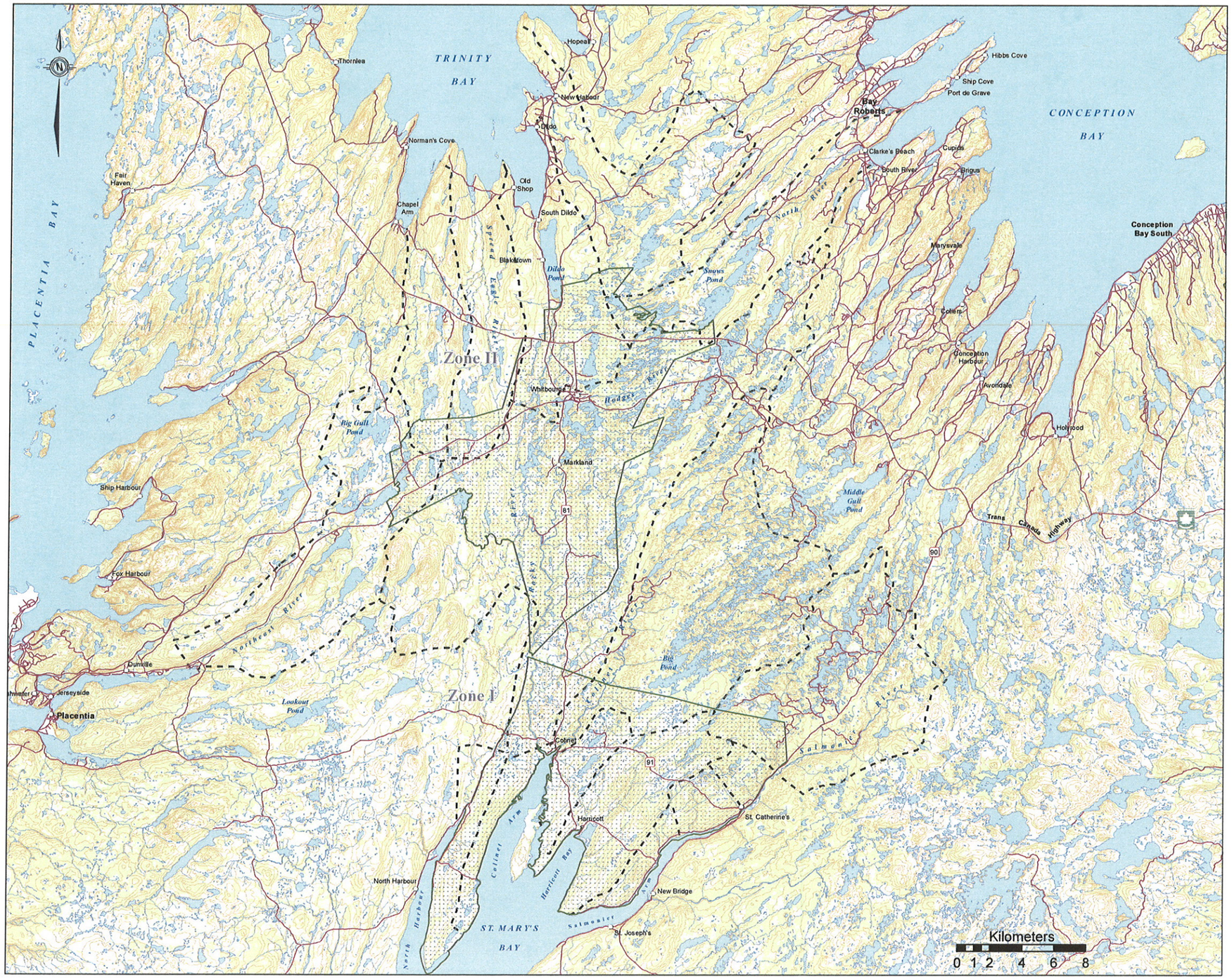
4.5 Groundwater Recharge & Availability

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 Markland ADA is estimated on the basis of a local groundwater catchment area equivalent to the area of the ADA of approximately 38,685 hectares, and a conservative recharge coefficient of 10% of the mean annual rainfall (i.e., 10% of 1,392 mm, equivalent to 139 mm). Based on these values, the groundwater recharge to the Markland ADA is estimated at $5.4 \times 10^7 m^3$/year or 1,392 m^3/hectares/yr.

Groundwater use within the Markland ADA is currently limited to minor individual domestic and industrial wells. No information is available regarding existing agricultural (i.e., irrigation and livestock) water demands in the Markland 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 4a

Drawings



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

PROJECT TITLE:

HYDROGEOLOGY OF AGRICULTURAL DEVELOPMENT AREAS, NEWFOUNDLAND AND LABRADOR

DRAWING TITLE:

MARKLAND ADA LOCATION AND DRAINAGE

Jacques Whitford

SCALE: 1:250,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-4-1	
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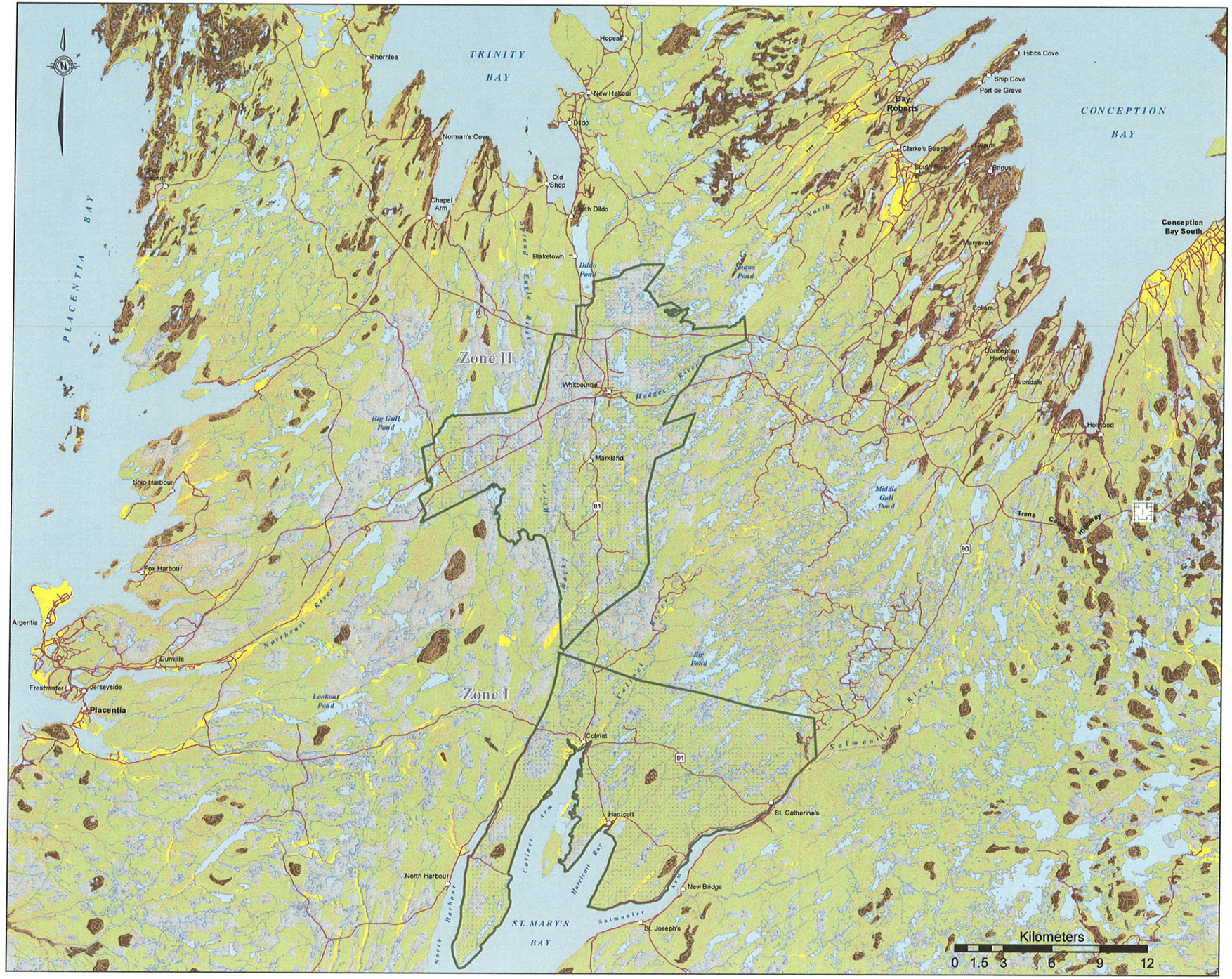

Surficial Geology Legend

- 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:

MARKLAND ADA SURFICIAL GEOLOGY

Jacques Whitford

SCALE: 1:250,000	DATE: 03/06/2008
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DRAWING No.: 1034406-4-2	
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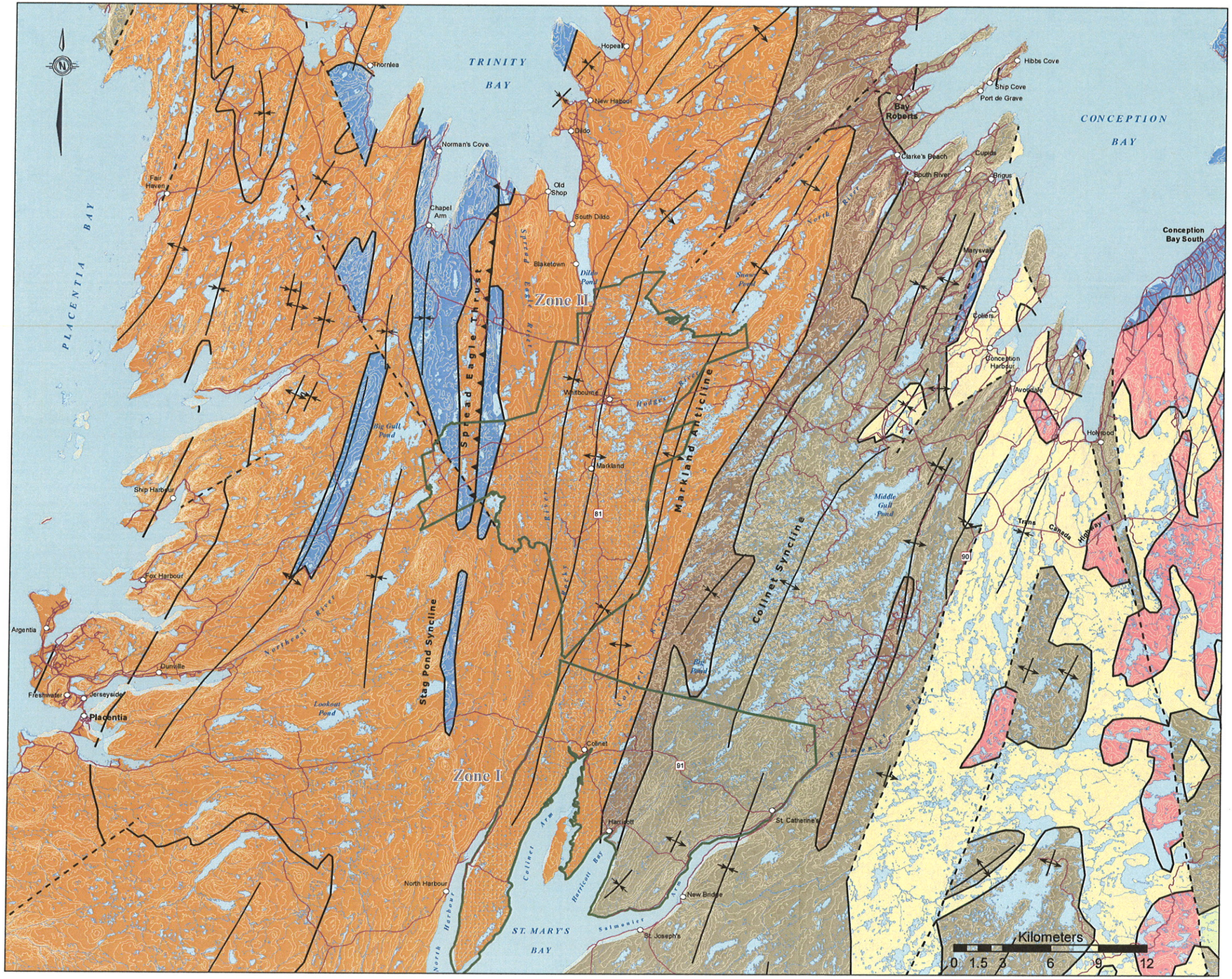
DD/MM/YEAR



Generalized Bedrock Geology Legend

AVALON ZONE

Stratified Rocks

Precambrian to Early Ordovician

- Shallow marine, mainly fine grained, siliciclastic sedimentary rocks, including minor unseparated limestone and volcanic rocks (Adeyton and Harcourt groups)

Precambrian

- Fluviatile and shallow marine siliciclastic sedimentary rocks, including minor unseparated limestone and bimodal volcanic rocks (Signal Hill Group; parts of Musgravetown, Long Harbour, Connaigre Bay, Marystown and Love Cove groups)
- Marine deltaic siliciclastic sedimentary rocks (St. John's Group)
- Sandstone and shale turbidites, including minor unseparated tillite, olistostromes and volcanic rocks (Connecting Point and Conception groups)
- Bimodal, submarine to subaerial volcanic rocks, including minor siliciclastic sedimentary rocks (Harbour Main Group, parts of Love Cove and Marystown groups)

Intrusive Rocks

Neoproterozoic to Cambrian

- Mafic intrusions
- Granitoid intrusions, including unseparated mafic phases

- Anticline
- Syncline
- 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:

MARKLAND ADA BEDROCK GEOLOGY

Jacques Whitford

SCALE: 1:250,000	DATE: 11/03/2008
DRAWN BY: JLB	CHECKED BY:
EDITED BY: JLB	REV. No. 0
DRAWING No.: 1034406-4-3	
MAP FILE: 1034406-XX.MXD	

APPENDIX 4b

Water Chemistry Data

Table 4.3 Surface Water Chemistry, Public Water Supply, Markland ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Whitbourne Hodges River WS-S-0779 (1987-2007)[1]		
			Irrigation Water	Livestock Water	Min	Max	Mean
Alkalinity	mg/L $CaC0_3$	na	na	na	0	10	5
Aluminum	mg/L	na	5	5	0.02	0.1	0.06
Ammonia	mg/L	na	na	na	0	0.38	0.08
Antimony	mg/L	0.006	na	na	0	0	0
Arsenic	mg/L	0.01	0.1	0.025	0	0.003	0.001
Barium	mg/L	1	na	na	0	0	0
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	0.01	0.003
Bromide	mg/L	na	na	na	0	0.03	0.02
Cadmium	mg/L	0.005	0.005	0.08	0	0.001	0.0003
Calcium	mg/L	na	na	na	1	3.55	2.02
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-
Chloride	mg/L	250*	100 - 700	na	7	18	13
Chromium	mg/L	0.05	na	na	0	0.005	0.002
Copper	mg/L	1*	0.2 - 1	0.5-5	0	0.03	0.004
Dissolved Organic Carbon	mg/L	na	na	na	2.3	10	5.3
Fluoride	mg/L	1.5	1	1 - 2	0	0.078	0.024
Hardness	mg/L $CaC0_3$	na	na	na	3	9	6
Iron	mg/L	0.3*	5	na	0.005	0.29	0.128
Kjeldahl Nitrogen	mg/L	na	na	na	0.03	0.45	0.22
Langelier Index	-	na	na	na	-6.44	-2.82	-4.97
Lead	mg/L	0.01	0.2	0.1	0	0.001	0.001
Magnesium	mg/L	na	na	na	0	1.04	0.71
Manganese	mg/L	0.05*	0.2	na	0.002	0.068	0.024
Mercury	mg/L	0.001	na	0.003	0	0.0005	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	0.025	0.006
Nitrite	mg/L	na	na	10	-	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-
pH	Units	6.5-8.5*	na	na	6.2	6.8	6.5
Potassium	mg/L	na	na	na	0	0.4	0.3
Reactive Silica	mg/L SiO2	na	na	na	-	-	-
Selenium	mg/L	0.01	0.02 - 0.05	0.05	0	0	0
Silver	mg/L	na	na	na	-	-	-
Sodium	mg/L	200*	na	na	5	13	8
Specific Conductance	uS/cm	na	na	na	35	86	61
Sulphate	mg/L	500*	na	1,000	0	6	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	27	128	48
Total Organic Carbon	mg/L	na	na	na	-	-	-
Total Phosphorus	mg/L	na	na	na	0	0.38	0.03
Total Suspended Solids	mg/L	na	na	na	1	2	1
True Color	TCU	15*	na	na	10	98	40
Turbidity	NTU	0.3/1.0/0.1**	na	na	0.19	0.9	0.52
Uranium	mg/L	0.02	0.01	0.2	0	0	0
Vanadium	mg/L	na	0.1	0.1	-	-	-
Canadian Water	-	-	-	-	81	88	85
Zinc	mg/L	5*	1 - 5	50	0	0.06	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 Department 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

"-" = Not analyzed

Shaded = Value does not meet applicable criteria

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

Table 4.4 Groundwater Chemistry, Private Drilled Wells, Markland ADA
Hydrogeology of Agricultural Development Areas, Newfoundland & Labrador

Parameter	Units	CDWQG	CWQG-AWU		Communities[1]					
					Colinet			Whitbourne	Chapel Arm	
			Irrigation Water	Livestock Water	11766	16944	16945	12768	10690	15701
Alkalinity	mg/L $CaC0_3$	na	na	na	70.2	53.5	74.7	111	52.9	76
Aluminum	mg/L	na	5	5	-	0.051	0.016	-	-	0.046
Ammonia	mg/L	na	na	na	-	0.048	0.021	-	-	0.017
Antimony	mg/L	0.006	na	na	-	-	-	-	-	0.001
Arsenic	mg/L	0.01	0.1	0.025	-	0.0007	0.0004	-	-	0.007
Barium	mg/L	1	na	na	-	0.026	0.158	-	-	0.27
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	-	-	-	0.02
Bromide	mg/L	na	na	na	-	-	-	-	-	-
Cadmium	mg/L	0.005	0.005	0.08	-	-	-	-	-	0.0001
Calcium	mg/L	na	na	na	9.8	15.4	24.33	21	11	13.5
Carbonate	mg/L $CaC0_3$	na	na	na	-	-	-	-	-	-
Chloride	mg/L	250*	100 - 700	na	12.8	11.9	23.5	5.6	36	60.3
Chromium	mg/L	0.05	na	na	-	-	-	-	-	-
Copper	mg/L	1*	0.2 - 1	0.5-5	-	0.016	0.011	-	0.01	0.01
Dissolved Organic Carbon	mg/L	na	na	na	-	-	-	-	-	0.4
Fluoride	mg/L	1.5	1	1 - 2	0.12	0.127	0.082	0.15	0.2	0.08
Hardness	mg/L $CaC0_3$	na	na	na	39.9	51.6	74.6	70.2	54.4	37.9
Iron	mg/L	0.3*	5	na	0.01	0.033	-	0.01	0.31	0.073
Kjeldahl Nitrogen	mg/L	na	na	na	-	-	-	-	-	-
Langelier Index	-	na	na	na	-	-	-	-	-	-
Lead	mg/L	0.01	0.2	0.1	-	0.0048	-	-	-	0.001
Magnesium	mg/L	na	na	na	3.75	3.2	3.37	4.32	2.3	1.02
Manganese	mg/L	0.05*	0.2	na	0.005	0.003	-	0.005	**0.38**	0.14
Mercury	mg/L	0.001	na	0.003	-	-	-	-	-	-
Nickel	mg/L	na	0.2	1	-	-	-	-	-	-
Nitrate	mg/L N	45	na	na	-	0.88	0.06	-	-	-
Nitrate + Nitrite	mg/L N	na	na	100	0.189	0.92	0.13	0.004	0.55	0.55
Nitrite	mg/L	na	na	10	0.001	0.04	0.07	0.001	-	-
Orthophosphate	mg/L P	na	na	na	-	-	-	-	-	-
pH	Units	6.5-8.5*	na	na	6.8	7.44	7.89	7.89	-	8.4
Potassium	mg/L	na	na	na	0.59	0.99	2.22	2.26	2.7	1.54
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	7.1	12.1	17.4	24	35	55.5
Specific Conductance	uS/cm	na	na	na	119.2	160	228	198.2	-	347
Sulphate	mg/L	500*	na	1,000	2.8	3.12	3.8	4.5	12	15.5
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	81	90	120	144	145	200
Total Organic Carbon	mg/L	na	na	na	-	-	-	-	-	-
Total Phosphorus	mg/L	na	na	na	0.01	-	-	0.01	0.02	0.02
Total Suspended Solids	mg/L	na	na	na	-	1	1	-	-	-
True Color	TCU	15*	na	na	-	-	-	-	-	-
Turbidity	NTU	0.3/1.0/0.1**	na	na	-	0.8	0.7	-	-	1.1
Uranium	mg/L	0.02	0.01	0.2	-	-	-	-	-	-
Vanadium	mg/L	na	0.1	0.1	-	-	-	-	-	-
Zinc	mg/L	5*	1 - 5	50	0.29	0.007	0.003	0.01	0.03	0.03

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

na = No applicable criteria

* = Aesthetic objective

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