# GEOLOGY AND AGGREGATE PRODUCTION OF THE COLWOOD DELTA

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## ABSTRACT

Industrial minerals from the Colwood Delta, which is arguably Victoria's most significant geological feature, have played an important role in the development not only of Victoria, but also Vancouver and Seattle. Since the turn of the century the Colwood Delta, which lies immediately west of Victoria on Vancouver Island, has been one of Canada's largest aggregate producing regions. The Metchosin gravel pit, operated by Construction Aggregates Limited, is the largest aggregate mine in the area. It is part of a large, raised, post-glacial delta that occupies 611 acres, and is easily visible from the City of Victoria. The operation uses conveyor belts to transport aggregate material from the pit to the processing plant. Up to 19 different types of aggregate are produced there and cheaply shipped to markets. The dominant material types are interbedded delta foreset sands and pebble to cobble gravels. When mining of this pit is completed, plans call for the reclaimed pit to be converted into a community development.

## INTRODUCTION

The Colwood Delta (Figure 1) is a large, raised glaciofluvial delta located west of Victoria. It is one of the more dominant physical features in the Greater Victoria area, it is visible from the city, and throughout the last century has been a major supplier of aggregate materials for southwest British Columbia and the city of Seattle. Over the years numerous sand and gravel producers have operated on the delta; at its peak, one of these was one of Canada's largest aggregate suppliers. Mining began on the delta as early as the 1890s, and has continued to the present. The delta, which was mapped by Monahan and Levson (2000), covers an area of 16.7 square kilometres; it is up to 10 kilometres long and 5 kilometres wide. Housing developments have expanded over most of the delta and the area available for aggregate extraction has rapidly diminished in recent years.

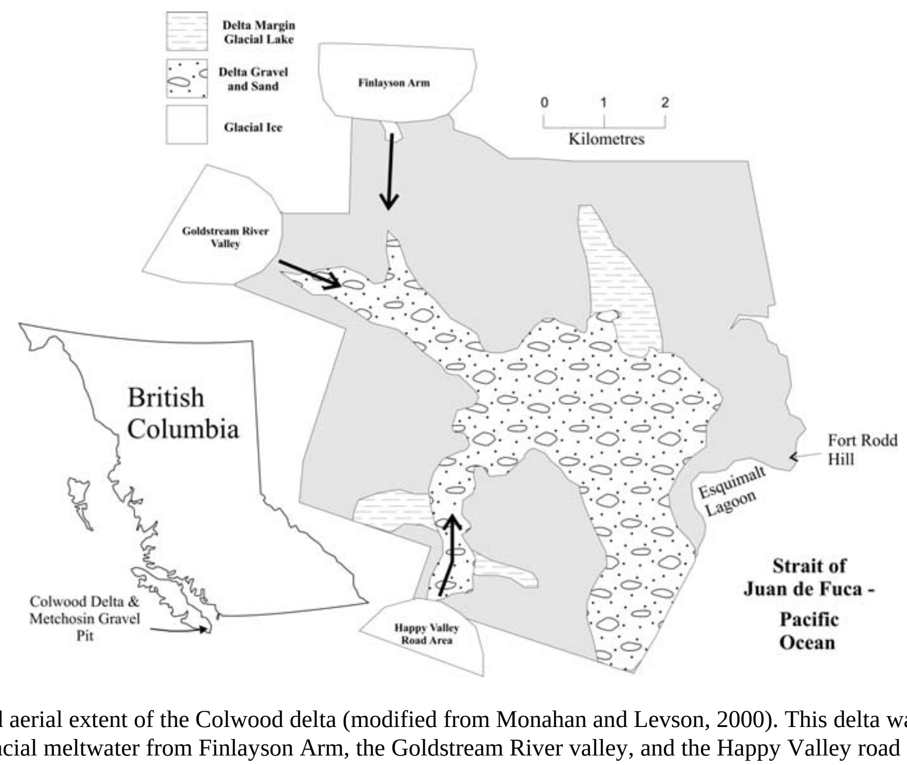


Figure 1. Location and aerial extent of the Colwood delta (modified from Monahan and Levson, 2000). This delta was fed by sediment laden glacial meltwater from Finlayson Arm, the Goldstream River valley, and the Happy Valley road area.

## GEOLOGY

The Colwood delta formed near the limit of the late-glacial marine transgression at the end of the last, or Late Wisconsinan, glaciation. At that time the area was isostatically depressed and relative sea level was approximately 75 metres higher than present. The main source of meltwater feeding the delta was glacial ice in the mountains west of Victoria. Feeder channels issued from glacial ice occupying the upper Goldstream River valley and Finlayson Arm at the west side of the delta (Figure 1). A secondary channel in the Happy Valley Road area may have also fed the delta from the south. Drainage was dammed in other valleys adjacent to the delta system, such as the Millstream Valley to the north, resulting in formation of small glaciolacustrine basins. A number of kettle holes occur in various locations across the entire length of the delta indicating that deposition occurred in contact with isolated blocks of ice. The absence of deltaic sediments north of Esquimalt Lagoon suggests that glacial ice still occupied that area when the delta was forming. As sea level dropped, a well-developed meltwater channel system was incised into the delta just prior to its abandonment.

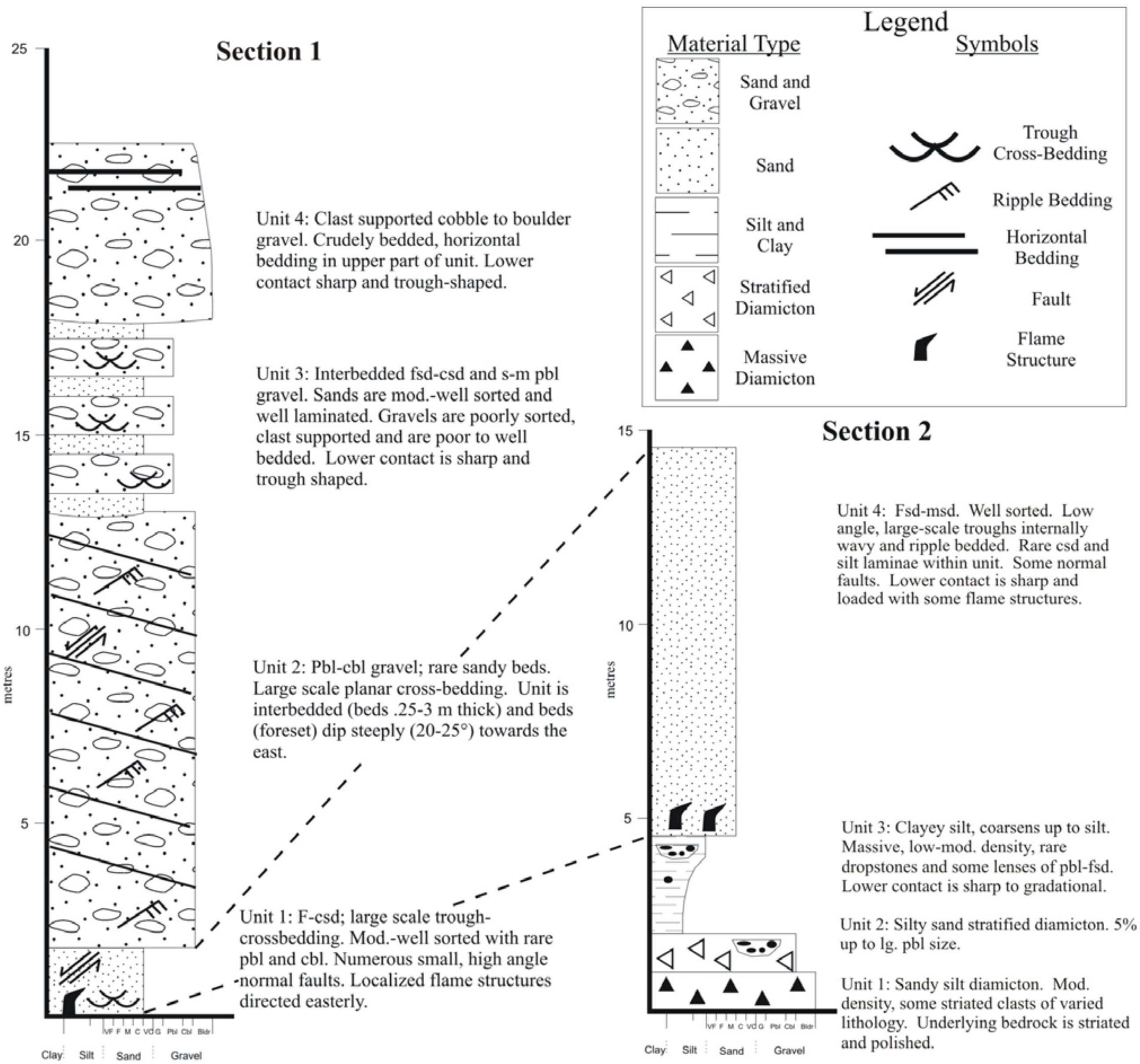


Figure 2. Sections illustrating the stratigraphy of the Metchosin gravel pit, Colwood Delta.

Five different stratigraphic units have been identified in the Metchosin gravel pit (Figure 2). The predominant unit consists of interbedded medium to coarse sands and pebble to cobble gravels (Blyth and Levson, 1993). These sands and gravels show large-scale planar and trough cross bedding and are interpreted to be prograding delta foreset beds (Figure 3a). In exposures at the southwest corner of the delta, beds dip up to 25° to the south-southwest and show well developed grading, a typical feature of subaqueous sediment gravity-flow deposits in river-dominated, delta foreset sequences. The unit coarsens upward, and the maximum thickness of gravel beds increases from about 0.3 metres at the base of the unit to 2 metres at the top. This reflects a facies change from distal, lower-slope deposits to more proximal upper-slope deposits. The gravel beds are mostly clast-supported and matrix-filled, but some coarse beds have an open framework. Clasts are well-rounded and are of mixed provenance. A petrographic analysis of sand and gravel from the Colwood Delta shows less than 30% siliceous minerals and pebble lithologies dominated by granitoid and finely porphyritic volcanic rocks. (British Columbia Research Council, 1967).

The foreset beds are locally underlain by a thin (2.5 metre) basal unit of gently dipping, finely laminated silts and clays interpreted to be bottomset beds (unit 3, section 2, Figure 2). The foreset gravels are erosionally overlain by about four metres of horizontally bedded sands and gravels that are inferred to be topset channel deposits (Figure 3b; unit 4, section 1, Figure 2). The lower contact of this unit is scoured and marked by numerous large clasts that are up to 50 centimetres in diameter. The unit fines upwards, indicating gradual channel abandonment.

The delta sands and gravels are stratigraphically underlain by a few metres of silty diamicton interpreted to be basal till (Figure 3c; unit 1, section 2, Figure 2) and retreat-phase debris flow sediments (unit 2, section 2, Figure 2). Pebble fabric analyses reveal a strong preferred orientation of the a-axes of elongated clasts to the southwest, typical of basal till deposits. The till locally overlies basaltic bedrock that is commonly well striated and glacially fluted. Glacially molded stoss and lee features and striae on the bedrock surface indicate a southwesterly (about 200°) ice flow direction. The diamicton is matrix-supported with 25% clasts, and the matrix is a moderately indurated, silty, fine sand. Clasts are mostly rounded to subrounded and up to about 30 centimeters in diameter. They consist of about 50% basaltic volcanics (including about 20% plagioclase porphyry), 20% diorite, 10 to 15% siltstone, 5 to 10% gneiss, 5 to 10% felsic intrusives and minor chert. These diverse lithologies and the presence of distally derived erratics are consistent with a glacial origin for this diamicton (Blyth and Levson, 1993). Older Pleistocene sediments locally underlie the till, and in one borehole in the pit they extend to a depth of 40 metres below sea level (Howes and Nasmith, 1983).

## AGGREGATE PRODUCTION

The largest operation on the delta is the Metchosin gravel pit or Producers Pit, which is presently owned and operated by Construction Aggregates Limited (Figure 4). The quality of aggregate from the pit is excellent because the sands and gravels are well-graded and contain few fines. As well, gravel clasts from this deposit are hard, do

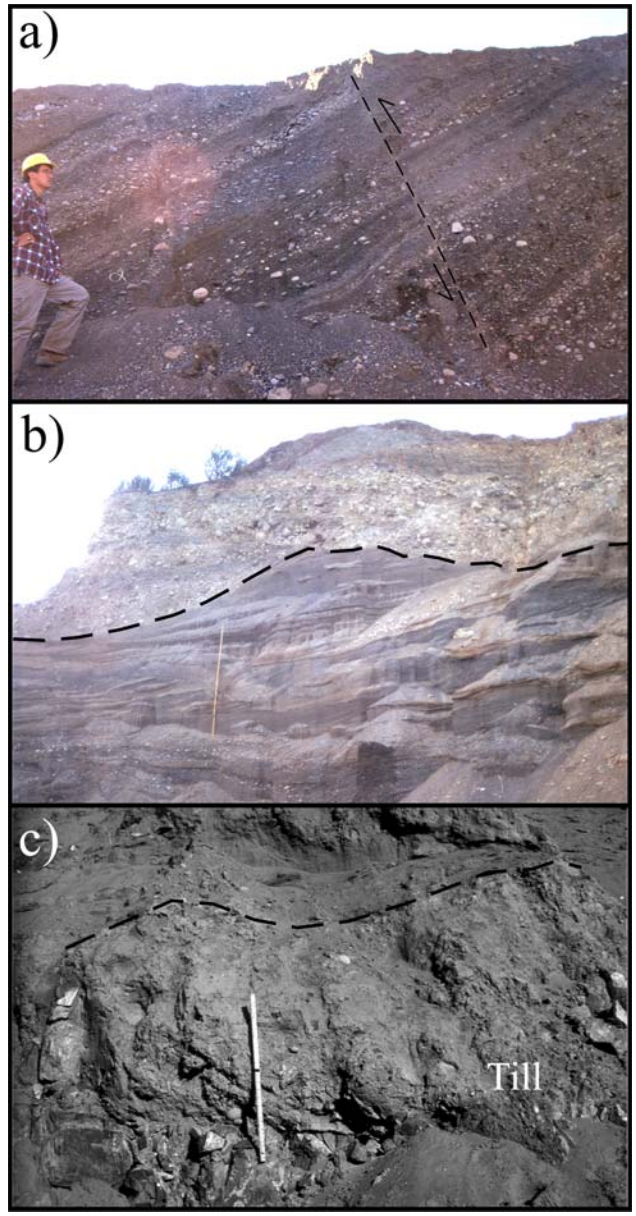


Figure 3. a) Photo of interbedded, medium to coarse sand, and pebble to cobble gravels (delta foreset beds). High-angle reverse and normal faults occur within this sediment. b) Clast supported cobble to boulder delta topset gravel deposit overlying trough cross-bedded fine to coarse sand and small to medium pebble gravels. c) Silty diamicton (basal till) underlying late-glacial sand and gravel in Producers Pit. In places, till is overlain by finely laminated silt and clay (delta bottomset beds).


Figure 4. Aerial extent of the Metchosin gravel pit (aerial photograph PIM-C-90013 #156, scale 1:5000). 1) barge loading facility, 2) washing and screening plant, 3) aggregate stockpile area, 4) water recycling tank, 5) tailing ponds and 6) field conveyor belt system.

not absorb much moisture, and have a high specific gravity. In addition, this gravel pit occurs near the ocean allowing for economic transport by barge. The deposit is approximately half sand and half gravel. This balanced grain size distribution is important because it allows a wider variety of aggregate material to be produced. In total, the Metchosin gravel pit produces aggregate that is sorted into as many as 19 different size fractions. Products include concrete sand and natural stone for buildings and roads; crushed rock for landscaping, road bases, asphalt, gravel driveways and parking lots; and specialty sands such as those used for sandblasting or masonry sand for mortar and stucco.

The earliest recorded gravel extraction on the delta began in the 1890s and a processing plant was operating by 1910. The pit, which is approximately 611 acres, is one of Canada's largest with a peak production of more than 20 000 tonnes/day or 4 million tonnes/year. Current output is about half this, and the pit is nearing the end of its operation. About 60 million tonnes of aggregates have been shipped from the Colwood Delta since 1919. Average cost per tonne of aggregate leaving the pit is $11.50, of which approximately $1.00 is profit.

A large processing plant was built in 1975 at a cost of more than $11 million. It has a barge loading capacity of 3000 tonnes per hour (Figure 5a). Before 1993, 40% of the aggregate from the Metchosin gravel pit was used in greater Victoria with the remainder going mostly to the Lower Mainland. Since then, 50% of the production has gone to Seattle, 40% to Victoria and 10% to the Lower Mainland. Development of the large Sechelt aggregate mine is believed to be responsible for the shift in markets. Sand and gravel from Metchosin has also been shipped as far away as Guam, the Alaskan panhandle and Hawaii.

## EXTRACTION AND PROCESSING

Before the 1970s, sand and gravel were extracted from the Metchosin pit by repeatedly scraping a large bucket on a slack-line across pit faces. Material dislodged from the face fell to the pit floor in piles that contained a relatively even grain-size distribution. Material from these piles was then loaded onto conveyor belts and transported to the crushing and screening plant.

Since Construction Aggregates Limited took ownership of the pit during the 1970s, they have used front-end loaders to excavate the gravel from pit faces, and then dump aggregate material into a feed hopper. The hopper provides a steady feed mechanism that allows large volumes of aggregate to be fed onto conveyor belts (Figure 6). To ensure that materials loaded into the hopper have an acceptable blend of grain sizes, loaders excavate material from a series of locations along the pit face. Aggregate material is conveyed to a primary field jaw crusher and then to the main plant (Figure 4, # 2) where it is screened, crushed, and washed. There are 3.5 kilometres of conveyor belts between the field mining system and the plant at this gravel operation (Figure 4, # 6).

In the mill, coarse (greater than 7/8 inch) rock is crushed and finer material is fed to a washing and screening plant. Concrete sand, which is blended automatically from coarse sand fractions and fine sand is produced and sent to a variety of stockpiles (Figure 4, # 3). Round stone is conveyed away for further washing and screening.

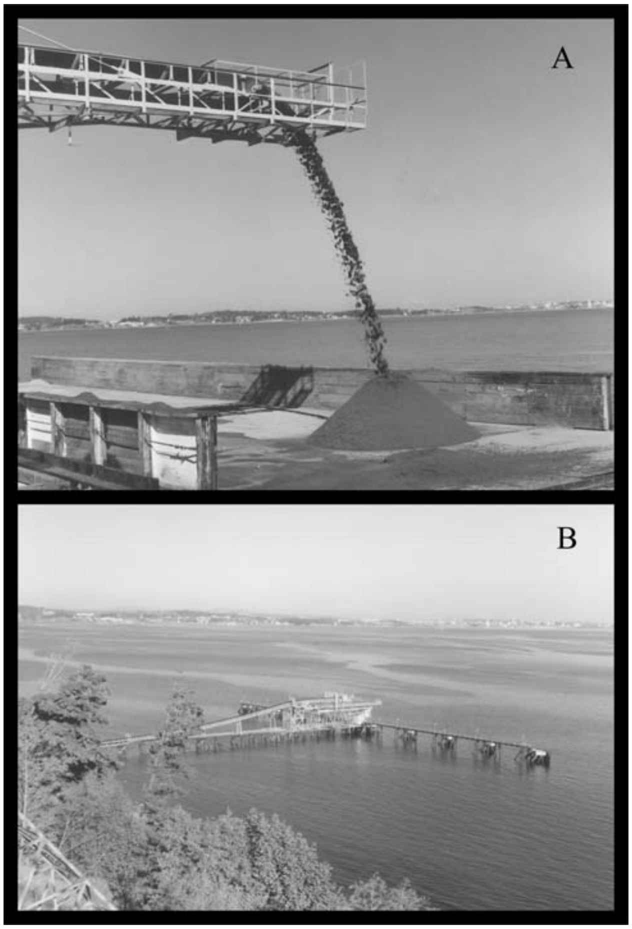


Figure 5. A) Photo showing how barges are loaded at Construction Aggregates Limited Producers Pit. B) Construction Aggregates Limited barge loading facility.

The thousands of litres of water used in the washing process are recycled in a large (36 metres in diameter) thickener tank (Figure 4, #4). Lime and flocculating agents are added to the water to help remove silt and clay. Treated water is reused in the washing plant while the fines are pumped into a tailings pond (Figure 4, # 5).

A 270 metre conveyor belt in a tunnel under the finished product stockpiles automatically withdraws and transports material to the barge loading facility (Figure 5b; Figure 4, # 1). Material can be blended in any quantity from a variety of different piles to produce a wide range of finished products (Construction Aggregates Ltd., 1975). The barge loading facility is capable of loading 3000 tonnes per hour and can fill barges with up to 9000 tonnes capacity (Rimes 1975). In the 1890s and early 1900s, before conveyor belts were used at the barge loading facility, workers loaded barges with wheelbarrows. Most of the aggregate produced at this pit is transported by barge.

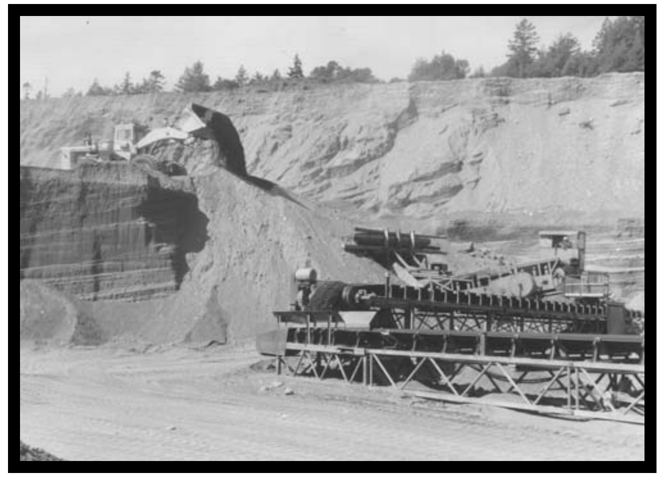

Figure 6. Front-end loader extracting gravel and dumping it into a feed hopper. This aggregate is run through a primary field crusher. Crushed aggregate is then conveyed to the processing plant for final screening.

A hard rock quarry was opened in the Producers Pit in 1993 to help extend diminishing sand and gravel reserves. This rock quarry has about 28 million tonnes of reserves. The quarried rock is dark grey Metchosin basalt. It is durable and has excellent characteristics for asphalt pavements, ready-mix concrete, road stone and erosion control applications (Consedine, 1995).

## LAND USE RECLAMATION ISSUES

Land use matters have always been an issue on the Colwood Delta, especially when the Metchosin gravel pit is involved. Some controversial issues with the local community have been road relocation, PCB storage, and the possibility of a landfill. All these issues have been resolved, and plans call for a community development in the area of the Metchosin gravel pit once it is shut down.

## CONCLUSION

The Colwood Delta, which is arguably Victoria's most significant geological feature, has played an important role in the development not only of Victoria, but also Vancouver and Seattle. Aggregate material from the Metchosin gravel pit has been used in building a large number of homes and buildings in these cities. Late glacial, sediment-rich meltwater issuing from retreating ice lobes in Finlayson Arm, the Goldstream River valley, and the Happy Valley road area built the delta. During the early Holocene isostatic rebound raised the delta above ocean level. It is approximately 75 metres above the present day coastline.

The largest mine on the Colwood Delta is the Metchosin gravel pit. Interbedded sands and pebble to cobble gravel from delta foreset beds, are the most common material and comprise the major aggregate resource within the pit. Aggregate has been mined here since the 1890's. Poor land use planning allowed residential and community development to build on other potential aggregate producing regions of the delta and urban development is crowding in on the existing Metchosin pit. This pit is slowly being phased out and after mining is completed the pit area will be reclaimed as a community development.

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