Shoreplan Engineering Limited
139 Merton Street, Suite 631
Toronto, Ontario M4S 3G7
T) 416.487.4756 F) 416.487.5129
E) mail@shoreplan.com

SHOREPLAN

September 8, 2008

Ms. Norma I. Bryant
The Municipality of West Elgin
22413 Hoskins Line
Box 490
Rodney ON
N0L 2C0

Dear Ms. Bryant:

Re: Sediment Transport Impact Assessment for
Proposed Harbour Entrance Improvements
Port Glasgow Marina
Our File: 06 - 892

This letter report presents our assessment of the potential updrift and downdrift impacts associated with the proposed entrance improvements at the Port Glasgow Yacht Club & Marina (PGYCM). Our assessment was carried out in response to comments from MNR and LTVCA, as described in our proposal dated May 9, 2008. We previously prepared a feasibility study report (Shoreplan, 2006) and a detailed design brief (Shoreplan, 2008) for the proposed entrance modifications. Those reports are referenced in this submission and should be made available to any readers of this report.

As part of our assessment we carried out a field review of both the site and the updrift shoreline on July 15, 2008. The photographs presented in this report were taken at that time. The water level during our site visit was approximately 174.4 metres IGLD, based on water levels recorded at the Canadian Hydrographic Service water level gauges in Erieau and Port Stanley.

Impacts on coastal processes from shoreline structures can be local and/or regional. Local impacts are those that occur in close proximity to the structure, generally within distances that are a small multiple of the length of the structure. Regional impacts are those that occur due to permanent or long term interruption of the sediment movement along the shore, reducing the sediment supply to downdrift shores. The proposed marina entrance structures were reviewed with respect to both types of impact.

Our analysis, described in detail below, showed that neither regional nor local impacts are expected to be significant. Potential updrift local impacts will be limited to a small increase in the size of the existing fillet beach. The extent of those changes will be dictated by future dredging practices.

No downdrift erosion will occur from local impacts because the shoreline is protected. Some reduction in the volume of sand in the groyne-retained pocket beaches downdrift of the marina could be experienced. Those changes are not expected to be significant and can be easily mitigated if they do occur.

Regional impacts are expected to include a loss in the order of 3,500 cubic metres of sediment that would have otherwise ended up on the fillet beach at Port Stanley. That is roughly equivalent to two years worth of dredging at Port Glasgow and is not a significant volume.

Potential Local Impacts

Local impacts are generally associated with disturbance of the nearshore flow field caused by the introduction of a structure along the shoreline. The length of this disturbance is usually a small multiple of the length of the structure. Changing wave patterns in the lee of the structure, wave reflection from the structure and a general deflection of the alongshore current can cause the disturbance. On shorelines with a well defined net sediment transport direction, such as occurs here, local impacts can be further sub-divided into updrift and downdrift impacts.

Updrift Impacts

Fillet beaches which form on the updrift side of structures due to the interruption of alongshore littoral drift are the most common form of updrift local impacts. The fillet beach on the west side of Sixteen Mile Creek was formed as a result of structures built on the west side of the creek. Figure 1 shows 2003 and 2006 aerial photograph of the Port Glasgow shoreline. It can be seen that the fillet beach is anchored by a small pile of field stone boulders at the east end of the relatively straight portion of the beach. Figure 2 is a photograph of those boulders taken during our site review. The field stones appear to be acting like a small groyne or headland.

The exact history of that small groyne or headland is unknown to us but we note that there has been some sort of structure in this area for some time. During our site review we observed the remnants of a stone filled timber groyne updrift of the field stone groyne. Appendix A from our feasibility study

(Shoreplan, 2006) includes a 1916 photograph showing a pier in this area and a 1978 photograph showing what appears to be a field stone groyne. Figure 3 shows a portion of an Ontario Base Map (OBM) produced from a 1985 aerial photograph along with the position of the shoreline from the 2003 and 2006 aerial photographs. It appears from Figure 3 that the current the field stone groyne/headland was modified after 1985 and has led to a small increase in the width of the fillet beach.

The width of the beach between the field stones and the marina entrance is controlled by dredging. The PGYCM carries out a dredging program on an as-needed basis in order to keep the existing entrance from filling in. The area immediately updrift (west) of the entrance is typically dredged in both the spring and fall but may be dredged during the summer boating season following southwesterly storms, if needed. Approximately 3,000 to 5,000 tonnes of sand and gravel are removed annually. Experience has shown that when the subaerial portion of the beach has extended to a certain point on the west pier, dredging is required immediately in order to keep the entrance free of accumulation (Norm Miller, personal communication).

Figure 4 shows the toe and crest outlines of the proposed new entrance structures superimposed on the OBM. It can be seen that the new entrance structures will extend further offshore than the field stones controlling the position of the fillet beach to the west of the creek. The structures will not cause a reduction in the size of the beach but they could cause an increase in the beach width and length, depending on future dredging practices. If future dredging is carried out at the present rate we would not expect to see a notable change in the size of the beach because with the current level of dredging it is the field stones shown in Figure 2 that control the size of the beach.

If dredging were to stop the beach between the field stones and the new breakwaters would “grow” lakeward as the coarser portion of the littoral drift was blocked by the western breakwater. The width of the beach would increase until the toe of the beach extended beyond the toe of the breakwater. At that point the beach would stabilize and all of the alongshore drift would either bypass or fill in the entrance. By the time that full beach width was established we would expect the field stones to be partially buried within the fillet beach. If that were to happen there would also be a small increase in the width of the fillet beach updrift of the field stones.

If dredging were to be suspended until the new entrance starts to fill in, then resume at the current rate, there might be an increase in the size of the fillet beach. That change, however, would be smaller than if no dredging took place.

Downdrift Impacts

We do not expect there to be any downdrift erosion impacts because the shoreline immediately downdrift (east) of the marina entrance has been protected. Figure 5 shows the shoreline traced from the 1985 OBM superimposed on the 2003 and 2006 aerial photographs. It can be seen from Figure 5 that the position of the shoreline east of the marina has not eroded since the 1985 OBM was prepared. The shoreline was protected with rubble along the shoreline and in groynes approximately 20 to 25 years ago and that protection appears to be stable. The sand deposits within the groynes are very mobile and transitory in nature. They do not play a major role in the stability of the shoreline due to their narrow width. Figure 6 shows a series of photographs of the shoreline east of the marina. The plan portion of Figure 6 shows where the photographs were taken.

The new structures will alter the nearshore currents on either side of the marina entrance. The wave induced alongshore currents will be deflected away from the shore for a short distance on either side of the new entrance. This will not have a noticeable effect on sediment transport on the updrift side of the marina due to the net transport direction. It is possible that deflecting the littoral sediments offshore could have an impact on the recreational beach east of the entrance but it is difficult to quantify the risk of that happening. We do not expect to see a noticeable loss of sand from the beach but recommend that the beach be monitored to verify this. If some sand loss is noticed it could be replenished with sand taken from the updrift side of the marina. The beach cell immediately to the east of the entrance could grow in size and attain a more easterly orientation due to increased sheltering of the new structures. Those changes will not be detrimental.

The main reasons that we do not expect to see a significant change in the beach deposits are related to the potential sediment transport characteristics at this site. Potential sediment transport modeling was carried out as part of the regional impact assessment and is discussed in more detail below. At this site the net transport is from west to east but there is a significant east to west component as well. The nearshore sediments get moved back and forth much more than they get moved continuously down the coast. This back and forth movement tends to trap the sediments between the groynes, giving a significantly different beach configuration at any given time.

The shoreline orientation either side of Port Glasgow varies by about 15 degrees. The normal to the shoreline updrift of the marina is directed towards an azimuth of approximately 145 degrees. The normal to the shoreline downdrift of the marina is directed towards an azimuth of approximately 130 degrees. Our sediment transport modeling showed that the shoreline orientation of 145 degrees is associated with the peak potential sediment transport capacity. The wave climate at Port Glasgow is capable of transporting more sediment along the updrift shore than it can along the downdrift shore. Some of the sand that bypasses the entrance structure will settle in the vicinity of the beaches because of that reduced transport capacity.

Potential Regional Impacts

Regional impacts are those that occur due to permanent or long term interruption of the sediment movement along the shore, reducing the sediment supply to downdrift shores. Regional impacts can be noticed as far downdrift as the boundary of the littoral cell, but whether or not those impacts are significant is dependant upon both the volume of sediment retained by the structures and the eventual fate of that sediment had it not been blocked. When there is a noticeable net alongshore transport direction, such as at Port Glasgow, there will be no regional impacts updrift of the site. The net transport at Port Glasgow is from west to east and the effective limit of the littoral cell is the fillet beach at Port Stanley.

In order to assess the potential regional impacts, the alongshore sediment transport rates and the cross-shore distribution of that transport were quantified. This was done using a sediment budget and a sediment transport pathways analysis, as described below.

Sediment Budget

Alongshore sediment transport rates in the vicinity of Port Glasgow are supply limited. The supply of sediment to the nearshore zone is less than that which could be transported by the available wave energy. When this is the case, alongshore transport rates are estimated through a sediment budget, an accounting of the sediment sources and sinks within the nearshore zone. Philpott (1983a) prepared a very detailed sediment budget covering the north central shore of Lake Erie, from Rondeau to Long Point, as part of the 1983 Port Burwell shoreline damage litigation. We estimated alongshore transport rates at Port Glasgow using data developed for that sediment budget analysis.

For a sediment budget the shoreline is divided into a number of segments or reaches and the sediment sources and sinks of each segment are determined. Sediment supply volumes for varying grain size ranges were quantified from four sources; bluff erosion, nearshore bottom erosion, gully erosion, and the watercourse supply of inland soils. Sinks considered were offshore losses of fine material, the comminution (breaking-apart) of soft sand grains, which were also lost offshore, and the increase in volume of the nearshore sediment deposit. A decrease in the nearshore sediment deposit volume would be a source. The volumetric differences between these sources and sinks is assumed to be transported alongshore. The net alongshore sediment transport rate at any point is found by summing the alongshore transport rates from all shoreline segments updrift of that point. Figure 7 shows the sources, sinks and inferred transport rates for a typical shoreline segment.

The shoreline segments or reaches used to define the Philpott (1983a) sediment budget were based on the location of available nearshore sediment deposit data but it was eventually found that with the existing data it was not possible to quantitatively assess the rate of change of the nearshore deposits (Philpott, 1983b). It was therefore concluded that the nearshore deposit change in the sediment budget (term S in Figure 7) would have to be taken as zero.

Philpott (1983a) found that bluff erosion, followed by nearshore bottom erosion, produced the greatest volume of sediment, contributing 70 and 29 per cent of the total sediment volume, respectively. Gully erosion and watershed erosion (sediment loading from creeks and drains) were found to be of minor importance, each contributing less than 1 per cent of the total.

The bluff erosion volumes for each sediment budget segment were estimated by combining bluff composition data from Zeman (1980) with shoreline recession rates estimated by Fleming (1983a). The stratigraphic cross-sections provided by Zeman were subdivided into 250 m long reaches of shoreline. For each reach the face areas allocated by Zeman to particular sediment samples were determined. These areas were then subdivided proportional to the grain size fractions given in the sample texture statistics from Zeman's report. The areas associated with each grain size fraction were then summed to form totals for each 250 m reach. The results were then multiplied by the average shoreline recession rates calculated by Fleming (1983a) to produce volumetric rates of sediment input for each 250m reach. Finally, to provide a consistent level of data resolution, the bluff sediment yield rates for the 250m reaches were grouped into the same reaches used to define the nearshore sediment data.

Fleming (1983a) estimated average annual recession rates at 100 m intervals for two periods; 1896 to 1936 and 1936 to 1969 or 1971, depending upon location. (For the shoreline updrift of Port Glasgow the latest survey data was 1971 for all but a short distance right at Port Glasgow so for clarity we have referred to the second interval as just 1936-1971.) The recession rates were computed from three sets of continuous historic survey data collected by Kolberg (1983). Several other collections of plans, charts and survey notes including shoreline data were examined and coordinated by Kolberg (1983) but none was found to be sufficiently complete for shoreline comparison. Because of the accuracy of the continuous survey data and the close spacing of the points where the bluff recession was measured, this data set was considered to be of the best quality and accuracy (PACEL, 1989).

It was found, however, that the variability of recession due to the irregular nature of the erosion process was large and made interpretation of all but the grossest features of recession patterns difficult and meaningless. To overcome this problem the raw recession data was smoothed with a “rolling mean” averaging process that left the overall average recession rates unaltered but eliminated most of the random fluctuations. The procedure involved taking the average of a group of consecutive data points symmetrically placed around each point in the data set. A 51-point rolling mean was used, which, given the 100m spacing of the data, means that 5 kilometers of recession data was averaged for each point. Smoothed average annual recession rates were thus determined for the two survey intervals.

As part of determining their regulation limits for the Howard through Dutton-Dunwich shoreline, Lower Thames Valley Conservation Authority used bluff recession rates calculated from registered plans and surveys that included the top of bank. It was anticipated that the LTVCA data would be used to supplement the Port Burwell recession data for the sediment budget, but the LTVCA data was found to be too sparse to use.

Figure 8 shows a comparison of the recession rate data for the portion of the littoral cell updrift of Port Glasgow. Lines of the smoothed 1896-1936 and 1936-1971 rates from Fleming (1983a) are shown, as well as a smoothed line for data covering the entire period from 1896 to 1971. The raw data points for the entire Port Burwell study period and from LTVCA are also shown for comparative purposes. (The LTVCA data chainages are estimates only as their location was reported by lot number) As the LTVCA data does not match any specific one of the different Port Burwell intervals better than the others, it was concluded that it could not be used to supplement the Port Burwell Data.

The baseline used in Figure 8 was established as part of the Port Burwell investigation. It starts near the northern tip of Point-Aux-Pins, approximately 950 metres north of the Harwich-Howard township line. Port Glasgow is located at a chainage of 26.81 kilometers. The Port Stanley harbour breakwaters, located at chainage 64.64 kilometers, were found to be a complete barrier to the alongshore transport of shingle, littoral drift, and sub-littoral drift, and were be considered to be the downdrift end of the littoral cell containing Port Glasgow. It is possible that Port Stanley is no longer a complete littoral barrier and that some of the finer sediments are now bypassing. Given the magnitude of the potential impacts (defined below) that possibility does not significantly alter our conclusions.

It can be seen from Figure 8 that there is a noticeable difference between the earlier and later recession data intervals with the rates from the later period being higher than the rates from the earlier period. Fleming (1983b) found a direct correlation between the recession rates, water levels and water level trends during the two intervals over which the recession rates were calculated. His analysis showed that there was a falling water level trend from 1849, through 1896, to 1937 and a rising water level trend from 1937 to 1975. It was concluded that the generally higher recession rates which occurred in the period 1937 to 1975 relative to those of the period 1896 to 1937 should be attributed to the fact that water levels were quickly rising following a sustained period with a falling water level trend.

An examination of water levels from 1975 to 2007 shows that the water levels are again trending downwards but at a rate about 50% higher than that which occurred from 1849 to 1937. It should be noted, however, that the mean water levels at this start of this latest downward trend were higher than at the start of the earlier downward trend. This suggests that while the average annual recession rates can be expected to be lower than occurred from 1936 to 1971 it does not mean they will be as low as occurred from 1896 to 1936. We therefore decided to base the sediment budget calculations for this impact assessment on the entire data interval (1896 to 1971) rather than one of the shorter intervals.

The Philpott (1983a) sediment budget grouped all grain sizes of sediment entering the nearshore zone into one of four size categories; shingle, littoral drift, sub-littoral drift, and washload. The grain size categories were determined on the basis of the behaviour of that size of material once it enters the nearshore zone. The grain sizes defining the category limits were based on the logarithmic Phi scale where $\Phi=-\log_2(d)$ and d is the sediment diameter in millimeters. Figure 9 shows how the Phi sizes compare to other commonly used grain size distributions.

Shingle (Φ<-1) consists of gravel and pebble which, under most conditions, remain close to the toe of the bluff or to the face of a beach.

Littoral drift (-1 < Φ < 2) consists of coarse to medium sand which generally remains within or close to the normal breaker zone. This is the main beach building material for the beaches found on Lake Erie. Approximately 10% of the littoral drift material is lost through comminution of soft grains which are then transported offshore to deep water.

Sub-littoral drift (2 < Φ < 4) consists of fine and very fine sand which is transported beyond the normal breaker zone. It is deposited during periods of high lake level and transported alongshore at lower lake levels. This material may contribute to, but does not alone form, beaches. For a similar sediment budget analysis PACEL (1989) assumed that approximately 50% of the sub-littoral material is lost offshore to deep water. That was noted to be an arbitrary division and based more on supposition than on a specific interpretation of any particular data. It was selected as a median value to attempt to minimize the error associated with the estimate. We have adopted a similar approach for the sediment budgets presented here and note that sub-littoral material was defined by Philpott (1983a) as that material found mainly below the level of active wave-induced littoral transport so the uncertainty associated with that assumption is not critical to this impact assessment.

Washload (Φ > 4) consists of silt and clay particles which are too fine to remain permanently in the nearshore zone and are eventually lost to deep water at the Lake centre. This fraction typically forms 80-95% of the total volume of unconsolidated Lake sediment and may be ignored in a littoral sediment budget (Philpott, 1983a).

Table 1 shows the alongshore sediment transport rates predicted for the sediment budget developed as described above. It can be seen that, on average, approximately 4,000 cubic metres of shingle, 8,000 cubic metres of littoral drift and 6,000 cubic metres of sub-littoral drift are predicted to be transported from the updrift shore to Port Glasgow each year. Approximately 6,000 cubic metres of sub-littoral drift and 230,000 cubic metre of washload are lost offshore to deep water over the same length of shoreline.

As part of our field review for this project we collected sediment samples from two locations at Port Glasgow and analysed them to determine their grain size distribution. One sample, referred to as the beach sample, was collected from the beach updrift of the field stones shown in Figure 2. The second sample, referred to as the dredge sample, was taken from the area where dredgate is placed adjacent to the west pier. That sample is considered to be representative of the sand and gravel removed during dredging operations.

Figure 10 shows the grain size distributions of the 2 samples, with the grain size expressed as the PHI value. It also shows distributions for shingle, littoral drift and sub-littoral drift as defined in the sediment budget, assuming the grain sizes limits apply to the 5% and 95% passing diameters. It can be seen from Figure 10 that the beach sample is entirely littoral drift and the dredge sample is a mix consisting of approximately 40% littoral drift and 60% shingle. These samples are consistent with what would be expected for those locations, considering that the sediment budget gradations were based on the behaviour of the sediments within the nearshore zone.

Sediment Transport Pathways

A sediment transport pathways analysis was carried out to see how the proposed new entrance structures might effect the alongshore sediment transport. An alongshore sediment transport model was used to calculate the potential alongshore transport rates in the vicinity of Port Glasgow. Input to the sediment transport model included:

- nearshore profiles
- nearshore wave conditions
- water levels
- wind conditions
- sediment characteristics

The profiles and wind, wave and water level conditions were taken from the data sets described in our detailed design brief (Shoreplan, 2008). Three separate sediment distributions were modeled; one representing the shingle distribution, one representing the littoral drift distribution, and one representing the sub-littoral drift distribution used in the sediment budget analysis described above.

Figures 11, 12 and 13 show representative results from the sediment transport modeling of the shingle, littoral drift and sub-littoral drift. These figures show the average annual potential transport rates and represent the volume of sediment that could be transported by the available wave energy if the sediment were not supply limited. The vertical lines representing the existing and proposed structures represent the position along the profile where the structures meet the lakebed.

The top plots of Figures 11 to 13 shows the cross-shore distribution of the net, gross, positive and negative transport rates. Positive transport is defined as transport moving from left to right when standing on the shoreline facing offshore. At this site positive transport is southwestward, towards Pointe aux Pins. Negative transport, which is from right to left, is northeastward, towards Port Stanley. The gross transport rate is the sum of the positive and negative transport rates and the net transport rate is the difference between the positive and negative transport rates. We refer to the top plot of Figures 11 to 13 as a sediment transport pathways plot because it shows where the alongshore transport occurs on the profile.

The bottom plots of Figures 11 to 13 show the cumulative distributions of the net transport rates. These distribution lines represent the area under the sediment transport pathways plot, summed from the offshore end of the profile moving landward. The value plotted at any point along the abscissa represents the total transport capacity that exists offshore of that point. Three specific values are also labeled on the bottom plot; the values of the transport capacity offshore of: the proposed new entrance structures, the existing entrance structures, and the shoreline. Because all transport takes place offshore of the shoreline, the transport capacity values shown at the shoreline represents the total annual net transport rate at this site, for the sediment gradations modeled.

It can be seen that wave energy updrift of Port Glasgow is capable of transporting 6,000 cubic metres per year of shingle, 60,000 cubic metres per year of littoral drift and 120,000 cubic metres per year of sub-littoral drift. Comparing those values to the actual net transport rates shown in the sediment budget confirms that transport is supply limited at Port Glasgow.

Analysis of Potential Impacts

On the basis of the sediment budget data and the potential sediment transport modeling results it is possible to estimate the potential downdrift regional impacts associated with the proposed new entrance structures. If maintenance dredging were to stop now, with the existing entrance structures, we would expect the vast majority of the shingle to be blocked by the west pier. A significant proportion of the littoral drift would be blocked but not much of the sub-littoral drift. These assumptions are based on both the predicted sediment transport rates and where on the profile the transport of the different sized sediments take place.

The small bay between the field stones (Figure 2) and the west pier would fill in relatively rapidly until the beach updrift of the field stones extended all the way to the west pier. As the bay filled in the relative proportions of the shingle and littoral drift trapped by the pier would increase and the proportions bypassing the pier would increase. As the bypassing increased the existing entrance would fill in. Once the small bay was filled all sediment approaching the marina would bypass the entrance.

If no dredging were to take place after the new structures were constructed a similar type of process would take place. Virtually all of the shingle would be initially blocked by the new west breakwater. A higher percentage of the littoral drift would be blocked by the new breakwater than the existing west pier, but not all of the littoral drift would be blocked. Some sub-littoral drift might be blocked but the vast majority would bypass the entrance.

The small bay between the field stones and the west breakwater would again fill relatively rapidly until the filling beach “backed-up” to the field stones. After that the beach would continue to grow lakeward but the fillet beach updrift of the field stones would also grow. The lakeward rate of growth of the beach would be slower because a longer length of beach would be growing.

Again, as the small bay fills and the fillet beach grows the relative proportion of material trapped by the breakwater would decrease and the proportion that bypasses the entrance would increase. As bypassing increases the new entrance will also fill in but the consequences of that infilling will be less than for the existing structure because the new entrance will be in deeper water. Eventually, when the updrift beach filled out far enough, all sediment approaching the marina would bypass the entrance.

From the above it can be seen that, in the absence of dredging, that system would reach a point of equilibrium where the regional “behaviour” of the new structures will be the same as the regional behaviour of the existing structures. A greater volume of sediment (estimated below) will have been trapped updrift of the harbour due to the new structures. Removing that volume of sediment from the downdrift portion of the littoral cell constitutes the regional impact of the new entrance. This would be a temporary impact only, as once that volume had been removed the system would behave as before.

It follows that if dredging were to be stopped when the new structures are built and resumed when the new entrance started to fill in, then the regional behaviour of the new entrance will be the same as the behaviour of the existing entrance (and attendant dredging practice). The volume of sediment that deposited against the breakwater during the interval for which there was no dredging would be lost to the downdrift littoral cell and, as in the case above, would constitute the regional impact of the new entrance. Again, this would be a temporary impact only.

The volume of sediment that would be trapped against the new west breakwater under the scenario described above (no dredging until new entrance starts to fill in) was estimated to be approximately 3,500 cubic metres. That estimate was made by assuming similar updrift beach profiles relative to the structures controlling those profiles. That is a relatively small volume and represent in the order of 2 years worth of dredging under existing conditions.

The Port Burwell litigation studies showed that the alongshore transport of sediment between Pointe aux Pins and Port Stanley did not affect the bluff recession rates until the Port Stanley fillet beach. The regional impacts of the proposed new entrance at Port Glasgow will therefore be to reduce the eventual volume of the Port Stanley beach by something in the order of 3,500 cubic metres. Considering the size of the Port Stanley fillet beach, this is not consider to be a significant impact. We therefore conclude that the regional impact associated with the proposed new entrance at Port Glasgow will be insignificant.

Conclusions

This letter report describes our assessment of the potential local and regional impacts on the existing sediment transport regime associated with the proposed new marina entrance structures at Port Glasgow. Previous reports described the preliminary evaluation of alternative solutions and the detailed design of the preferred solution.

Neither regional nor local impacts are expected to be significant.

Potential updrift local impacts will be limited to a small increase in the size of the existing fillet beach. The extent of those changes will be dictated by future dredging practices.

No downdrift erosion will occur from local impacts because the shoreline is protected. The first beach cell adjacent to the new entrance could increase in size due to the increased sheltering. Some reduction in the volume of sand in the groyne-retained pocket beaches further downdrift of the marina could be experienced. Those changes are not expected to be significant and can be easily mitigated if they do occur.

Regional impacts are expected to include a loss in the order of 3,500 cubic metres of sediment that would have otherwise ended up on the fillet beach at

Port Stanley. That is roughly equivalent to two years worth of dredging at Port Glasgow and is not a significant volume.

Closing Comments

We anticipate that this impact assessment will meet the requirements of both MNR and LTVCA. Please feel free to contact us if you have any questions or comments about this report.

Yours truly,

Shoreplan Engineering Limited

B. Pinchin

LICENSED PROFESSIONAL ENGINEER
B. M. PINCHIN
Sept 8 2008
PROVINCE OF ONTARIO

Bruce Pinchin, P.Eng.

REGISTERED PROFESSIONAL ENGINEER
M. STURM
Sept 8, 2008
PROVINCE OF ONTARIO

Milo Sturm, P. Eng.

References, Figures and Tables follow:

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Figure 1 2003 and 2006 Aerial Photographs

Figure 2 Field Stone Boulders Controlling Fillet Beach

Figure 3 1985 Ontario Base Map with 2003 and 2006 Shorelines

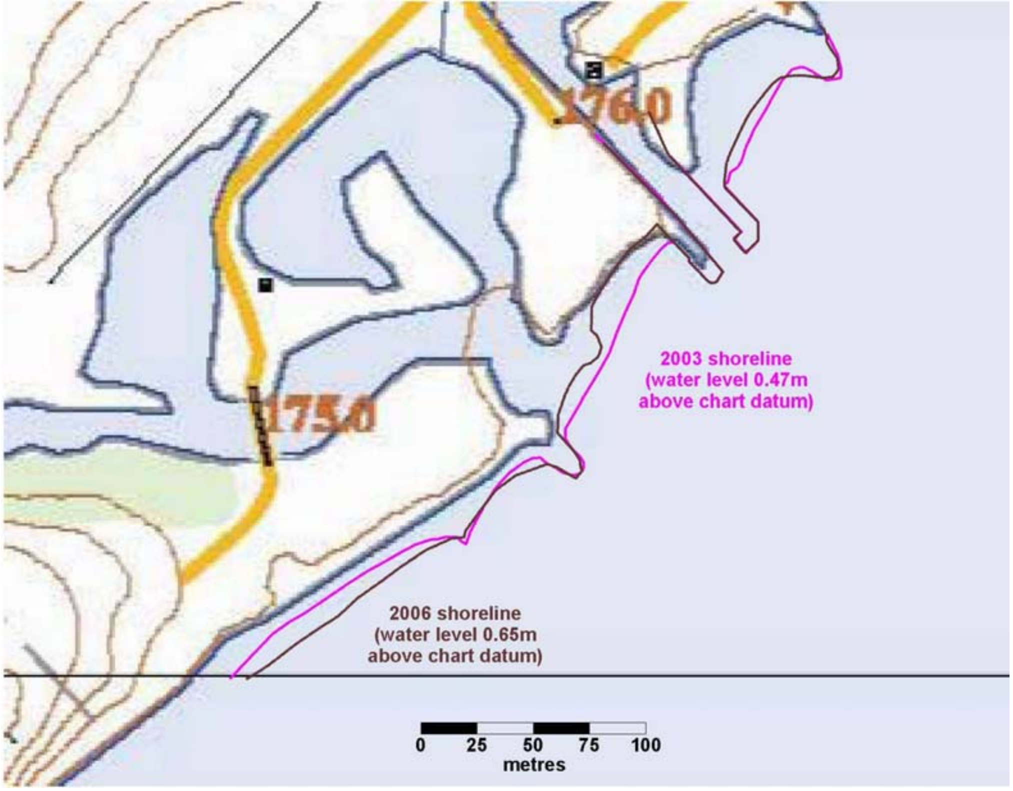


Figure 4 Outline of Proposed Entrance Structures

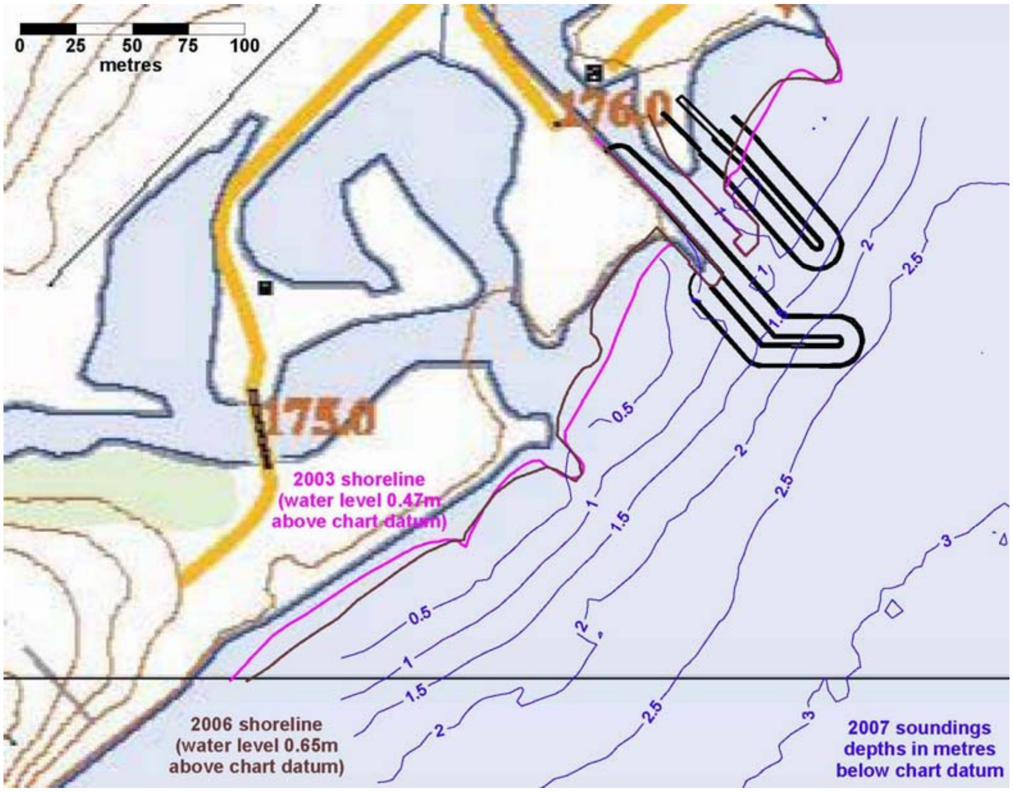


Figure 5 1985 OBM Shoreline on 2002 and 2006 Photographs

Figure 6 Shoreline East of Port Glasgow

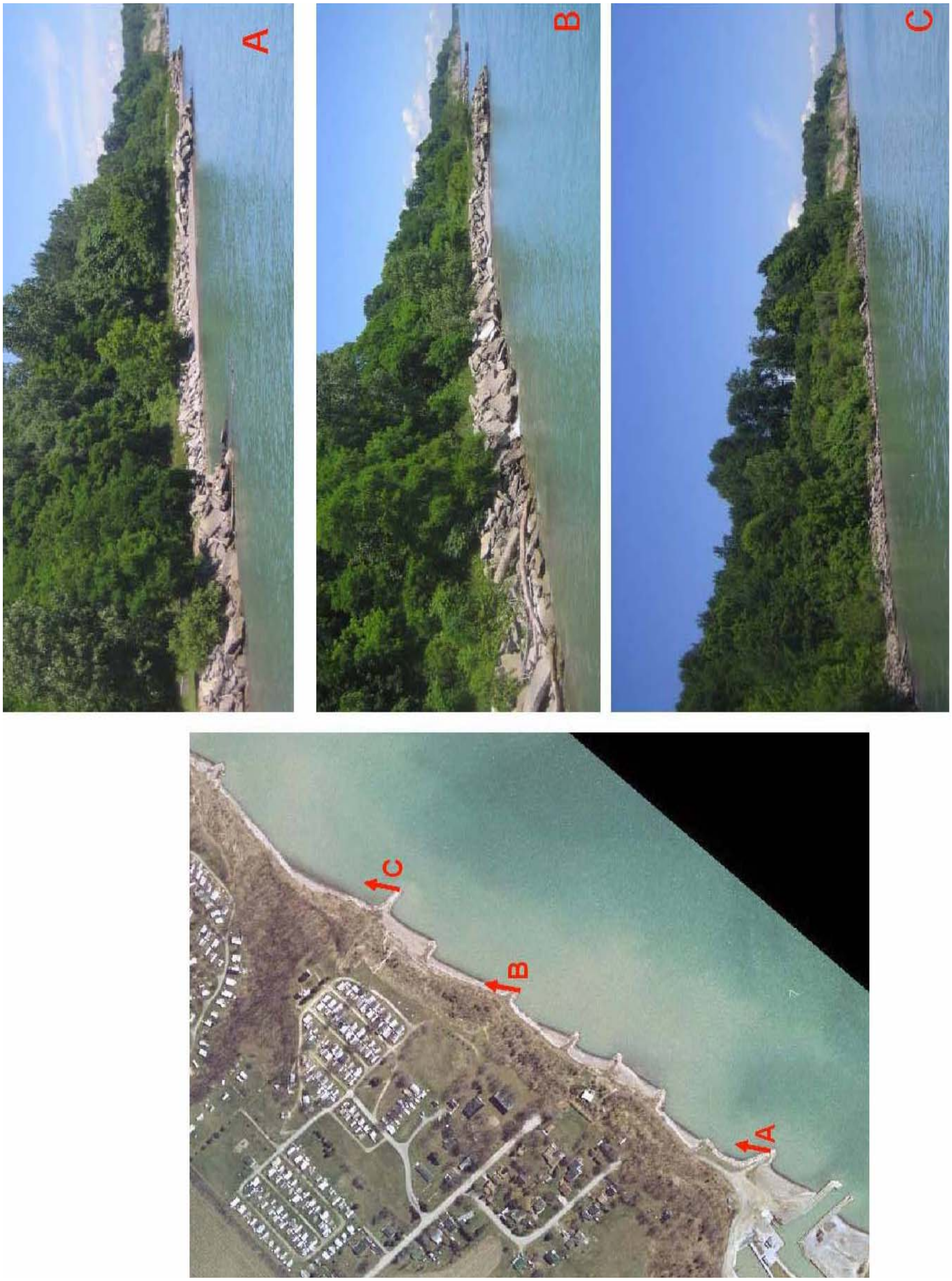
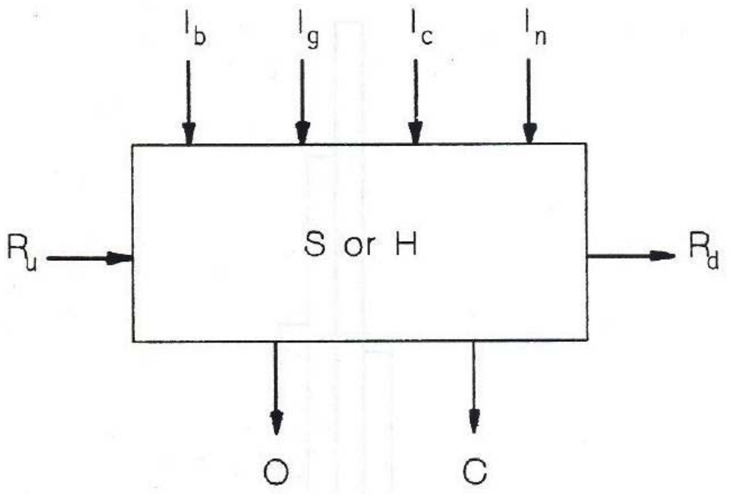


Figure 7 Typical Shoreline Segment in Sediment Budget Analysis



$$R_d = I_b + I_g + I_c + I_n - S - H - O - C$$

$$R_N = \Sigma R_u + R_d$$

where:

I_b = input from bluff erosion
I_g = input from gully erosion
I_c = input from creeks and rivers
I_n = input from nearshore bottom erosion

O = offshore losses
C = comminution of soft grains (also lost offshore)
S = gain in nearshore deposit (negative for loss)
H = gain in harbour deposit (negative for loss)
R_u= sediment transport rates from updrift segments
R_d= sediment transport rate to downdrift segment
R_N= net alongshore sediment transport rate

Figure 8 Average Annual Shoreline Recession Rates

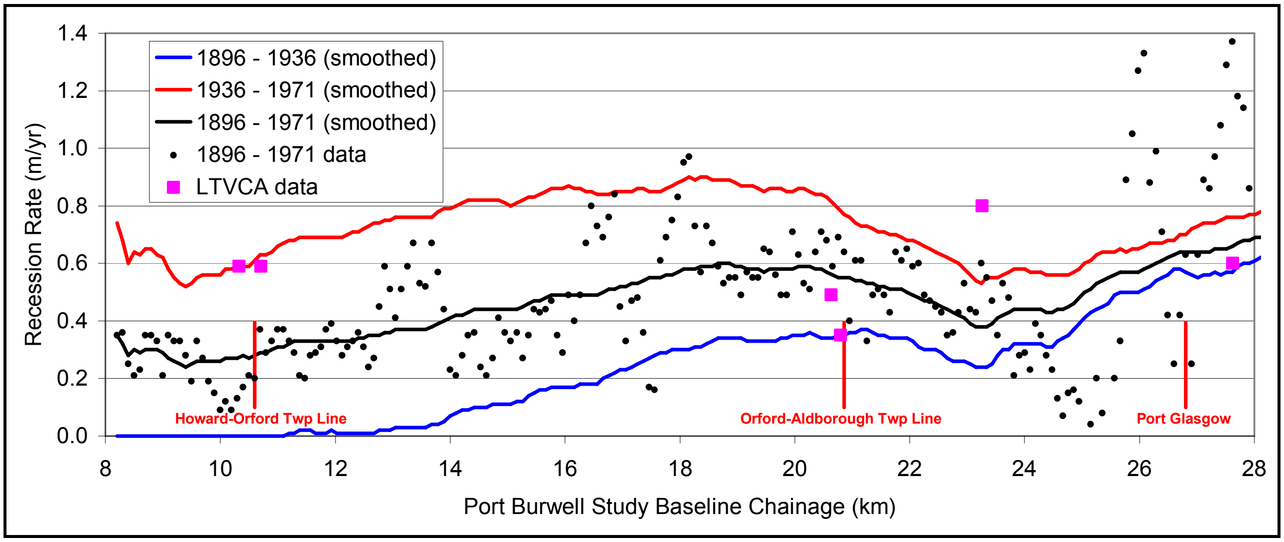
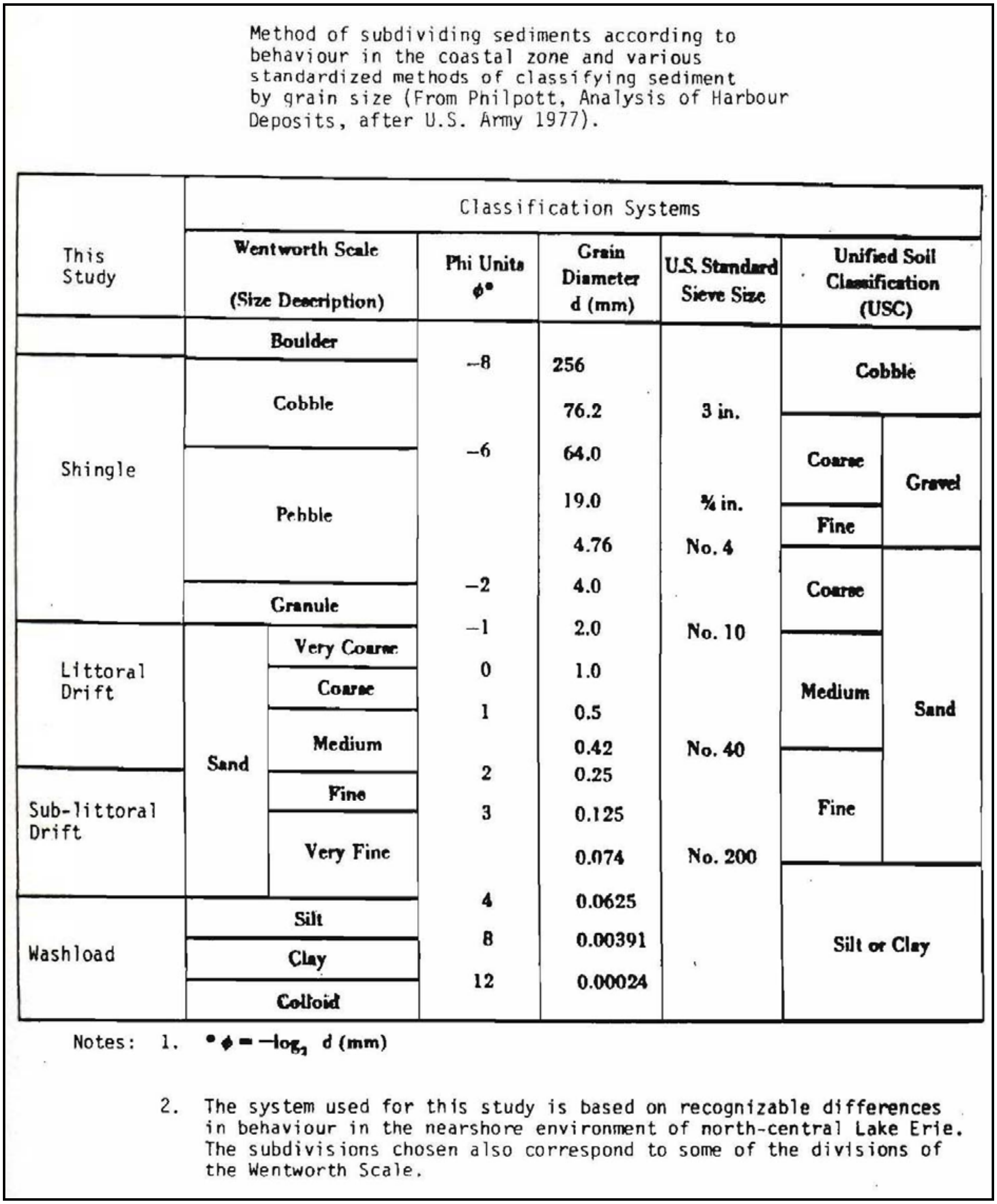


Figure 9 Sediment Particle Size Classifications from Philpott (1983a)



Method of subdividing sediments according to behaviour in the coastal zone and various standardized methods of classifying sediment by grain size (From Philpott, Analysis of Harbour Deposits, after U.S. Army 1977).

This Study	Classification Systems						
	Wentworth Scale (Size Description)		Phi Units ϕ*	Grain Diameter d (mm)	U.S. Standard Sieve Size	Unified Soil Classification (USC)	
	Boulder						
Shingle	Cobble		–8	256		Cobble	
				76.2	3 in.		
	Pebble		–6	64.0		Coarse	Gravel
				19.0	¾ in.	Fine	
				4.76	No. 4	Coarse	Sand
	Granule		–2	4.0			
Littoral Drift	Sand	Very Coarse	–1	2.0	No. 10		
		Coarse	0	1.0		Medium	
		Medium	1	0.5			
				0.42	No. 40	Fine	
Sub-littoral Drift		Fine	2	0.25			
		Very Fine	3	0.125			
				0.074	No. 200	Silt or Clay	
Washload	Silt		4	0.0625			
	Clay		8	0.00391			
	Colloid		12	0.00024			

Notes: 1. * $\phi = -\log_2 d$ (mm)

2. The system used for this study is based on recognizable differences in behaviour in the nearshore environment of north-central Lake Erie. The subdivisions chosen also correspond to some of the divisions of the Wentworth Scale.

Figure 10 Grain Size Distributions

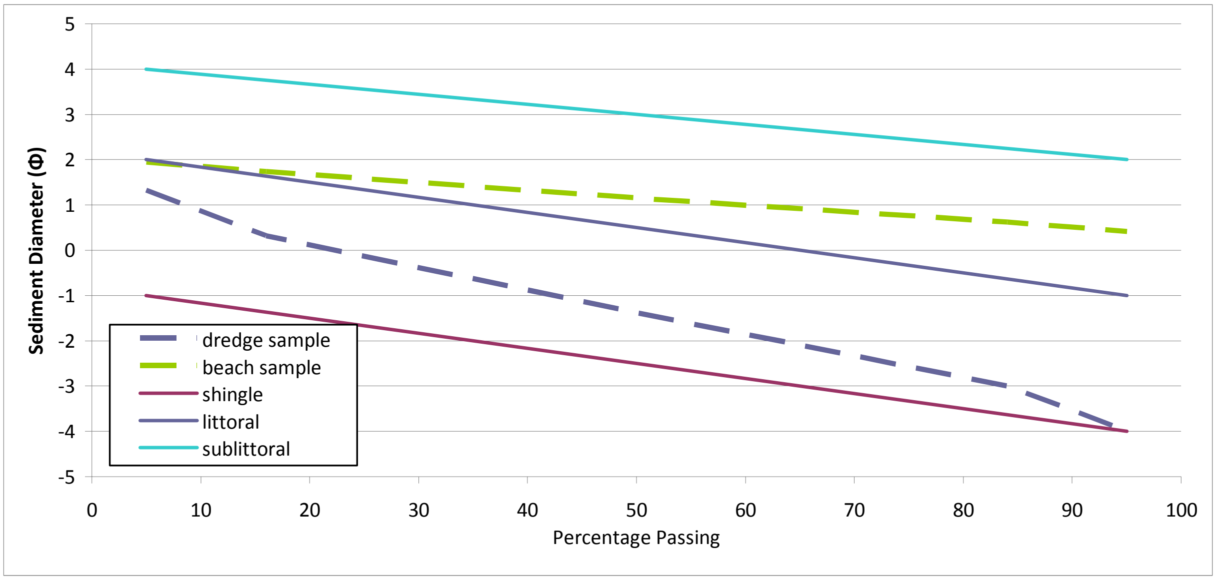


Figure 11 Potential Sediment Transport Rates for Shingle

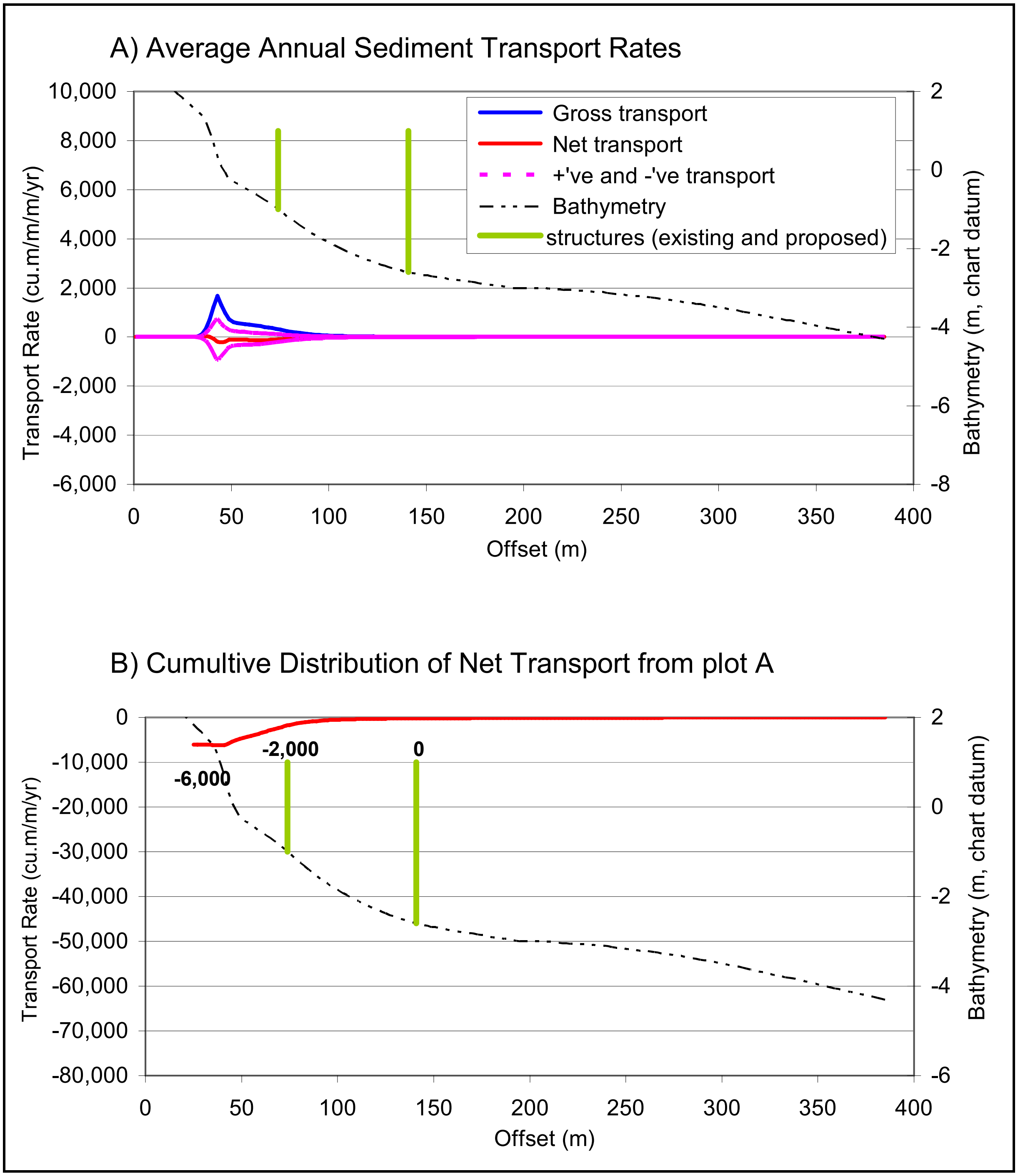
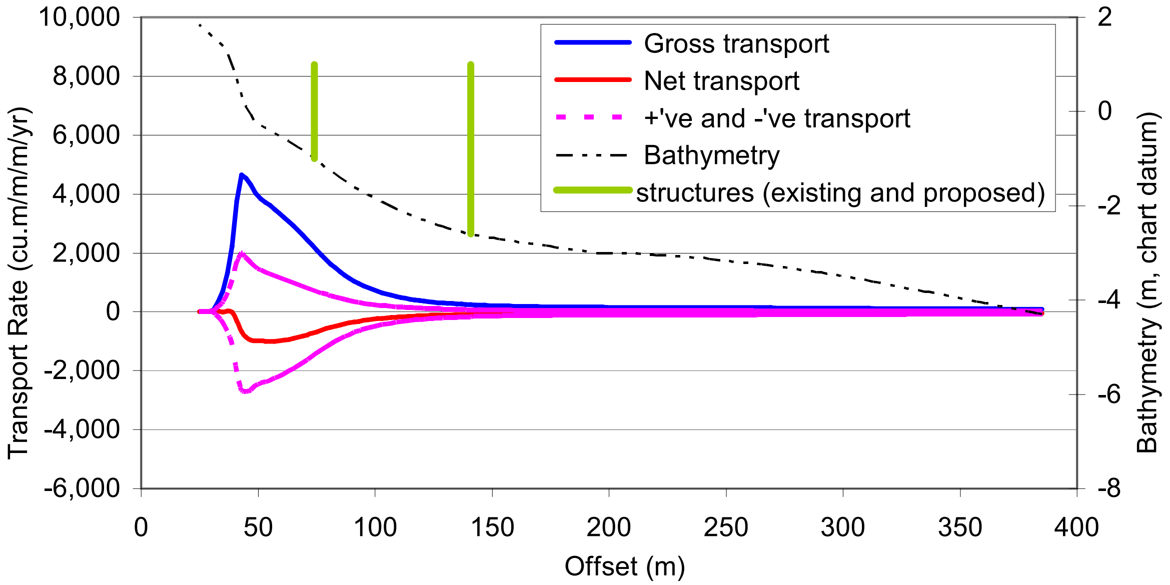


Figure 12 Potential Sediment Transport Rates for Littoral Drift

A) Average Annual Sediment Transport Rates



B) Cumultive Distribution of Net Transport from plot A

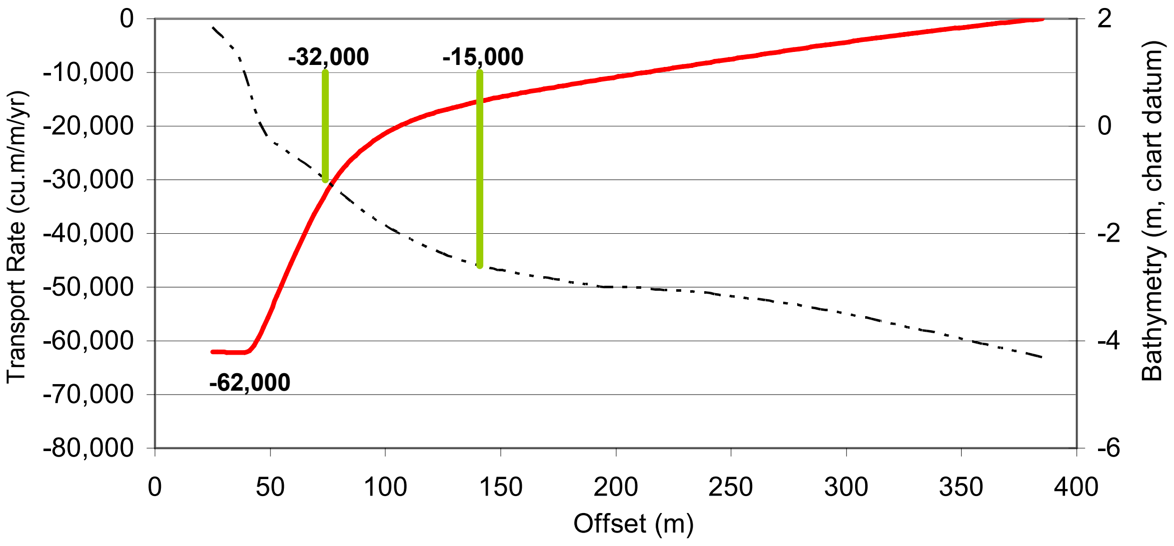
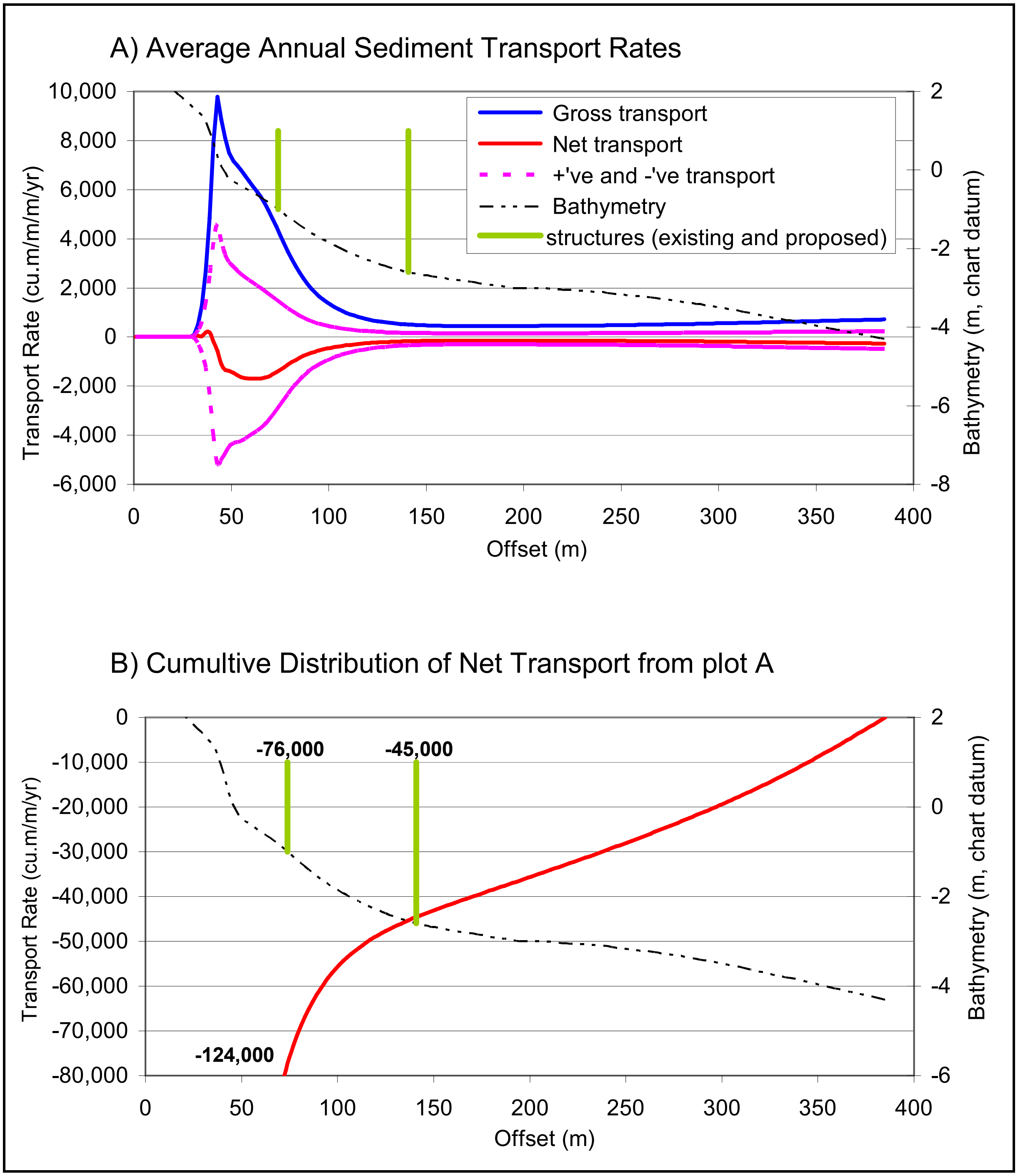


Figure 13 Potential Sediment Transport Rates for Sub-Littoral Drift



A) Average Annual Sediment Transport Rates

B) Cumultive Distribution of Net Transport from plot A

Table 1 Sediment Transport Rates Using Sediment Budget Approach

Baseline Chainage (km)	Alongshore Transport Rates (1,000's of cubic metres per year)			Cumulative Offshore Losses (1,000's of m^3/yr)
	Shingle ($\Phi < -1$)	Littoral Drift ($-1 < \Phi < 2$)	Sub-littoral Drift ($2 < \Phi < 4$)	mostly Washload ($4 < \Phi < 12$)
8.20	0	1	0	13
9.78	0	1	1	29
11.74	1	3	2	55
13.73	1	4	3	83
16.35	3	5	3	114
18.23	3	6	4	136
19.65	4	7	5	168
21.65	4	7	5	190
23.20	4	8	5	204
24.57	4	8	6	213
25.88	4	8	6	234
26.81	Port Glasgow / Sixteen Mile Creek			
26.97	4	9	9	300
29.60	5	11	16	431
36.66	5	13	20	556
43.15	5	14	22	632
48.97	6	20	29	856
55.51	6	22	36	1,211
61.21	6	22	39	1,276
64.64	Port Stanley harbour breakwater			

$\Phi = -\log_2(d)$, where d = grain size in mm

Sediment Budget Parameters

0%	shingle lost offshore
10%	littoral drift lost offshore
50%	sub-littoral drift lost offshore