NORTHEAST BRITISH COLUMBIA AGGREGATE MAPPING PROGRAM: A SUMMARY OF SELECTED AGGREGATE OCCURRENCES NORTHEAST OF FORT NELSON

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ABSTRACT

The main objective of the Northeast British Columbia Aggregate Mapping Program is to complete an inventory of new and existing local sources of aggregate in areas where there is a high demand. Mapping aggregate potential in the region has been challenging due to the subdued topography and ubiquitous presence of thick organics and clay-rich morainal and glaciolacustrine sediments. Various innovative methods and data sets have been employed to meet program objectives. To date, the program has identified eight aggregate deposits northeast of Fort Nelson, in the vicinity of the Sierra-Yoyo-Desan (SYD) Road, that contain a total resource of >6 000 000 m^3 of aggregate. Twenty-five sand and gravel prospects have also been discovered in the same region. All are contained within a mappable geomorphic or geophysical feature and have been field tested. Based on the genesis and size of the mappable feature, field observations, and a preliminary assessment of aggregate demand, the majority of these newly identified prospects have high potential to host an economic sand and gravel deposit.

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INTRODUCTION

The Northeast British Columbia Aggregate Mapping Program was initiated by the British Columbia Ministry of Energy and Mines (MEM) in order to meet the construction aggregate needs of the province's growing oil and gas industry (Levson *et al.*, 2004). The objectives of this program are to: 1) carry out a regional-scale inventory of existing and new local sources of construction aggregates; and 2) conduct detailed area-specific aggregate potential investigations to address aggregate needs of provincially supported road initiatives such as the Royalty Credit Road Program, the Sierra-Yoyo-Desan (SYD) Road upgrade, and the Heartlands Oil and Gas Road Rehabilitation Strategy (HOGRRS). Various innovative methods and data sets have been employed to meet these objectives including, but not limited to, airborne geophysics, light detection and ranging (LiDAR) and RADARSAT digital elevation models (DEMs), and waterwell, shot hole, and conductor pipe logs. The reader is directed to more detailed discussions on the use of these methods and data sets provided by Best *et al.* (2004), Levson *et al.* (2004), Demchuk *et al.* (2005), and Best *et al.* (in press). The purpose of this paper is to summarize selected new aggregate deposits and prospects discovered over the past two years.

LOCATION AND PHYSIOGRAPHY

This paper focuses on selected aggregate prospects that occur within NTS map areas 94I, J, and P (Figure 1). Occurring mainly within the Fort Nelson Lowlands physiographic region, a subdivision of Canada's Interior Plains (Holland, 1976), this area has flat to subdued topography that reflects the horizontally bedded sedimentary rocks that underlie the region. The combination of low-relief topography and clay-rich soils results in poor drainage with a shallow water table in most areas. As such, small (<5 ha) shallow lakes, and narrow (<3 m), often meandering, low gradient streams are common.

The Etsho Plateau (Figure 1) is a prominent physiographic feature located in the central portion of the study area and is considered to be an outlier of the Alberta Plateau (Holland, 1976). Rising approximately 350 m above the surrounding Fort Nelson Lowlands, to an elevation of approximately 700 m above mean sea level, the plateau area forms a broad topographic high about 140 km long and 80 km wide, that trends roughly northwest. The surrounding lowlands are areally-extensive and continue north into Northwest Territories and east into Alberta. Relief in these low areas is negligible.

In topographic lows, and on level ground, black spruce (*Picea mariana*) dominate. These trees commonly occur in close association with thick peat deposits, forming areally-extensive black spruce bogs. Areas that

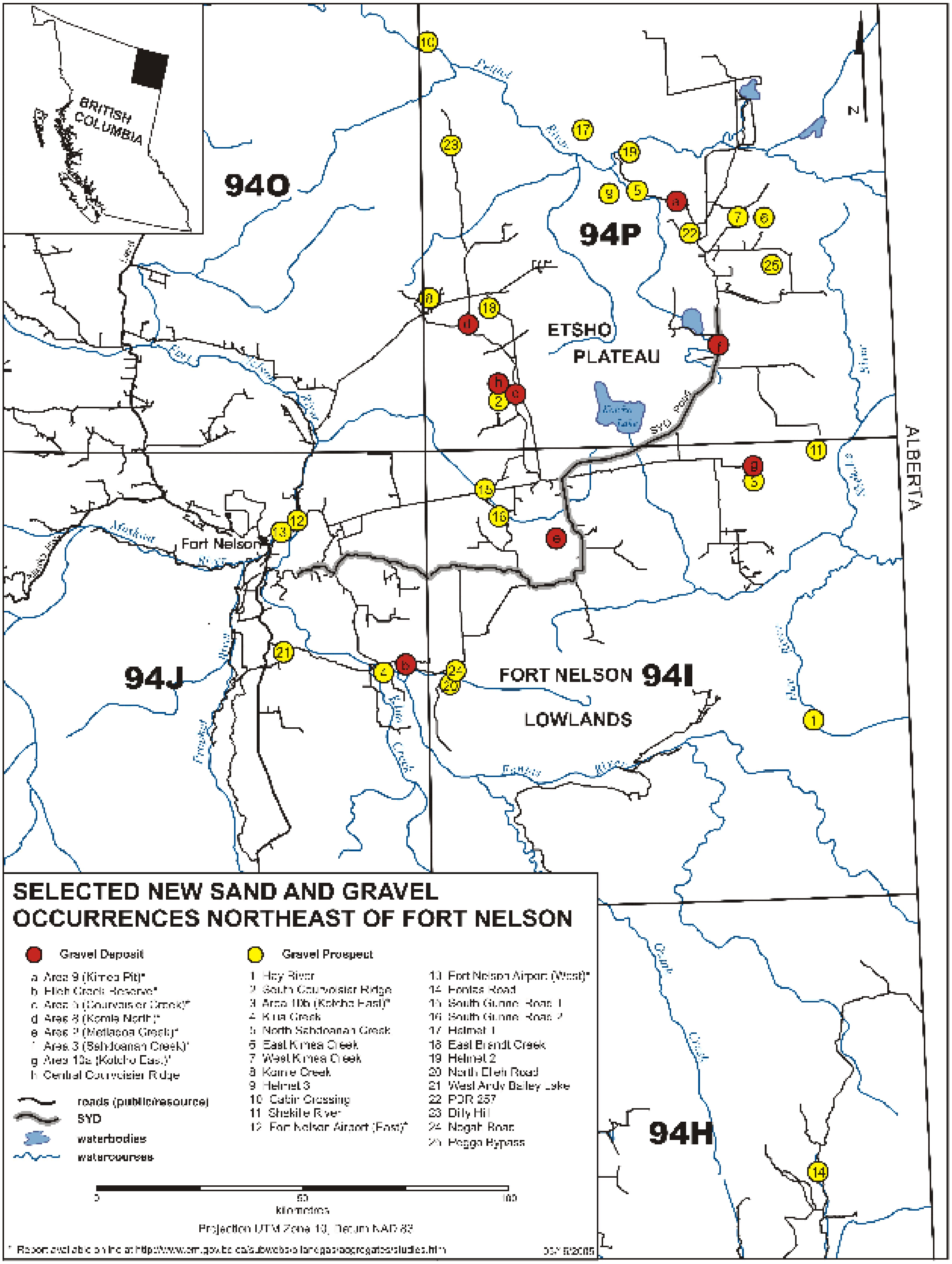

Figure 1. Location of selected new sand and gravel deposits and prospects northeast of Fort Nelson.

are elevated, even slightly (<1 m), above the regional water table are largely forested with trembling aspen (*Populus tremuloides)* and white spruce (*Picea glauca*). Lodgepole pine (*Pinus contorta* var. *latifolia*) is most commonly observed on this higher ground but does grow locally in black spruce bogs.

The study area is mainly accessible by helicopter and all terrain vehicle (ATV). Truck access during summer months is limited to a small network of all-season petroleum development roads (PDR) that branch off of the SYD Road, the major resource trunk road for the region. Truck access to the area increases significantly during the winter months due to the construction of numerous winter roads and ice-bridges.

BEDROCK GEOLOGY

The Fort Nelson Lowlands are predominantly underlain by marine shales of the Lower Cretaceous Fort St. John Group, probably belonging to the Shaftsbury Formation (Stott, 1982; Thompson, 1977). These shales are dark grey, and can be flaky to fissile, but at surface are commonly weathered to clay. The upper contact of this formation, with the overlying Dunvegan Formation, is gradational with sandy siltstones and fine-grained sandstones occurring as interbeds within silty shales (Stott, 1982). Shales of the Fort St. John Group are interpreted to have been deposited in a prodelta or shelf environment in the Early Cretaceous (Thompson, 1977).

The Duvegan Formation, of the Upper Cretaceous Smoky Group, forms the resistive cap of the Etsho Plateau. Here, these sandstones are fine-grained whereas equivalent assemblages range from clay-rich shale and mudstone to boulder conglomerate. This variability reflects facies changes in terrestrial, deltaic, and pro-deltaic environments in which the sediments were deposited (Stott, 1982; Thompson, 1977). Shales have also been observed in borrow pits at higher elevations on the Etsho Plateau, in direct contact with overlying Late Pleistocene till. It is not known whether these shales belong to the Dunvegan Formation or if they are perhaps marine shales of the overlying Kaskapau or Kotaneelee formations. Other outcrop in the region is rare and is limited to stream cuts and in some borrow pits resulting from PDR development activity.

SURFICIAL GEOLOGY

The surficial geology of the region has been summarized by Levson *et al.* (2004). During the Late Pleistocene, the Laurentide ice sheet advanced westward up the regional slope into northeast British Columbia. The dominant surficial materials in the study area are organic, and silt and clay-rich morainal and glaciolacustrine deposits. Elevated areas that support tree cover are invariably underlain by morainal deposits whereas organic materials and glaciolacustrine sediments dominate lower, more poorly drained areas. Morainal landforms include low relief plains, crevasse-squeeze ridges, flutes, and rolling, recessional and interlobate moraines. Glaciofluvial landforms are relatively uncommon to the region but eskers, kames, fans, deltas, and terraces do occasionally occur. The latter occur mainly within larger meltwater channel systems such as the Kimea Creek – Petitot River system (Figure 2).

The configuration of advancing and retreating ice fronts during the Pleistocene appears to have been complex. Cross-cutting relationships observed in large-scale landforms (*e.g.* flutes, recessional and interlobate moraines) suggest that regionally there was more than one ice-flow event (Figure 2). Although the entire region was covered by the Laurentide ice sheet during the glacial maximum, the preserved large-scale landform record indicates that, at least during the later stages of glaciation, ice lobes rather than a single ice sheet were active in the region.

During deglaciation, numerous meltwater channels were incised by streams generally flowing west from the retreating Laurentide ice sheet (Figure 2). Although sands and gravels were locally deposited in association with meltwater channels, many of these channels appear to be entirely erosional and may have formed subglacially. During retreat of the Laurentide ice sheet, some rivers were dammed in front of the ice margin as it retreated back down the regional slope. This resulted in the widespread deposition of glacial lake sediments over pre-existing Quaternary deposits (Mathews, 1980). These glaciolacustrine deposits, in addition to morainal sediments, are common at the surface and are one reason why shallow or surface sand and gravel deposits are relatively rare in the region. The majority of aggregate occurrences identified to date are hosted in late-glacial or retreat-phase glacialfluvial features.

Dating of Pleistocene sediments in the area has been facilitated by the discovery of an interglacial peat underlying a thin till approximately 30 km east of Kotcho Lake. Radiocarbon analyses on two wood pieces yielded ages of >38 690 BP (Beta 183832) and >40 590 radiocarbon years BP (Beta 183831). Another fragment of wood recovered from gravels stratigraphically underlying till in the Elleh Creek area, 100 km southwest of the interglacial site, was dated at 24 400 +/- 150 radiocarbon years BP (Beta 183598). Collectively, these ages and the associated stratigraphy, provide new constraints on the Pleistocene history of the region and indicate that ice free conditions probably existed from before 40 000 until after about 24 000 years BP.

SAND AND GRAVEL OCCURRENCES

Sand and gravel occurrences can be divided into three categories: 1) deposits, 2) prospects, and 3) showings. As used here, a deposit is an occurrence that can be mined economically (typically assessed by a detailed test pit program) and (or) that is a current or past producer of construction aggregate. A prospect is an occurrence within a mappable geomorphic or geophysical feature that is known to contain sand and (or) gravel. Although detailed field investigations have not been conducted, a reasonable preliminary assessment of the occurrence's potential to host an economic aggregate deposit can be made based on the genesis and size of the

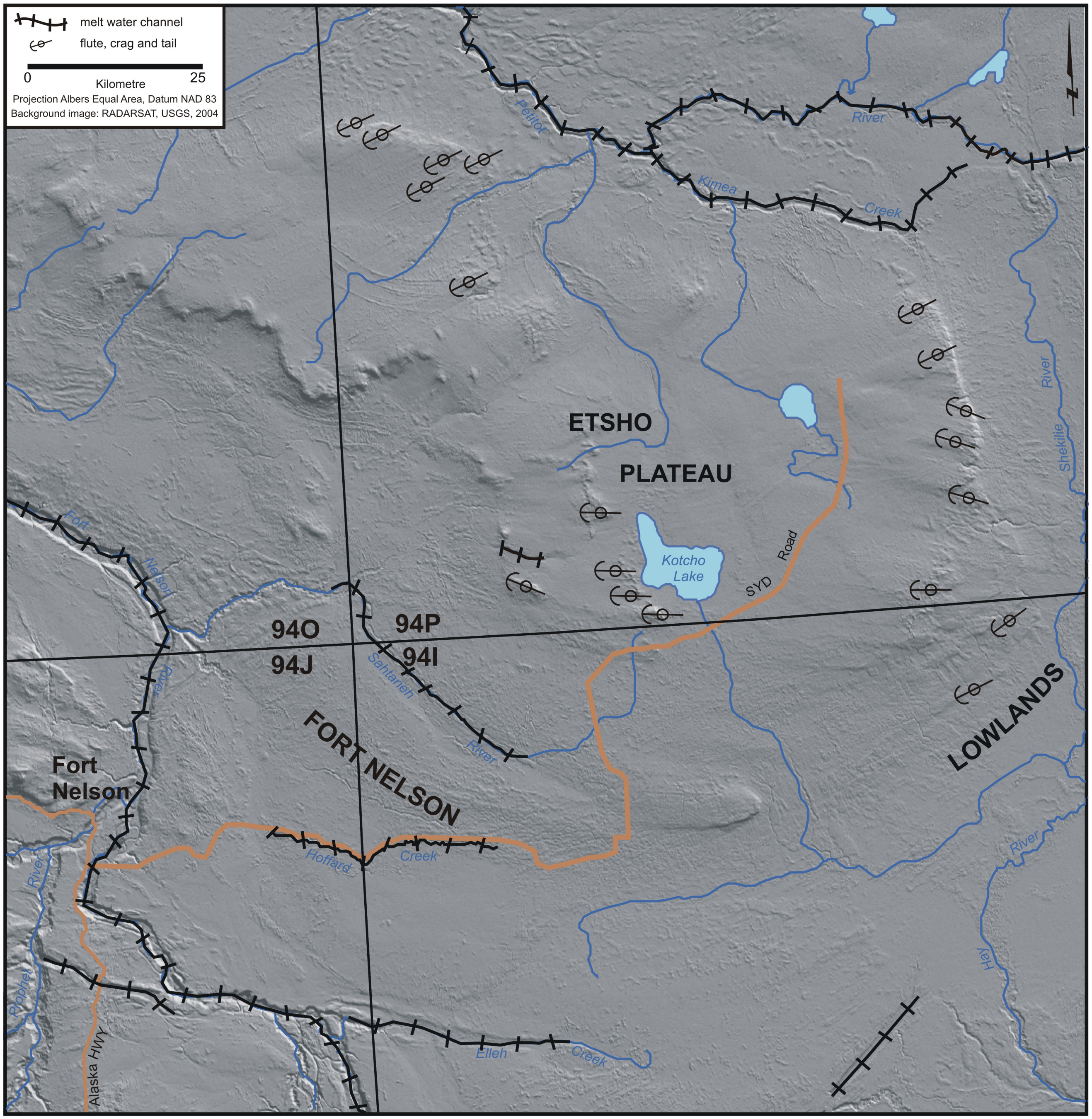

Figure 2. Selected glacial features of the study area.

mappable feature and field observations on surficial materials present. A showing is simply an occurrence that contains sand and (or) gravel, but that is not part of a mappable geomorphic or geophysical feature and (or) that has had insufficient work done to establish economic potential (*i.e.* potential volume and quality). Aggregate volume and quality constitute a portion of the economic potential of a prospect. Location of demand for construction aggregate, and resultant transportation costs to where there is a demand, must also be considered in an economic assessment as hauling costs almost always exceed the cost of extraction and processing. For example, shorter haul distances from a lower quality deposit may be chosen over longer haul distances from a higher quality deposit.

The following is a discussion and summary of newly identified sand and gravel deposits and prospects in the region that have resulted from field and office work conducted as part of this program.

Deposits

To date, eight sand and gravel deposits have been identified within the study area (Figure 1). Four of these deposits, Kimea (Area 9), Courvoisier Creek (Area 5), Metladoa Creek (Area 2), and Sahdoanah Creek (Area 3) (sites a, c, e, and f, respectively, Figure 1) are former producing gravel pits that were initially thought to contain a depleted or exhausted resource (Thurber Engineering, 2001, 2002). In spring 2003, a test pit program was designed by MEM, and implemented by AMEC Earth and Environmental, to determine what volume of sand and gravel, if any, existed within, or adjacent to, these areas and in a number of new areas identified by MEM (Dewar and Polysou, 2003a to d; Levson *et al.*, 2004). The primary objective of this program was to identify the required volume of construction aggregate for the proposed upgrades to, and future maintenance of, the SYD Road (Levson *et al.*, 2004). Not only did this program expand the known resource of these four deposits, but it also identified three new occurrences that have since been classified as deposits - Elleh Creek, Komie North (Area 8), and Kotcho East (Area 10a) (sites b, d, and g, respectively, Figure 1). In addition, an eighth deposit (Central Courvoisier Ridge – site h, Figure 1) was discovered and investigated in the winter of 2005 (see below). The details of these eight deposits, including preliminary volume estimates, are summarized in Table 1.

In total, the test pit program identified a preliminary resource estimate of >5 000 000 m^3 of sand and gravel in five key areas in the vicinity of SYD Road. A subsequent study of aerial photographs, airborne geophysical data, and RADARSAT and LiDAR DEMs show that only portions of the mappable features (*i.e.* geomorphic or geophysical) in Elleh Creek, Komie North (Area 8), Kimea (Area 9), Courvoisier Creek (Area 5), Sahdoanah Creek (Area 3), and Kotcho East (Area 10a) deposit areas were tested. This suggests that these six deposits have potential to host an even larger resource. Detailed discussions of all deposits mentioned above, including test pit results, are provided in individual reports by Dewar and Polysou (2003a to d). These reports are available for download and viewing at www.em.gov.bc.ca/subwebs/oilandgas/aggregates/studies.htm.

The Central Courvoisier Ridge deposit (site h, Figure 1) was first identified by aerial photograph interpretation in 2003, and became an exploration target in 2004 after reviewing LiDAR DEMs for the area. Located in the south-central portion of NTS map area 94P/04, on the western flank of Etsho Plateau (Figure 1), this deposit is approximately 34 km north-northwest of the SYD Road and, since the construction of the new Courvoisier Road in early 2005, it is accessible year-round on all season roads. Detailed field investigations were conducted on the deposit during the winter field program (March 2005) and it has since been put into production. This deposit is hosted in the central and widest portion of a north-trending, 10 km long ridge system that is composed of a series of discrete, sub-parallel, sinuous ridges (Figure 3). Typical dimensions of these ridges are 2 to 4 m high, 50 to 200 m wide, and 100 to 450 m long. North of the deposit, the ridge system appears to curve northwest and possibly terminate in a fan-like feature. The southern extent of the system is situated at the western end of the west-trending Courvoisier Creek meltwater channel (*i.e.* Area 5, Figure 3). Access to northern and southern portions of the ridge are limited to winter only.

Exposed in new roadcuts and in two borrow pits, individual ridges in the central portion of this system are composed of stratified (slope parallel), pebble to cobble-sized gravels and trough cross-bedded medium to coarse sands. Locally, within the gravels, sandy channel fill sequences occur. Although all exposed ridges are composed of granular material, compositionally this material varies between ridges. This feature is interpreted as an esker complex that may be contemporaneous with the formation of the Courvoisier Creek meltwater channel. The source of sediment for this ridge system could have been from the incision of this meltwater channel and (or) the transport of sediment from Etsho Plateau towards the west. The details of this deposit are summarized in Table 1.

TABLE 1. SUMMARY OF AGGREGATE DEPOSITS IN STUDY AREA.

Deposit ID (figure 1)	Deposit Name	Location	Glaciofluvial Feature	Status	Access	[1]Resource Estimate (m^3)
a	Area 9 (Kimea Pit)	94P\10	terrace	producer	year round	>3 000 000
b	Elleh Creek	94J\09	kame	producer	year round	>1 000 000
c	Area 5 (Courvoisier Creek)	94P\04	terraces & ridges	producer	year round	570 000
d	Area 8 (Komie North)	94P\05	delta	producer	year round	> 300 000
e	Area 2 (Metladoa Creek)	94I\14	meltwater channel	past-producer	winter	98 800
f	Area 3 (Sahdoanah Creek)	94P\02	esker	past-producer	year round	29 200
g	Area 10a (Kotcho East)	94I\15	buried channel	producer	winter	410 000
h	Central Courvoisier Ridge	94P04	esker complex	producer	year round	725 000

[1] With the exception of Central Courvoisier Ridge, all resource estimates are provided by Dewar and Polysou (2003a to d).

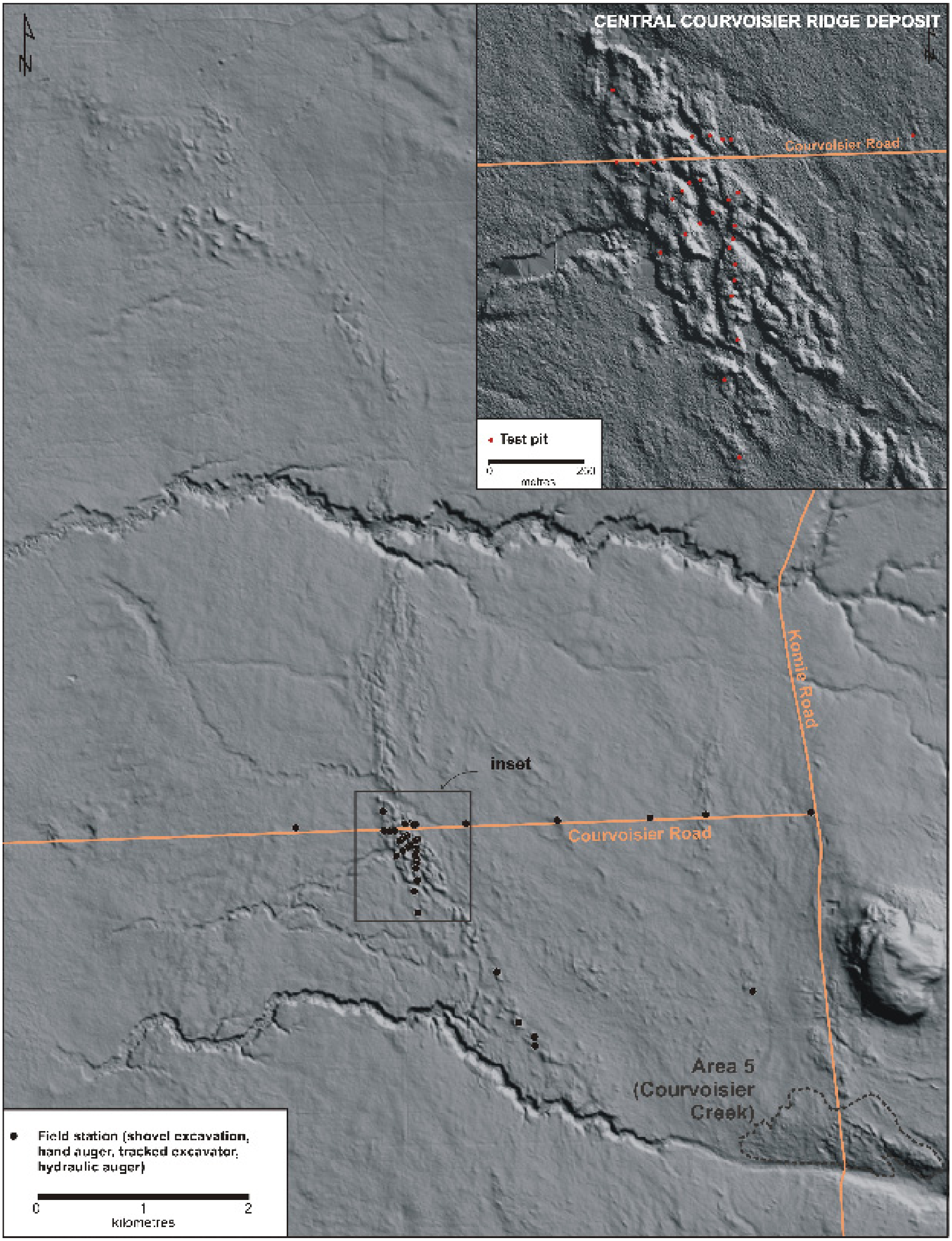

Figure 3. The Central Courvoisier Ridge deposit. Shown here in a LiDAR DEM, this deposit is hosted in the central portion (inset) of a large ridge system interpreted to be an esker complex (inset). Detailed test pitting (25 test pits) was conducted in this central portion and results were used to delineate the deposit. Preliminary field investigations in the southern portion of this complex suggest that this area could also host an aggregate deposit. Note the extension of the ridge complex well to the north of the area investigated to date.

In March 2005, detailed field investigations were conducted in the central portion of the ridge system. In total, 24 test pits were dug (up to 5 m deep) along existing seismic cutlines. Observations were also made in two borrow pits that exposed 3 m high sections in ridges. In general, there are massive to crudely stratified pebble to cobble-sized gravels at surface on the ridge-tops, varying in thickness from 2 to >4 m. These gravels are typically underlain by silty sands (containing 5 to 10% silt) with occasional pebble and cobble-sized clasts. On some ridges, a thin silty sand unit (<1.5 m thick) overlies the gravels. Ridge-flanks, and low areas between ridges, also contain pebble to cobble-sized gravels but are typically overlain by up to 1.5 m of silty diamicton or silty medium to coarse sand. Smaller ridges, investigated along the margins of the system, are composed of >2 m of silty diamicton. The water table was typically encountered at approximately 2 m below surface in test pits between these ridges. For exposures within ridges, water was encountered only once at 6 m below surface in a borrow pit located in the centre of a large ridge near the eastern edge of the deposit. Based on test pit results, and field observations in two borrow pits, the Central Courvoisier Ridge deposit was delineated and a preliminary volume estimate of 725 000 m^3 determined (Figure 3, inset). To date, approximately 12 000 m^3 of pit-run gravel has been mined from this deposit and used to surface local PDRs being built and maintained by EnCana Corporation.

Reconnaissance-scale field investigations were also conducted at the southern end of the feature northwest of the Courvoisier Creek meltwater channel (*i.e.* Area 5, Figure 3). Ridges occurring in the southern 2 km of the ridge system are less densely spaced and narrower than those occurring to the north (Figure 3). Five hydraulic auger holes were drilled (ranging in depth from <1.0 to 9.5 m below surface), four of which encountered granular material. Sands and gravels in this portion of the ridge system are typically buried under 3 to 4 m of silt that grades into a pebbly silt, or perhaps diamicton, with depth. Pebble to cobble-sized gravels can, however, occur at surface or can be overlain by up to 3.5 m of poorly sorted sands. The only auger hole that did not encounter granular material was located between two ridges. In this hole >3 m of clayey-silt diamicton was overlain by 2.5 m of silt. Preliminary results indicate that this southern area has potential to host a deposit similar to that of the central portion of the ridge system. Further field investigations in this area, and the area north of Central Courvoisier Ridge deposit, will likely result in an increase in the estimated volume of aggregate in the Courvoisier ridge system.

Prospects

To date, 25 new sand and gravel prospects have been discovered in the region (Figure 1). All are contained within a mappable geomorphic feature and, at a minimum, have been tested by shallow hand excavations (shovel or auger to ~1 m below surface) in some portion of the mappable feature. South Courvoisier Ridge, Kotcho East (Area 10b), Fort Nelson Airport (east and west), Dilly Hill, and Peggo Bypass (sites 2, 3, 12, 13, 23, and 25, respectively, Figure 1) are exceptions in that an excavator and (or) hydraulic auger have been used to test for granular material. Of the 25 new prospects, Dilly Hill and Kotcho East (Area 10b) are unique as they are both buried under 2 to >5 m of silt and clay-rich morainal and glaciolacustrine sediments and cannot be mapped from surface landforms. In case of Kotcho East (Area 10b), however, the deposit has been mapped using airborne electromagnetic data (Best *et al.*, 2004; Best *et al.*, in press).

Based on the genesis and size of the mappable feature, field observations of surficial materials, and a preliminary assessment of aggregate demand, suggest the majority of the 25 newly identified prospects have high potential to host an economic sand and gravel deposit. To further evaluate the potential of these prospects, and to determine preliminary volume and quality estimates, systematic test pit programs will be required. The details of these prospects including location, feature morphology, access, and investigation method are summarized in Table 2. A detailed discussion on the Fort Nelson Airport East and West prospects are provided by Ferbey *et al.* (2004) and Johnsen *et al.* (2004). A preliminary discussion on the correlation between high resistivity values and the occurrence of granular material in Kotcho East (Area 10b) is provided by Best *et al.* (2004) and Best *et al.* (in press). All of these reports are available for download and viewing on the website provided above.

SUMMARY

To date, the Northeast British Columbia Aggregate Mapping Program has identified >6 000 000 m^3 of construction aggregate northeast of Fort Nelson, in the vicinity of the SYD Road. This resource is hosted in eight sand and gravel deposits: Kimea (Area 9), Courvoisier Creek (Area 5), Metladoa Creek (Area 2), Area 3 (Sahdoanah Creek), Elleh Creek, Kotcho East (Area 10a), Central Courvoisier Ridge, and Komie North (Area 8). The latter three deposits have been put into production since their identification during this program. Seven of the eight deposits (Kimea (Area 9), Courvoisier Creek (Area 5), Area 3 (Sahdoanah Creek), Elleh Creek, Kotcho East (Area 10a), Central Courvoisier Ridge, and Komie North (Area 8)) have the potential to host an even larger aggregate resource.

Additionally, 25 new sand and gravel prospects have been discovered. All are contained within a mappable geomorphic or geophysical feature and have been tested to approximately 1 m below surface (in some cases up to 9.5 m) by shovel excavation and hand-auger, excavator, and (or) hydraulic auger. Based on the genesis and size of the mappable feature, field observations, and a preliminary assessment of aggregate demand, the majority of these newly identified prospects have high potential to host an economic sand and gravel deposit.

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TABLE 2. SUMMARY OF AGGREGATE PROSPECTS IN THE STUDY AREA.

Prospect ID (Figure 1)	Prospect name	Location	Glaciofluvial Feature	Access	Exposure and Investigation Method[2]
1	Hay River	94I\08	delta	winter	streamcut, shovel excavation
2	South Courvoisier Ridge	94P\04	esker	winter	hydraulic auger
3	Area 10b (Kotcho East)	94I\15	buried	winter	test pit
4	Klua Creek	94J\09	fan-delta	year round	roadcut, shovel excavation
5	North Sahdoanah Creek	94P\11	terrace	year round	streamcut, shovel excavation
6	East Kimea Creek	94P\07	kame	winter	shovel excavation
7	West Kimea Creek	94P\07	terrace	winter	shovel excavation
8	Komie Creek	94P\05	esker complex	winter	shovel excavation, hand auger
9	Helmet 3	94P\11	?	winter	shovel excavation, hand auger
10	Cabin Crossing	94P\13	terrace	winter	shovel excavation, hand auger
11	Shekilie River	94I\16	kame, shorelines	winter	shovel excavation
12	Fort Nelson Airport (east)	94J\15	?	winter[1]	test pit
13	Fort Nelson Airport (west)	94J\15	?	winter[1]	test pit
14	Fontas Road	94H\08	esker	winter[1]	shovel excavation, hand auger
15	South Gunnel Road 1	94I\13	esker	winter[1]	roadcut, shovel excavation
16	South Gunnel Road 2	94I\13	?	year round	shovel excavation
17	Helmet 1	94P\11	esker	winter	shovel excavation, hand auger
18	East Brandt Creek	94P\05	kame	winter	shovel excavation, hand auger
19	Helmet 2	94P\11	esker	winter	shovel excavation, hand auger
20	North Elleh Road	94I\05	kame	year round	roadcut, hand auger
21	West Andy Bailey Lake	94J\10	?	winter	shovel excavation, hand auger
22	PDR 257	94P\07	kame	year round	roadcut, shovel excavation
23	Dilly Hill	94P\12	?	year round	test pit
24	Nogah Road	94I\12	burried	year round	shovel excavation
25	Peggo Bypass	94P\07	terrace	winter	hydraulic auger

[1] Winter access only, but less than 1 km from existing all season road.
[2] Unless specified, exposure is from surface.

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