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GRANULAR AGGREGATE RESOURCE MAPPING ON THE SOUTHERN AVALON PENINSULA (NTS MAP AREAS 1K/11, 12, 13, 14, 15 AND 1L/16)

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ABSTRACT

Granular aggregate mapping on the southern Avalon Peninsula is part of a continuing regional survey to locate aggregate deposits to alleviate construction problems, resulting from aggregate shortages and poor-quality aggregate found in the immediate area. Follow-up survey work was conducted in some of the resource areas previously mapped in 2006 (NTS map areas 1K/11, 14 and 15). Other deposits previously identified from aerial photographs were sampled, and mapping was extended in the adjoining NTS map areas 1K/12, 13 and 1L/16.

Sand and gravel deposits were identified at many locations throughout the surveyed area, and although many are small, there are several large deposits that can support a quarry operation for many years. These deposits vary in texture from medium-grain sands to cobble–boulder gravel, and range in quantity from 10 000 m^3 to 5 000 000 m^3. Most deposits are within 1 km of a road and have potential for use in road upgrading, for winter ice-control, or for local community use.

INTRODUCTION

Aggregate can be defined as any hard, inert material such as gravel, sand, crushed stone or other mineral material that is used in the construction industry. The demand for aggregate is closely associated with construction activity, and road construction and maintenance is by far the most important use of mineral aggregates. Water and sewer systems, driveways, building foundations, backfill and landscaping, all require aggregate. Aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to the marketplace, as well as its quality and size (Vanderveer, 1982). Comprehensive planning and resource-management strategies are required to make the best use of available resources, especially in areas experiencing rapid development. Such strategies must be based on sound knowledge of the total mineral aggregate-resource base at both local and regional levels.

Aggregate materials can be, i) processed and used as Class A gravel (aggregate with a diameter of less than 19 mm having a specified proportion of finer grain sizes and 3 to 6 percent silt–clay; Department of Transportation, 1999) or Class B gravel (aggregate with a diameter of less than 102 mm, having a specified proportion of finer grain sizes and 3 to 6 percent silt–clay (Department of Transportation, 1999), ii) processed to mix with a cementing agent to form concrete, asphalt and mortar, or iii) used as unprocessed, out of pit material.

The suitability of quarry materials for aggregate use depends on their composition. The silt–clay quantity is important; high silt–clay volumes can cause instability, such as flowage; low silt–clay volumes can result in loss of compaction. Too much silt–clay in concrete (>2 percent) can interfere with the bonding process between the aggregate and the cementing agent. High silt–clay aggregate (greater than 15 percent) can be used for earth filled dams, fill and sub-grade road material. The presence of deleterious substances (such as silt–clay coatings or iron oxide staining on the surface of the aggregate), or of blade shaped fragments, can cause bonding problems with the cementing agent, or the breakdown of aggregate with time.

Knowledge of the nature and distribution of the surficial aggregate deposits (sand, gravel and other low silt–clay materials) can assist in estimating construction cost of projects requiring aggregate. When it is necessary to identify new aggregate sources for production of large quantities of construction material, the surficial geology of the area and the bedrock lithology are important considerations. In a large-scale operation, it might be more economical to truck granular products longer distances than use inferior material close at hand; processing cost could be lower and the quality of the product higher, therefore, offsetting the high cost of transportation.

The suitability of aggregate also depends on physical properties and the capability of the rock to withstand stresses placed upon it when it is used as a construction material.

The lithology of the pebble fractions (16 to 32 mm) has been evaluated to define petrographic characteristics (Canadian Standards Association, 1973; Bragg, 1995; Ontario Ministry of Transportation, 1994). The petrographic number can range from 100 to 1000, and is derived by taking the sum of the percentage of each rock type present in the pebble fraction (in a sample of approximately 100 pebbles) multiplied by a petrographic factor (based on soundness and durability) assigned to that rock type (Ricketts and Vatcher, 1996). The petrographic factor is determined mostly by the type and grain size of the rock in a given sample, and also by weathering (fresh, slightly, moderately, highly, or intensely weathered), staining, sphericity, and rounding and fracturing. The lower the petrographic number, the better the quality of aggregate material. For example, clean, hard, fresh granite would normally have a petrographic number of 100, whereas soft, friable, weathered shale would have a petrographic number of 1000. Most deposits contain a combination of different rock types having different petrographic factors. The proportion of each of these components determines the petrographic number. For most purposes, aggregate material used in concrete requires a petrographic number of 135 or less, whereas in road asphalt and Class A and B gravels a petrographic number up to 150 is acceptable (Department of Transportation, 1999). The presence of silt–clay coatings (clean, thin, medium, or thick), rounding of pebbles, and the number of fracture faces and their sphericity are important considerations in using an aggregate for concrete. These factors affect the bonding capabilities of concrete, the amount of water necessary to make a concrete, which has a direct relation to the strength of a concrete.

LOCATION AND PHYSIOGRAPHY

The study area is located on the Avalon Peninsula, Newfoundland (Figure 1), south of latitude 47°00'. It covers six 1:50 000-scale map areas (Figure 2); Trepassey (NTS map area 1K/11), St. Shotts (NTS map area 1K/12), St. Mary's (NTS map area 1K/13), Biscay Bay River (NTS map area 1K/14), Renews (NTS map area 1K/15) and St. Bride's (NTS map area 1L/16). The topography varies from generally rolling hills and areas of bog, to stony, barren surfaces and the gently sloping shorelines around St. Mary's Bay. Elevations are generally less than 175 m above sea level (asl), a few areas rising to about 215 m, and northeast of Holyrood Pond rising more than 240 m asl. Like most of Newfoundland, the area has numerous small streams and ponds. Till is the dominant overburden in the area, generally thicker in the eastern and northern parts of the study area. Glaciofluvial deposits are more common in valley areas along the coastline and bog cover is common throughout the map area.

Table 1. Description of aggregate material based on grain-size characteristics

Description	Composition
Silty sand	5 to 20% silt
Sand	>95% sand
Gravelly sand	5to 20% gravel
Very gravelly sand	>20% gravel
Sand-gravel	About equal
Very sandy gravel	>20% sand
Sandy gravel	5 to 20% sand
Gravel	>95% gravel

PREVIOUS WORK

The Avalon Peninsula was covered by an ice cap centred over St. Mary's Bay that subsequently disintegrated into a number of smaller dispersal centres along the major peninsulas of the Avalon (Summers, 1949; Henderson, 1972). Most glaciofluvial deposits associated with melting of the ice cap were deposited down the major valleys and are found offshore today (Henderson, 1972).

Catto (1998) interpreted the glacial limits of the Avalon mostly from striations and glacial landflow, and recognized three phases of glaciation. Phase One marked the accumulation of ice centres along the axes of the major peninsulas, and expansion seaward. During Phase Two, lowering sea level allowed the development of an ice centre in St. Mary's

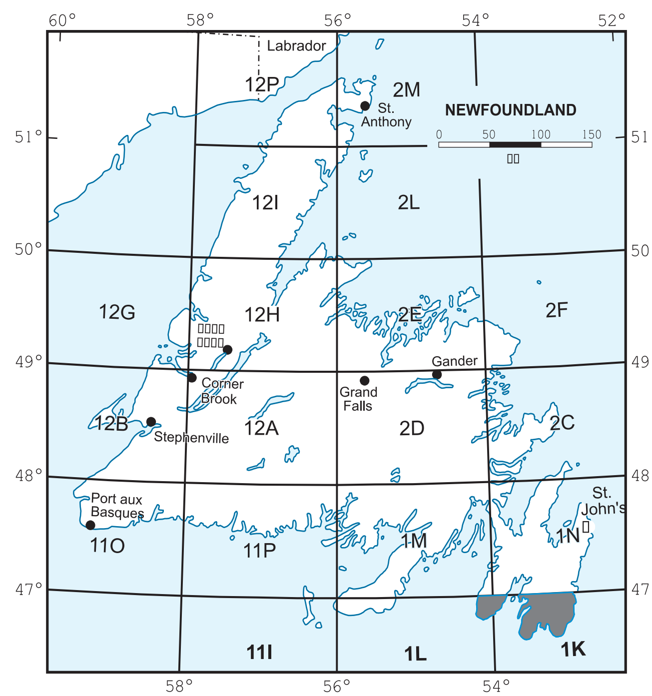

Figure 1. *Location of study area.*

Bay that expanded north, covering most of the Avalon. Phase Three was marked by the collapse of the St. Mary's Bay ice centre, rapid drawdown of ice into St. Mary's and Conception bays, and the persistence of the Trinity Bay ice stream. Ice became centred again on the main peninsulas, some of which actively retreated while others stagnated.

McKillop (1955) released a preliminary report on a survey of beaches throughout the area, provided detailed description of most beaches, including type of beach (bar or strand), their dimensions, size of material, lithology, and sometimes the sphericity and rounding of material. McKillop (*op. cit.*) also provided recommendations for the types of local or general use to which these resources may be applied. In recent years, beach removal has been restricted or banned entirely, due to erosion and damage to roads and property in back beach areas.

Surficial geological maps by Catto and Taylor (1998a, b, c, d, e, and f) at a 1:50 000 scale showed deposit types, and ice-flow features. Liverman and Taylor (1989) compiled surficial data at 1:250 000 scale and later released this data in digital format (Liverman and Taylor, 1994).

An aggregate resource study was conducted by the Department of Mines and Energy from 1978 to 1982 (Environmental Geology Section, 1983a and b; Kirby *et al.*, 1983) that covered a 6-km-wide corridor along all roads in Newfoundland and Labrador. This study outlined areas of potential aggregate within the corridor area. In addition to these data, geotechnical bedrock maps were compiled at a scale of 1:250 000 (Bragg, 1985). Later, Bragg (1994) released site location maps at 1:50 000 scale showing rock types and petrographic numbers; this was followed by a report (Bragg, 1995) that contained information on the petrographic quality of different rock types to determine their potential use as construction aggregate.

MAPPING AND ANALYTICAL METHODS

Assessing the potential use and value of granular aggregates can be complex, especially so when a variety of different material types (having different specifications) occur within any given aggregate deposit. Interpretation of airphotos (1:50 000-scale black-and-white, 1:20 000-scale black and white and 1:12 500 colour) is the first stage in locating potential deposits. Airphoto interpretation is used often to produce preliminary landform classification maps; these maps show the distribution and nature of the various sediment types found within an area. Commonly they show a variety of tills, sand, and gravel deposits. Till is a sediment deposited by glaciers, and is characterized by wide ranges in grain sizes. Sand and gravel are commonly formed by fluvial action, either by glacial meltwater or streams, or could be deposited along the present modern coastlines or on raised beach. Granular aggregate maps are a derivative of landform classification maps supplemented by ground-checking and sampling; these maps subdivide potential aggregate deposits into high, moderate, or low potential for aggregate production. The size of the deposit can be determined if its areal extent and average thickness are known or can be estimated. Thickness values are approximations, based on the face heights of pits developed in the deposit, roadside exposures or features of the general landscape such as the height of ridges or terraces above the surrounding terrain. From all data, individual deposits may be assigned one of four zones, with Zone 1 being the area of highest potential (Kirby *et al.*, 1983).

In addition to the data collected from aerial photographs, information on the various sediment types was obtained in the field by examining natural exposures (*e.g.*, stream cuts, shorelines, and gullies) or man-made exposures (*e.g.*, roadcuts, and pit and quarry excavations). Where exposures were not available, samples were collected from 1-m-deep hand-dug pits. In some places, hand-dug pits were not practical because of boulders or a thick, cemented B-horizon, making it difficult to see the undisturbed original material. Lack of exposures meant that deposit thickness was difficult to assess. The scarcity of vertical sections, combined with the presence of a concealing surface mat of organic material in many places, made positive interpretation of the nature and extent of the glacial sediments heavily dependent upon evaluation of the geomorphology. Thus, in most instances, surface form was an important aspect in recognition of the unit mapped. Obvious landform boundaries were the basis of much delineation. Other features recorded in the field were sediment thickness, stoniness, presence of compact layers and the presence of vegetation.

Approximately 15 kg of material were collected for field sieving at each site. Field sieving and petrographic analyses were performed on most samples containing >8 mm size material (Ricketts, 1987). A split (70 to 140 g) of the sand–silt–clay fraction (<8 mm) was retained for laboratory sieve analysis, which involved drying and splitting the sample to a manageable size (70 to 140 g) and wet and/or dry sieving of each sample following the procedures outlined by Ricketts (1987). This data was used to outline zones of aggregate potential on aggregate resource maps.

AGGREGATE POTENTIAL

Till is widespread over the area, varying in composition, commonly in relation to the underlying bedrock. Sandstone may produce a till having a sandy matrix, and siltstone produces a till having a silty matrix. In some localities, loosely compacted sandy tills, overlying well-compacted

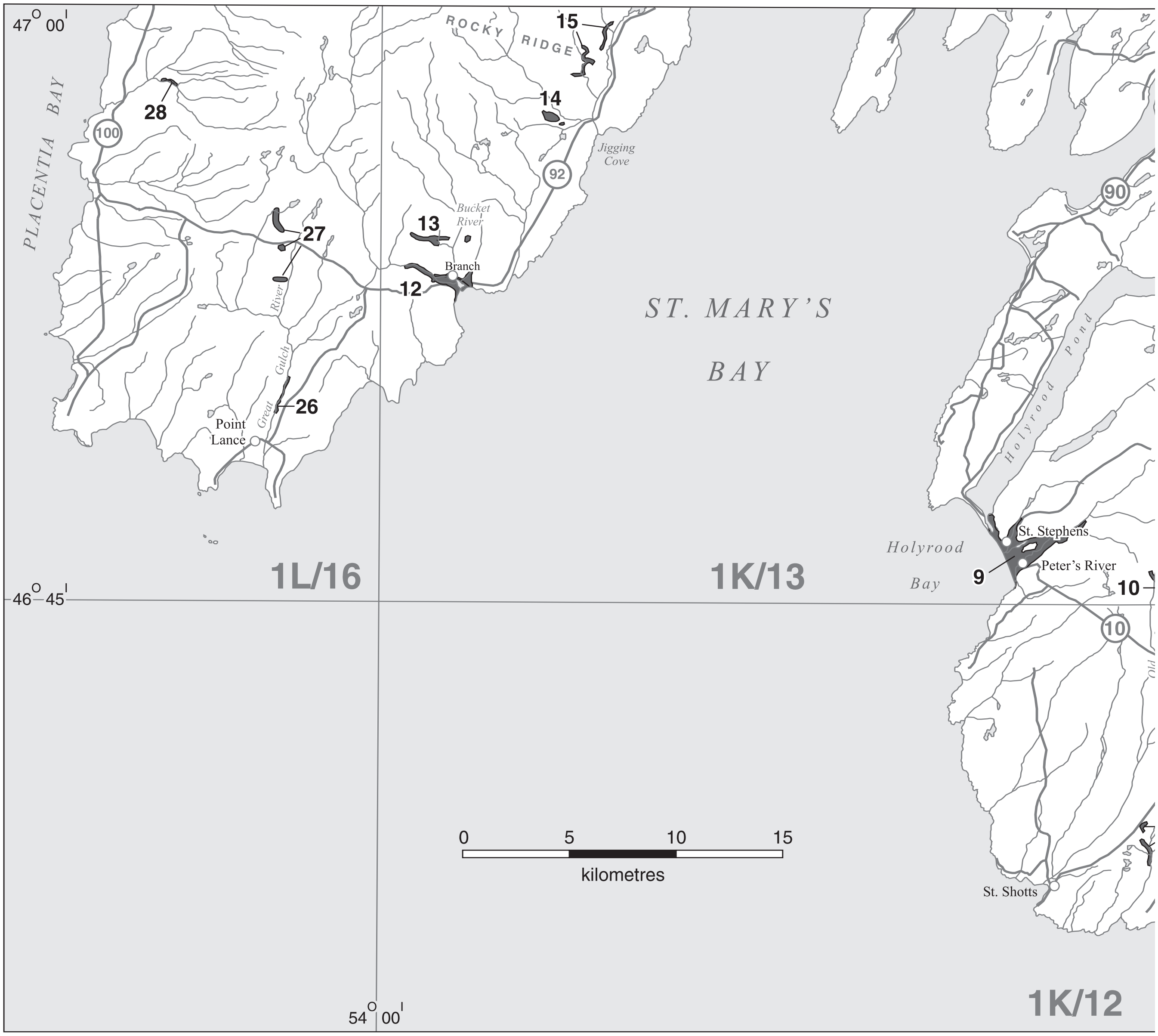

Figure 2. *Granular aggregate deposit locations in the southern part of the Avalon Peninsula.*

silty till was noted. Generally tills have a silt–clay content of 15 to 30 percent, which renders most of these deposits unsuitable for most construction purposes, unless first washed to remove the silt. Potential quarry sites for low silt–clay tills will be outlined on 1:50 000 scale maps to be released as open-files in 2008.

Glaciofluvial deposits, such as eskers, terraces and deltas, are generally the most suitable deposits for aggregate material. These deposits are commonly clean sand and gravel materials with low silt–clay, deposited by meltwater from glaciers. Some eskers in the study area form multiple ridges where they diverge at one or more places to form esker complexes. Most of the larger esker ridges contain gaps of varying lengths (Northwest Brook, Biscay Bay River, Rocky Ridge and Bucket River) where material either was not deposited or has been removed by erosion. Gaps may be no more than the width of a small stream or they may be tens of metres or kilometres. Eskers generally vary in height up to 8 m, with a few eskers reaching heights of 10 to 12 m and averaging around 5 or 6 m. Based on sample grain-size data, all deposits outlined appear to contain clean sources of aggregate, ranging from approximately 10 000 to 5 000 000 m^3. Several deposits are within one kilometre of major roads. Other deposits are less accessible, or are too small to outline as potential resource areas. A total of 143 samples were collected for grain-size analyses, mostly from 1-m-deep hand-dug pits. Petrographic analyses were completed

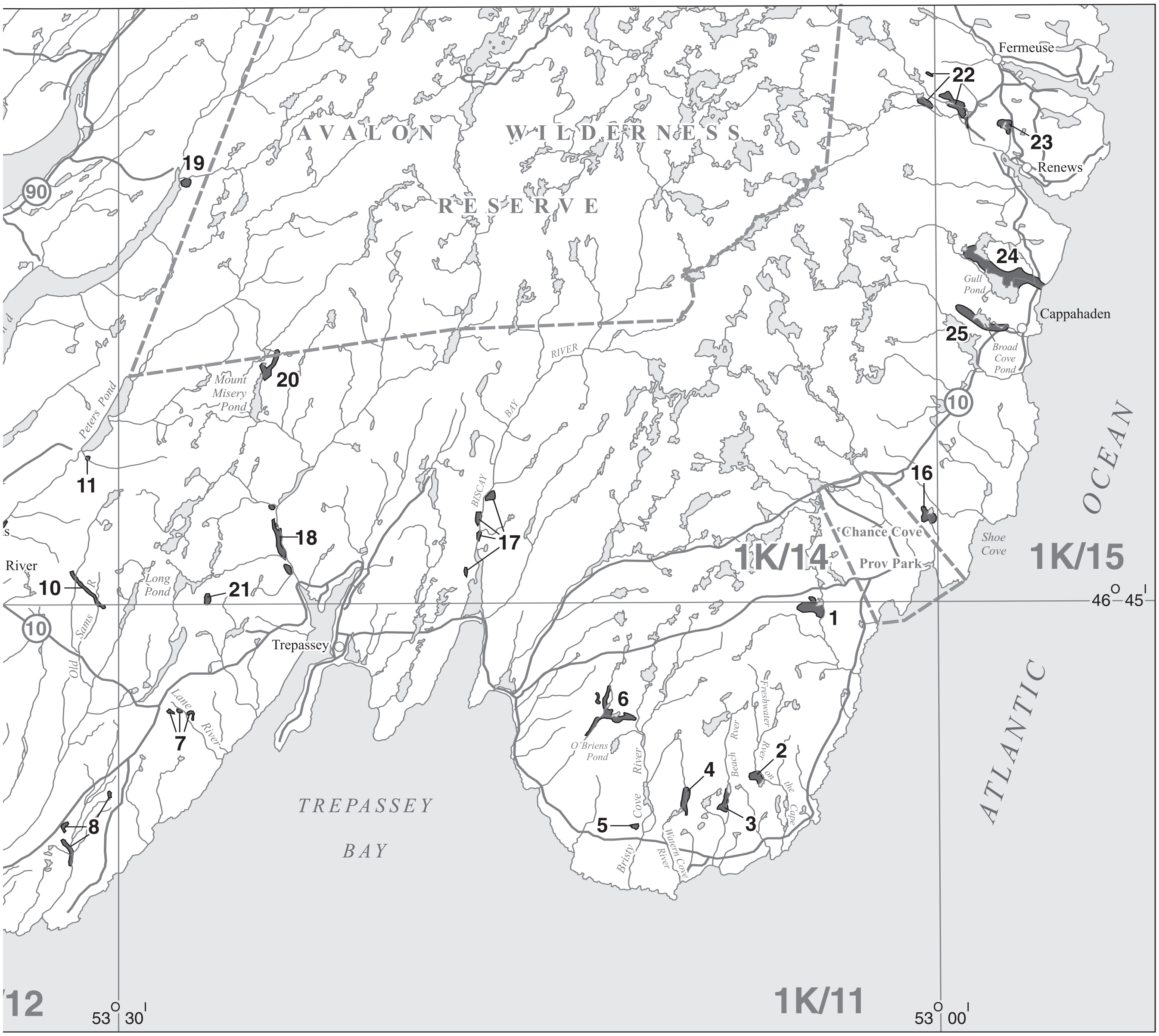

Figure 2. *Continued.*

on 116 pebble samples, and show a range of petrographic numbers from 100 to 500 (Table 2). Although reserves are large in some areas, the presence of varying amounts of weathered shale, siltstone and sandstone decreases their petrographic quality.

In most deposits, sample analysis indicate clean, coarse aggregates showing less than two percent silt–clay and variable sand–gravel concentrations. Although some deposits listed in Table 2 indicate a sandy gravel or very sandy gravel texture (Table 1), cobbles and boulders may be common in some areas but are not indicated in sieve analyses for logistical reasons (too large to be accurately weighted in field sieves). Where cobbles and boulders are common, percentages are estimated by field observations at sample-site locations. Twenty-six of the twenty-eight deposits listed range from gravelly sands to cobble–boulder gravels, and are mostly suitable for coarse-grained aggregate uses. Only two deposits, at Point Lance and Shoe Cove, could be classified as fine-grained aggregate deposits. Other deposits may be quarried for fine-grained aggregate, but will have greater volumes of waste material if the coarse fraction is not used. Deposits identified in the study area are summarized by NTS map areas. These NTS map areas are 1K/11, 1K/12, 1K/13, 1K/14, 1K/15 and 1L/16.

Table 2. Summary of sample data collected from glaciofluvial deposits in the southern Avalon Peninsula

Deposit	Estimated m3	No. Of Samples Analyzed	Mean Grain-size Analyses % Gravel (+5 mm)	% Sand (.078mm to -5 mm)	% Sl-Cl (-.078)	Petrographic Numbers (PN) No Of Samples Analyzed	PN Average	PN Range	Notes	Texture
1. Chance Cove Provincial Park	600 000	5	76.4	23.3	0.3	5	116	110-122	Eskers & hummocks	Boulder, cobble and gravel
2. Freshwater River on the Cape	50 000	1	77.9	21.6	0.5	1	106		Hummocks	Boulder-cobble gravel
3. Beach River	80 000	2	63.2	36.5	0.3	2	114	108-121	Esker complex	Sandy gravel & sandy-cobble-gravel
4. Watern Pond	15 000	3	70.3	29.6	0.1	3	118	113-123	Esker	Gravel and pebble-coarse sandy gravel
5. Bristy Cove River	15 000	2	70.7	28.4	0.9	2	118	112-125	Esker	Gravel and boulder-cobble, sandy gravel
6. O'Briens Pond	1 000 000	6	77.6	22.2	0.2	6	103	101-105	Esker	Gravel, pebble-cobble, and cobble-boulder
7. Lane River	20 000	2	81.7	18.2	0.1	2	117	104-130	Esker	Gravel, and cobble gravel textures
8. St. Shotts	10 000	8	76.8	22.9	0.3	4	125	102-142	Esker	Gravel, sandy-gravel, and boulder-cobble-pebble gravel
9. Peter's River- St. Stephens	5 000 000	14	74.7	24.6	0.7	13	123	100-175	Terrace	Gravel and boulder gravel
10.Old Sams River	60 000	3	82.7	17.2	0.1	3	112	103-119	Esker	Pebble gravel, gravel and cobble-pebble gravel
11.Peters Pond	200 000	1	81.9	17.0	1.1	1	127		Delta	Gravel
12. Branch	500 000	3	68.9	30.8	0.3	4	410	345-500	Terrace	Silty, and boulder-cobble gravel
13. Bucket River	190 000	8	70.1	28.9	1.0	7	255	165-350	Esker	Pebble-cobble to very sandy gravel
14.Jigging Cove	200 000	2	77.5	22.4	0.1	2	111	108-114	Esker & hummocks	Cobble to very sandy gravel
15.Rocky Ridge	200 000	6	71.0	28.2	0.8	4	128	114-164	Esker	Boulder, pebble and very sandy gravel
16. Shoe Cove	25 000	3	46.0	53.7	0.3	3	108	100-118	Esker complex	Sand-gravel to very sandy gravel
17. Biscay Bay River	150 000	5	66.7	32.7	0.6	3	110	103-119	Esker complex	Cobble to very sandy gravel
18. Northwest Brook	600 000	10	70.2	29.6	0.2	7	103	100-107	Delta & eskers	Boulder, pebble and very sandy gravel
19. Holyrood Pond	200 000	2	61.6	37.6	0.8	2	125	121-128	Delta	Boulder gravel and very sandy gravel
20. Mount Misery Pond	10 000	3	71.4	28.0	0.6	3	104	102-105	Eskers	Boulder to sandy gravel and sand
21. Long Pond	80 000	3	55.8	43.5	0.7	2	110	113-107	Esker gravel	Boulder to sandy gravel and sand
22. Fermuse	120 000	8	70.7	29.0	0.3	8	114	101-133	Terrace and eskers	Gravelly sand
23. Renews	350 000	2	71.9	27.3	0.8	2	110	106-113	Delta & esker	Cobble-boulder to very sandy gravel
24. Gull Pond	120 000	5	60.8	38.7	0.5	5	129	114-167	Esker	Cobble to very sandy gravel
25. Broad Cove Pond	40 000	4	64.7	33.6	1.7	2	120	112-128	Esker	Boulder-cobble to very sandy gravel
26. Point Lance	300 000	1	9.9	89.4	0.7	1	307		Terrace	Gravelly sand
27. Great Gulch River	100 000	10	62.9	36.9	0.2	8	317	199-449	Esker	Cobble-boulder to very sandy gravel
28. Cuslett	70 000	2	74.8	25.1	0.1	2	248	216-281	Terrace	Cobble to very sandy gravel

Note: Estimated quantities in table are based on airphoto analysis, and field investigations along road cuts, shallow hand-dug pits and natural exposures. Grain-size results and petrographic numbers (PN) are based on a compilation of sample data for each deposit.

SURVEY RESULTS

In NTS map area 1K/11 there are 7 notable deposits of esker and hummocky gravels (Figure 2). Deposits in the northeast and east part of the map area are located near Chance Cove Provincial Park, Freshwater River on the Cape, Beach River (Plate 1), Watern Pond, Bristy Cove River, and O'Briens Pond (Plates 2 and 3). One deposit was sampled in the west part of the map area, near Lane River (Plate 4). All deposits appear to be clean sources of gravel and sand with variable textures of gravel, pebble–cobble and cobble–boulders (Table 2). Only the deposits at Beach River indicate a significant amount of sand (36.5% sand). All other deposits contain less than 30% sand. All deposits have good petrographic qualities, resulting from mostly siliceous siltstone and sandstone common throughout the area. Petrographic numbers range from 101 to 130.

Plate 1. *Part of esker ridge complex near Beach River in NTS map area 1K/11. Ridges average about 9 m high.*

In NTS map area 1K/12, there is one area of interest for sand and gravel potential, located along the St. Shotts road, 4 to 7 km northeast of St. Shotts (Figure 2). This area consists of a number of esker ridges, ranging in height from 3 to 5 m. Textures at 8 sample sites vary from sandy gravel to boulder–cobble–pebble gravel (Table 2). Sand content varies between 11 and 33% in samples collected in this area. Petrographic quality is generally good, consisting of mostly hard sandstone and siltstone. Petrographic numbers of 4 samples analyzed are 102, 126, 129 and 142. Quarry activity near the road has depleted part of this esker system, but about 50 000 m^3 of aggregate remains.

In NTS map area 1K/13, there are 7 notable deposits. These deposits are located at Peter's River–St. Stephens (Plate 5), the south end of Peters Pond, Old Sams River along the Branch River, near Bucket River (Plate 6), along

Plate 2. *Part of an esker system located north of O'Briens Pond in NTS map area 1K/11. The esker averages 6 to 8 m in height, but may reach 10 to 12 m in places.*

Plate 3. *A 6 m exposure of sandy gravel, along side of 7-m-high esker, north of O'Briens Pond in NTS map area 1K/11.*

Red Head River near Jigging Cove, and east of Rocky Ridge. Sand content in these deposits vary from 17.0% to 30.8% based on average analyses from the samples collected (Table 2). These deposits are quite variable in petrographic quality. In the west, near Branch, the underlying bedrock contains large amounts of shale, which leads to the poor petrographic quality of material derived from it. Samples collected in the Branch River and Bucket River deposits had petrographic numbers ranging from 165 to 500. In the north and east part of this map area, the bedrock geology consists mainly of hard sandstone, siltstone and arkose, resulting in good petrographic quality as indicated in samples collected in deposits near Peter's River–St. Stephens, Old Sams River, Peters Pond, Jigging Cove and Rocky Ridge. Petrographic numbers in these areas range from 100 to 175.

Plate 4. *The Lane River esker is a 400-m-long and 5-m-high ridge located 1.3 km east of Route 10 in the northwest part of NTS map area 1K/11.*

Plate 5. *A 5-m-high sandy gravel exposure along stream bank near Peter's River in NTS area 1K/13. The deposit may be up to 30 m thick in some areas.*

Plate 6. *Dissected esker ridge located 1 km north from the community of Branch, near Bucket River in NTS map area 1K/13. The ridge is over 2.5 km long and 6 to10 m high.*

Plate 7. *A 5-m-high esker near Biscay Bay River in NTS area 1K/15. The esker may be up to 10 m high at some locations.*

In NTS map area 1K/14, there are 6 notable deposits. These deposits are located west of Shoe Cove, along Biscay Bay River (Plate 7), along Northwest River, near the northeast end of Holyrood Pond, near the north end of Mount Misery Pond, and near Long Pond (Figure 2). In the Shoe Cove deposit, the average sand content is 53.7%, and up to 94% at one sample location. Other deposits in this area show a range of sand content from 28% to 43.5% based on averages from samples collected in each deposit (Table 2). The main rock types in this area are siliceous siltstone and sandstone that have very good petrographic quality. Petrographic numbers range from 100 to 128.

In NTS map area 1K/15, the largest deposits were sampled southwest of Fermuse (Plate 8), northwest of Renews, Gull Pond, and Broad Cove Pond (Figure 2). Based on sample data from these areas, the deposits contain between 27% to 39% sand and 0.3% to 1.7% silt–clay (Table 2). The main rock types in this area are siliceous siltstone and sandstone that have very good petrographic quality. Petrographic numbers range from 101 to 167.

In NTS map area 1L/16, the deposits were sampled near Point Lance, Great Gulch River and Cuslett. Near Point Lance samples were collected from a 1.8 m exposure at the top of a 4- to 5-m-high gravel and sand terrace (Figure 2). Gravel was sampled from the top 0.7 m (containing 20.6% sand), over a sand unit containing 9.9% gravel. Deposits at Great Gulch River and Cuslett contain 36.9% sand and 25% sand based on sample analyses. The bedrock geology in this

Plate 8. *Esker ridge 2 km southwest of Fermeuse in NTS area 1K/15. It is part of an esker complex with ridges 350 to 700 m long and 4 to 7 m high.*

area has large zones of shale, which is reflected in the poor petrographic quality of samples collected in the area. Petrographic numbers range from 216 to 344.

SUMMARY

Aggregate mapping on the southern Avalon Peninsula indicates that there are many sources of good quality gravel and sand that have a low silt–clay content, low petrographic numbers, and accessibility. Several deposits may be too small, or their accessibility from roads may make the economics of quarry activity unfeasible. There are a few deposits where poor petrographic quality will be a major deterrent. However, the physical properties of most deposits are good and they are located close to roads or can be easily accessible by building short access roads.

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