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GSC Open File 3688 (sheet 1 of 3)

Interpretation of Seafloor Instability in the Strait of Georgia, British Columbia, from EM 100 Multibeam Bathymetry Surveying

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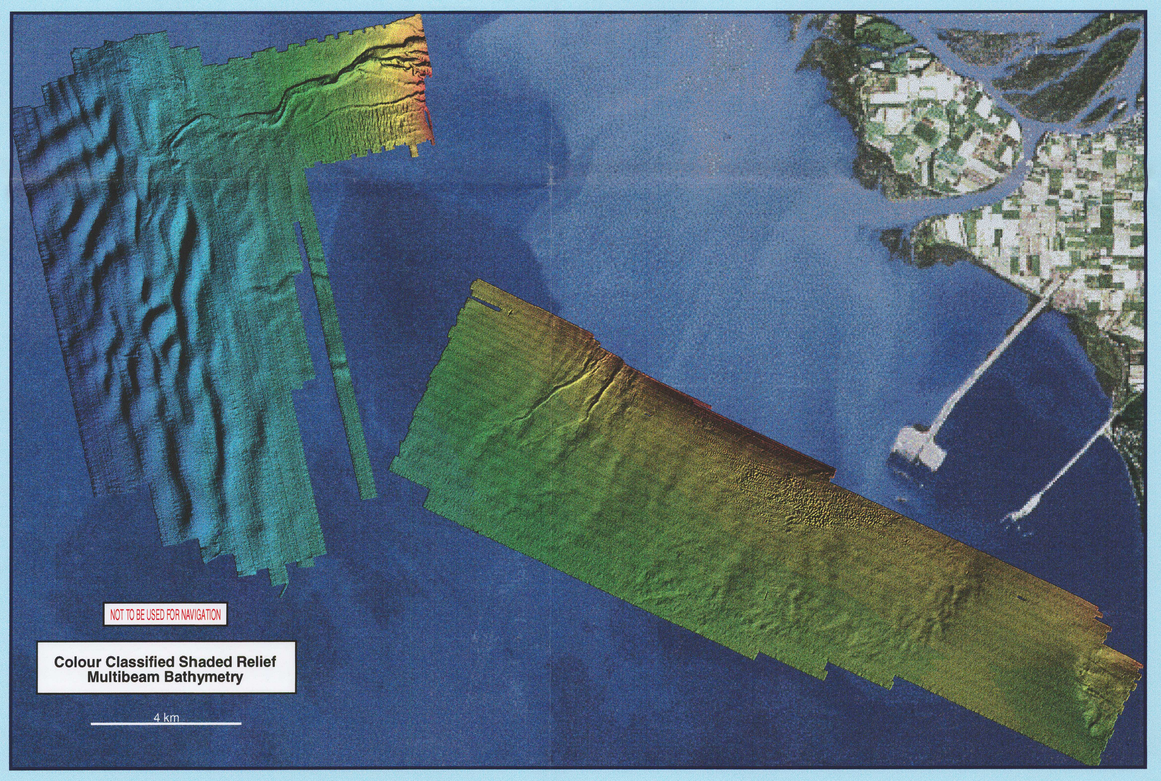
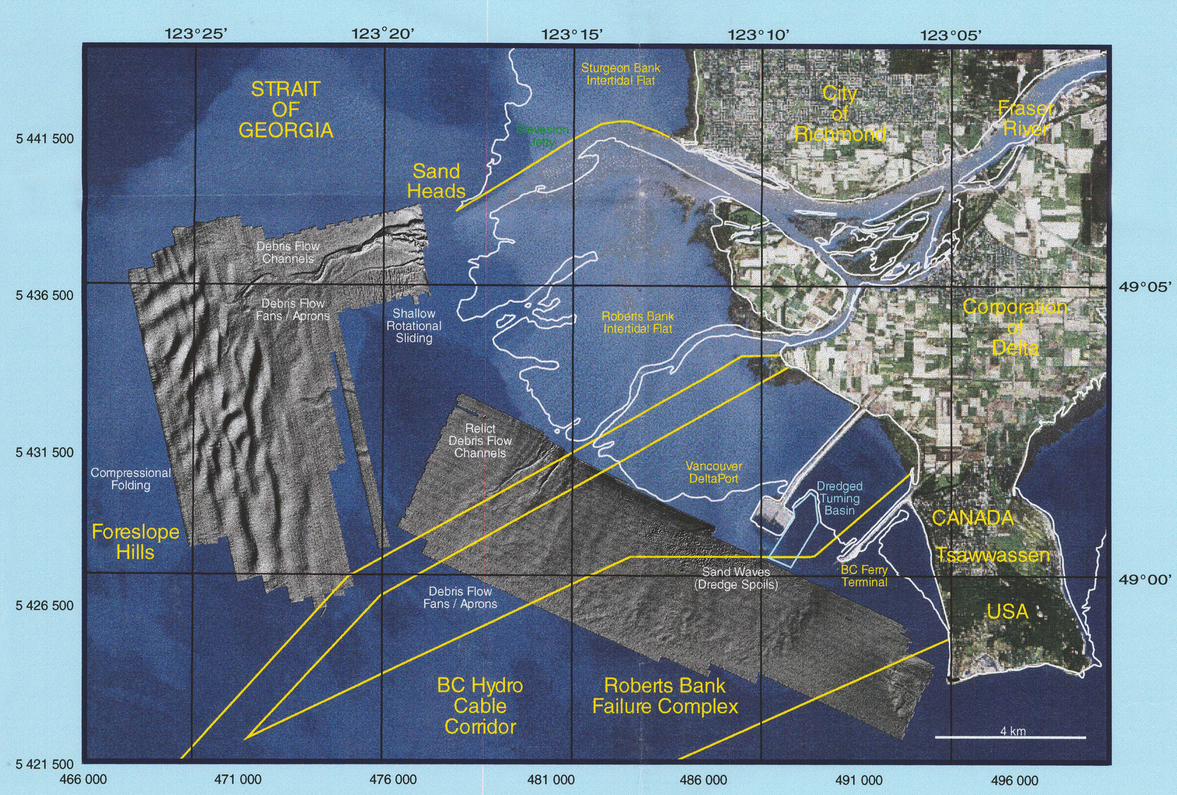


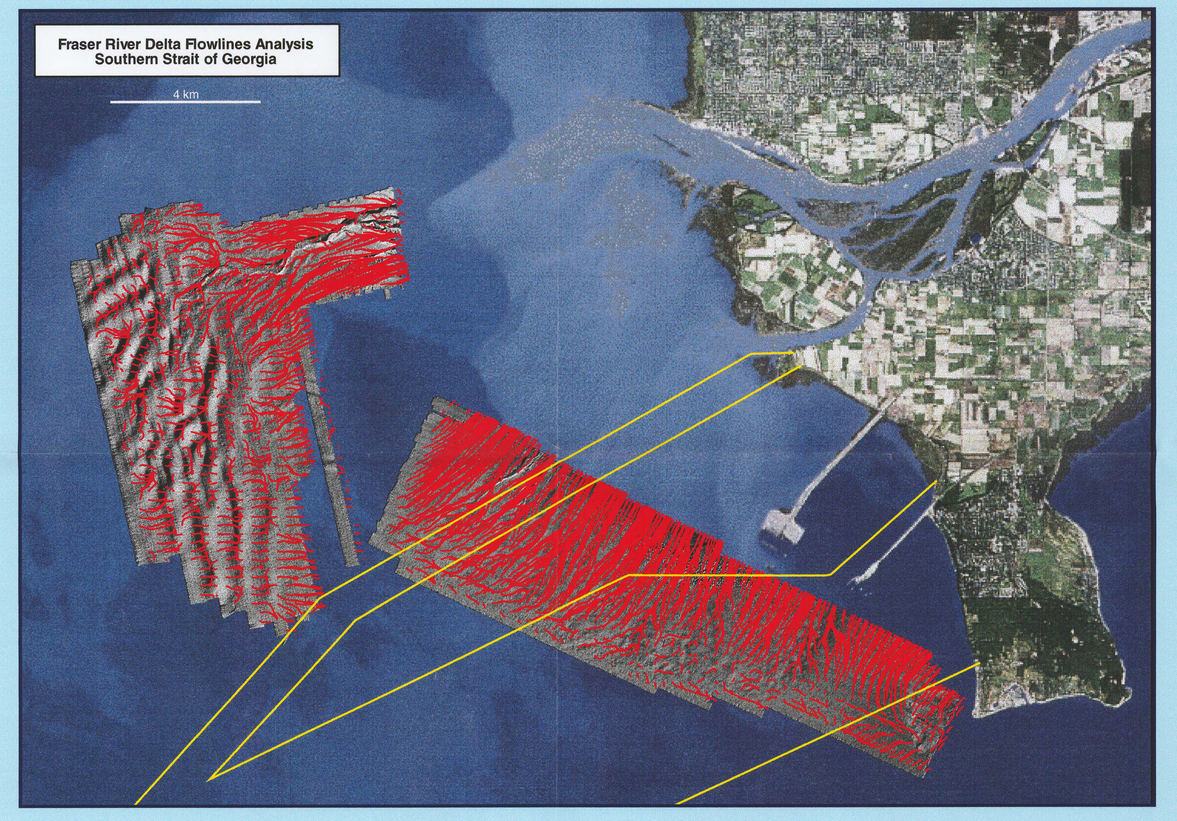
The Fraser River delta is both a tide-dominated and a river-dominated system, encompassing about 1000 sq km in area. Shown above is a colour-coded bathymetric image of the extreme southwestern margin of the intertidal zone, along with the southern Strait of Georgia. This shaded-relief image was derived from multibeam bathymetry data, collected in 1994 by GeoResources Inc., using an EM100 system. The underlying image is a Landsat Spot photograph provided by MacDonald Dettwiler and Associates Ltd. The colour bands illustrate variations in water depth from the crest of the delta slope (0 to 10 m is red band) to the deepest portion of the Strait of Georgia (350 m is deep blue). A number of unusual seafloor features are visible as bathymetric mounds, ridges, valleys and ripples.

Scientific research into the origin of these features has focussed on the possibility that they are developed either from static failure of the delta foreslope and toe, or that they occurred in response to past major earthquakes. The west coast of Canada is subject to large-scale magnitude 8 and greater Cascadia Margin subduction events having a return period of approximately 500 years, as well as more frequent moderate magnitude 7 crustal events, occurring on and east of Vancouver Island, on average about every 50 years. Portions of the Fraser delta subaerial plain and foreslope have been found to be susceptible to cyclic softening and slope instability, based on evaluation of seismic resistances obtained through geotechnical engineering investigations.



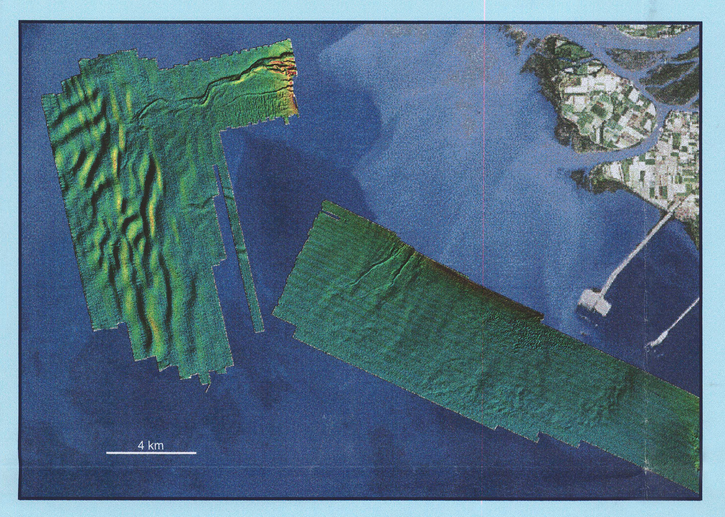
The above map shows an interpretation of key seafloor features in the Strait of Georgia, believed to represent both active and relict instability processes. Also shown are the key shoreline and port facilities on Roberts Bank, including the Vancouver DeltaPort (site of bulk coal shipments overseas by Westshore Terminals Ltd), international containerized shipments by the Vancouver DeltaPort Corporation and site of a proposed expansion to include grain shipments by the Saskatchewan Wheat Pool. BC Ferries operates a major transfer facility at Tsawwassen. The Steveston Jetty crosses the intertidal zone and was constructed as a river entrainement structure. BC Hydro operates a major hydroelectric cable installation within the Strait of Georgia, providing power to southern Vancouver Island.

Triggering mechanisms to explain the origin of observed morphological features include static failure and mass wasting of loose gas-charged sands deposited on locally steep slopes adjacent to major river distributary mouths, adjacent downslope creep and rotational slumping believed caused by rapid sedimentation and gravitational loading, large-scale compressional folding and displacement of weak prodelta marine sediments in response to deltaic progradation, and static or seismic strain-softening of upper slope sands and silts, producing mobile gravity flow slides, evident at the base of the foreslope. Lesser processes include sand waves developed within dredge spoil deposits by strong delta front tidal currents. Studies are ongoing to develop an understanding of the relative importance and potential for further instability of these deposits, in the event of future engineering development of the delta front under the seismic geohazard.



To consider the potential impact of post-shaking slope instability, this analysis uncoupled the initial seismic failure from post-shaking deformations, developed as a direct result of a reduced (cyclically-softened) sediment undrained shear strength and ambient gravitational driving stresses. The likelihood of downslope gravity flows is high on upper Roberts Bank, depending of the degree of cyclic-softening that develops as a result of earthquake shaking. To illustrate the potential path followed by translational gravity flow slides, bathymetric flowlines were generated from the local gradient of the gridded multibeam EM100 dataset (collected by GeoResources Inc. in 1994). The flowlines are not representative of the distance travelled during such movements.

This map datum was prepared in UTM Zone 10, on the NAD83 datum. The shaded relief image was generated with illumination from the north at an attitude of 45 degrees. The bathymetry is vertically exaggerated by a factor of 10. The underlying Landsat Spot image was used with the permission of MacDonald Dettwiler and Associates.



The Fraser River delta has prograded into the Strait of Georgia, entirely in Holocene time (beginning 12 000 BP). Onshore geological and geotechnical investigations show that sandy foreset sequences generally dip west to southwest at angles of between 4 and 8 degrees and as low as 1 degree at depth. This sand unit conformably overlies a soft marine sequence which drapes and infills a high-relief Pleistocene surface. At present, delta front slope instability appears to be restricted to channelized sea valleys located at the terminations of major distributaries of the Fraser River (Sand Heads, Canoe Passage). Digital multibeam bathymetry were imported into a GIS system (GRASS), to facilitate an overall evaluation of delta foreslope stability. Calculated average slope angles were colour-coded and are shown superimposed on a shaded-relief bathymetric image.

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Fraser River Delta Slope Angle Analysis
Southern Strait of Georgia

2 4 6 8 10 12
Slope Angle (degrees)

References

Chillarige, A.R.V., Morgenstern, N.R., Robertson, P.K. and Christian, H.A. 1997. Seabed instability due to flow liquefaction in the Fraser River delta. Canadian Geotechnical Journal, **34**(4), pp. 520-533.

Chillarige, A.R.V., Robertson, P.K., Morgenstern, N.R. and Christian, H.A. 1997. Evaluation of in-situ state of Fraser River delta sand. Canadian Geotechnical Journal, **34**(4), pp. 510-519.

Christian, H.A., Mosher, D.C., Mulder, T., Barrie, J.V. and Courtney, R.C. 1997. Geomorphology and potential slope instability on the Fraser River delta foreslope, Vancouver, British Columbia. Canadian Geotechnical Journal, **34**(4), pp. 432-446.

Christian, H.A. and Woeller, D.J. 1996. Investigation of spontaneous liquefaction flow slides at the margin of the Fraser River delta, Vancouver, British Columbia. Proceedings of the Second International Congress on Environmental Geotechnics, 5-8 November, Osaka, **1**, pp. 337-342.

Christian, H.A., Woeller, D.J., Robertson, P.K. and Courtney, R.C. 1997. Site investigations to evaluate flow liquefaction slides at Sand Heads, Fraser River delta. Canadian Geotechnical Journal, **34**(3), pp. 384-397.

Hart, B.S., Prior, D.B., Barrie, J.V., Currie, R.G. and Luternauer, J.L. 1992. A river mouth submarine channel and failure complex, Fraser Delta, Canada. Sedimentary Geology, **81**, pp. 73-87.

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