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Your Ref. Our Ref. S2335/HGM/HDO

Secretary,
Highlands & Islands Development Board,
6 Castle Wynd,
INVERNESS.

18th April, 1969.

Dear Sir,

Cromarty Firth Feasibility Studies

1.00 INTRODUCTION

1.01 In accordance with the terms of your letter dated 11th November, 1968 we have pleasure in submitting a Feasibility Study on the dredging of an access channel for super tankers from the Moray Firth into the Cromarty Firth and for the reclamation of Nigg Bay suitable for industrial development.

2.00 APPOINTMENT OF CONTRACTOR

2.01 A contract for site borings, laboratory testing of samples and hydrographical surveys of the areas was placed with Messrs. Dredging Investigations Ltd., who are a member of the Westminster/Bos & Kalis group of dredging companies which is one of the World's largest dredging and reclamation organisations. Work commenced on the site at the beginning of December, 1968 and the site borings and surveys continued until 11th February, 1969.

3.00 SITE INVESTIGATIONS

3.01 Twenty-five exploratory bore holes were sunk in Nigg Bay to varying depths and four bore holes were sunk in the area of the access channel in the Moray Firth. At the outset, it was the intention to sink eight bores in the access channel, but because of extremely difficult weather conditions and the substantial cost being expended in standing time, we decided that the information obtained from the four bores in the channel gave sufficient indication as to the nature of the materials for dredging purposes.

3.02 The location of bores and borehole logs for the outer channel are shown on Plan No. 3 and for Nigg Bay on Plan No. 11.

4.00 ENTRANCE CHANNEL

4.01 The information obtained from the four bore holes sunk in the approach area indicates that there should be no difficulty in dredging in the materials encountered an entrance channel suitable for 200,000 ton tankers entering the Cromarty Firth. A vessel of this tonnage would have a draught of 58 to 62 feet and it would be advisable to provide about 70 feet depth of water.

4.02 If it is required to navigate laden 200,000 ton vessels into the Cromarty Firth at any state of the tide and in any weather conditions then a channel dredged to a minimum depth of -70.0 below Chart Datum should be provided. At lowest astronomical tides this would give a depth of water in the channel of about 68 feet and for a vessel of 62 feet draught a clearance between the channel bed and the bottom of the ship of 6 feet. At Low Water Ordinary Spring Tides the clearance would be just over 7 feet. It is considered that 6 feet should be the absolute minimum clearance allowed for such large vessels. Any clearance provided must allow for one or a combination of the following conditions: -

a) Rolling and pitching of the vessel including any deflection of the hull in a seaway.
b) Out of trim or listing.
c) Squat of a vessel in a confined channel.
d) Possible siltation of the channel.

Referring to a) above it should be noted that the maximum wave height observed by the Coxswain of the Cromarty Lifeboat outside the Sutors, was 15 feet in the vicinity of the Cromarty Bank with lengths of waves between 200 and 250 feet.

If it is acceptable to the operating companies concerned that vessels would only enter the Firth during high water periods on all days in the year then a channel of a lesser depth could be provided. Assuming that the lowest predicted High Water Neap Tide in a year is +10.0 above Chart Datum and a minimum depth of 70 feet of water is provided in the channel then the channel could be dredged to a depth of -60.0 below Chart Datum.

4.03 If the channel is to be dredged sufficiently to allow access to the Cromarty Firth at all stages of the tide, the quantity of material which would require to be dredged would be $5\frac{1}{2}$ - 6 million cubic yards, but if access was restricted to times of High Water only, the quantity of material to be dredged would be reduced to about $1\frac{1}{4}$ million cubic yards.

4.04 Assuming that the material would be re-used for reclamation of Nigg Bay it would be necessary to transport the material in the dredger hopper and deposit it at a point in Nigg Bay suitable for redredging and pumping to the area to be reclaimed. The cost of dredging the material from the channel and dumped only in Nigg Bay would be 2/6d. per cubic yard for larger quantities, and 2/8d. per cubic yard for the smaller quantities, giving total costs of approximately £700,000 and £170,000 respectively. The cost of redredging and pumping the material to the area to be reclaimed, is referred to later in this report. The time required to dredge the channel for the Low Spring Tide conditions would be 30 - 35 weeks and for the lowest High Water Neap Tide conditions about 10 weeks.

4.05 The type of dredger normally employed for dredging in deep and exposed waters would be a trailer suction dredger which normally cannot pump the material for reclamation, hence the need to redredge and pump.

4.06 The location of the channel as surveyed is shown on Plan No. 2 and was chosen on the basis of being the line which would give a channel requiring the minimum amount of capital dredging. It is suggested that the outer end of the line can be moved slightly northward to give a better approach line to Nigg Point without appreciably increasing the quantity to be dredged.

4.07 The velocity and direction of spring tides at the entrance to the Cromarty Firth are shown on Plan No. 1. The directions at position C indicate that they would set across the channel in any location in an arc between bearings of 270° and 300° at the entrance to the Cromarty Firth, but with lesser effect in the northern sector. The channel width of 750 feet which has been assumed allows for any slight "crabbing" of a 200,000 ton vessel, in its passage inward or outward, due to tides of up to 2 knots setting at right angles to the line of the channel.

4.08 All vessels leaving the inner end of the channel on an inward passage, in any alignment of the channel chosen will have to contend with the flood tide of 1.6 kn. springs setting across the Cromarty Bank. It is considered preferable, therefore, that vessels should make any turns necessary in the open sea, where there is the least effect of current, rather than in a location where there is a stronger current and closer to the berthing jetty.

4.09 Before a final alignment of the channel is determined it will be necessary to carry out a float and current meter survey of the area.

4.10 There is some evidence of littoral drift from the north as indicated by the sand dunes at Nigg Point, and in comparing earlier Admiralty hydrographic surveys with recent charts there is also evidence of accretion in the vicinity of the Cromarty Bank. Therefore it would appear to be advisable to keep the inner end of the channel clear of the Cromarty Bank to reduce to a minimum practicable siltation in the channel from this source. Before any works are carried out on dredging a channel, its effect on the possible movement of the sea bed material should be investigated.

5.00 RECLAMATION OF NIGG BAY

Strata

5.01 The borings in Nigg Bay have disclosed fine to medium and coarse sands, medium to coarse gravel with cobbles and substantial quantities of organic silt. Location of the surface material is shown on the attached Plan No. 4. Rock was encountered on the east and west sides of the Bay at depths of from 9 feet to 14 feet below the sea bed. The rock, however, dips from both sides towards the centre and the borings were stopped in the gravels or boulders. The silt which is in layers 8 feet to 13 feet deep lies within a few feet of the surface of the Bay extending from the western shore eastwards to the Big Audle and from the edge of the deep water channel northwards to the shore at Barbaraville, Kilmuir and Tarbat. The silt swings into the head of the Bay but in this area it is overlain by sands extending to 20 feet thickness.

Suitability of Materials for Reclamation

5.02 The organic silt which is extremely soft is totally unsuitable as dredged material for reclamation but the sands lying in the deeper water near the channel and at the eastern side of the Bay and also the sand overlying the silt at the head of the Bay are suitable for dredging and reclamation works by a pumped suction dredging and reclamation system. However, the sand areas on the east side and at the head of the Bay are areas which would be most suitable for industrial development after reclamation by sand pumping because it would be possible to proceed with construction immediately, and only the heaviest structures would require piled foundations. In the area of the head of the Bay where 20 feet of sand overlies the silt, the silt will have been partially consolidated by the weight of the overburden of sand, and therefore the additional loading on the silt imposed by the reclaimed material to bring the level up to requirements, would cause less settlement than in the other areas of the Bay where the silt lies near the surface.

5.03 In these other areas of the Bay where silt lies only a few feet below the surface, and extends from 8 feet to 13 feet in depth, progressive consolidation of the silt would occur when the surface is surcharged by the reclaimed material. This consolidation would extend over 8 to 10 years and could amount to between 35 and 40 inches in the deep layers of silt material and from 25 to 30 inches in the shallower layers. In such a soft material part of the consolidation and settlement would occur early when the build up of sand has been completed thereafter the consolidation would be at a slower rate and continue for several years. The laboratory tests of the silt indicate that this material will fail in shear under the loading of approximately 4 feet of filling. Such a shear failure may create problems during reclamation due to the displacement of the soft material.

5.04 In the areas where the silt is present it would be necessary for all structures to have piled foundations except for very light and isolated structures where uniform settlement over a period would not be detrimental.

5.05 The general effect would be that the structures on the piled foundations would remain static but the surrounding areas would gradually become depressed. Therefore, it would be necessary to give consideration to this in the early stages by laying out the industrial development in such a way that changes in the relative levels of the surrounding ground and the floors of industrial buildings and structures could be overcome by ramp accesses modified from time to time. Roads and railways would require reinstatement periodically.

6.00 PROPOSALS FOR RECLAMATION

SCHEME I

6.01 As mentioned previously, the area on the east side of the Bay would be the best area to reclaim for industrial development because of the sand and gravel formation where no settlement would occur and only the heaviest of structures would require piled foundations. An area reclaimed in this locality also has the advantage of being linked with the relatively level ground on the Nigg Peninsula. The proposed area is shown as Area 1 on Plan No. 5 attached, and is divided into two zones, Zone 1A being an area where there is no silt present and Zone 1B, where there is silt lying below deep sands but where some consolidation of the silt has already occurred. Structures in Zone 1B would require piled foundations and although settlement of the ground surface would occur, it should be much less than in other areas of the Bay where there is silt at shallow depths.

6.02 The Arabella Canal would be diverted in an excavated channel around the head of the Bay to link with the Balnagowan River which would require only minor modifications at the mouth to divert the flow alongside the reclaimed area.

6.03 Area 1 extends to 1650 acres divided into Zone 1A of 910 acres of good construction land and Zone 1B of 740 acres, where some consolidation would occur and where structures would require piled foundations. The southern portion of Zone 1A which extends to approximately 600 acres could be reclaimed as a first stage.

Material for Reclamation

6.04 The total material required for the reclamation of Area 1 is about 35 million cubic yards and the only suitable material available in the Nigg Bay locality is a deep deposit of sand at the mouth of the Big Audle and thinner layers on the northern side of the deep water channel. The estimated quantity of this material is 16 million cubic yards, consequently, it would be necessary to obtain a further 19 million cubic yards of suitable sand from another source. This can be found outside the Cromarty Firth in considerable quantities and if the access channel is dredged to the deep level, $5\frac{1}{2}$ to 6 million cubic yards would be available for repumping to reclaim Area 1, the balance being obtained from the same source.

Level of Reclamation for Industrial Development

6.05 In our opinion it is essential that for large industrial complexes sited on reclaimed land the ground should be above any possible flood level. This means that the areas should be reclaimed to give satisfactory clearance above a tide which could rise by 4 feet to 5 feet above Mean High Water Springs. Such a tide can occur during an astronomical high tide coupled with a North Sea surge and the North Sea surge which occurred in 1953 was about 3 feet in the North-East of Scotland, 9 feet in the South-East of England and about 12 feet in the Northern European coast. We consider, therefore, that the level of the reclaimed land should be not less than 19 feet above Chart Datum (12.5 feet Ordnance Datum, Newlyn). This level would be about 6 ins. above the probable maximum flood and the quantities referred to above are based on reclaiming to this level.

Protection of Slopes and Surfaces

6.06 The sloping surfaces of the reclaimed areas would be protected by gravels dredged from the Big Audle and from an area near the deep water channel. The gravel could be dredged by a suction dredger and pumped in a similar fashion to the sands although with a much reduced output, but the cost of obtaining the material from the Bay should be cheaper than importing from a quarry source. Heavier imported stone would be provided on the slopes of the reclaimed areas fronting the deep water channel in the Firth.

6.07 Once the area has been reclaimed to level the sand surface dries out and is readily eroded by wind. It is necessary therefore to protect the sand surface by some means such as a thin layer of gravel or by oil and latex which retains the sand in position until grass can be grown to protect the surface. Gravel would be best for an area to be used for industrial development.

Road, Rail, Water and Electric Power Services

6.08 Road and rail access to the reclaimed area in Scheme I would be provided by the construction of a new road commencing from the existing main road at Ballchraggan thence round the head of the Bay to the industrial area. The rail access could follow approximately the same route. Only the cost of providing road and rail services from the main road to the site should be included in the cost of the reclamation scheme as internal communication roads, rail sidings, etc. would be common to the industrial area in another location. The cost of extending water mains from an alternative industrial area at say Delny, should be included. The question of the capital cost of providing electrical power to the industrial area should not normally arise as it is customary for the electrical authorities to bring power to the site free of charge if the annual demand is sufficient. Industrial development on the scale envisaged for the reclaimed areas would no doubt require sufficient power to meet the above condition.

Cost of Scheme I

6.09 The estimated total cost of Scheme I is £12,300,000 to reclaim 1650 acres including allowances for Road, Rail and Water services, the cost per acre being £7,450. Using four dredgers it would take 22 months to reclaim the area.

6.10 The material required to reclaim 600 acres at the south of Zone 1A is approximately 16½ million cubic yards. This would cost £6,550,000 including road, rail and water services; the cost per acre being £10,900. The time required would be 10 months.

7.00 SCHEME II

7.01 As approximately 11 million cubic yards of good sand is available at the head of the Bay and can be dredged and pumped at economic rates for reclamation, we have prepared an alternative Scheme II for reclaiming areas for industrial development which would also include reclaimed land for agriculture. This scheme is shown on Plan No. 6 attached.

General Location of Reclaimed Areas

7.02 The areas to be reclaimed in Scheme II would be situated mainly over the parts of the Bay where the soft silt is close to the surface and except for the major part of the Area 2 which corresponds generally to the southern portion of Zone 1A of Scheme I and a small part of Area 3, settlement of the ground surface would occur, and all foundations would require to be piled./

/The total area reclaimed would be 2,400 acres fronting the deep water channel leaving the Big Audle between Areas 2 and 3 as a water course for harbour development and also for drainage of the unreclaimed northern portion of the Bay which in the ultimate development with the stone causeway forming the northern boundary of the reclaimed area, would become a fresh water lake. The Balnagowan River and the Arabella Canal would discharge into the lake and an adjustable weir to regulate the level of the water in the northern part of the Bay would be constructed in the causeway. By regulating the level of the water the foreshore areas down to the +9 contour (above Chart Datum) could be used for agricultural development as proposed by the Department of Agriculture and Fisheries.

7.03 The reclamation could be undertaken in the separate Areas 2 to 5 as shown on Plan No. 4 the areas of the individual portions being 720 acres, 550 acres, 560 acres, and 570 acres.

The stages in the reclamation of Scheme II are shown on Plan No. 6 assume the reclamation progressing from east to west, starting on good foundation conditions and advancing on to the silt and mud areas where greater settlements of the reclaimed land would take place. Reclaiming the area from east to west would also enable an early start to be made on the Port area at the mouth of the Bid Audle.

If a policy of development from Invergordon eastwards is adopted for the present lands zoned for industrial purposes, it may be preferable to consider reclamation starting with Area 5 working towards Nigg Point, but a greater period of time will have to be allowed for settlement to take place before starting industrial development. The main advantage in reclaiming from west to east in Scheme 2, however, is that the causeway would only be constructed for the length appropriate to the area being reclaimed at any time until such time as say half the Bay was being reclaimed and the flow of water from the head of the Bay through the reduced width of the channel during a falling tide became troublesome, when it would become necessary to construct the whole of the causeway including the discharge weir, thus forming the fresh water lake which would also permit the land near the shore to be prepared for agricultural development. Adopting this method would avoid the cost of the whole of the causeway being incurred when only a small portion of the ultimate scheme is developed as a first stage if this is done from the east side.

Material for Reclamation

7.04 The total quantity of material required for the Areas 2 to 5 inclusive would be approximately 75 million cubic yards and Area 2 requiring 22 million cubic yards could be reclaimed using the sands from the head of the Bay and from sand dredged from the edge of the deep water channel in front of the Big Audle. This would leave a balance of 4 million cubic yards to be used towards the reclamation of Area 3. The balance of materials for Areas 3, 4 and 5 i.e. a total quantity of 49 million cubic yards could be obtained from sources in the Moray Firth outside the Sutors and would be brought in by trailer dredger and deposited in positions suitable for redredging and pumping to the reclaimed areas.

Road, Rail and Water Services.

7.05 In Scheme II the road, rail and water services would be constructed on a wide stone causeway between Ballintraid and Nigg on the northern boundary of the reclaimed areas. Should Area 2 only be developed as a first stage it would be necessary to construct the causeway from Ballintraid, or alternatively, to adopt the road system round the head of the Bay as for Scheme I.

Agricultural Land.

7.06 The reclaimed agricultural land indicated on Plan No. 6 will depend upon the water level of the fresh water lake being maintained at a top water level not exceeding +7.00 above Chart Datum. The areas would require to be fenced and drained in the normal way of any agricultural land but, a period of treatment to desalinate the land and develop humus would be required before full use could be made for agriculture.

The drainage of existing lands at the head of the Bay would also be improved due to these operations thus increasing their value.

Cost of Scheme II

7.07 The estimated total cost of reclamation works in Scheme II is £25,800,000 and the time required to complete the whole area would be just over five years. The cost of developing the individual areas and the times of construction are as undernoted: -

Area 2 (including causeway and services)	720 acres,	£8,520,000	-	Time	(4 dredgers)	18 months
Area 3	550 acres,	£5,520,000	-	Time	(3 dredgers)	16 months
Area 4	560 acres,	£6,150,000	-	Time	(3 dredgers)	14 months
Area 5	570 acres,	£5,610,000	-	Time	(3 dredgers)	15 months

The estimated costs per acre for Scheme II are:

Area 2 = £11,850 per acre (carries cost of causeway and services)
Area 3 = £10,000 per acre
Area 4 = £10,950 per acre
Area 5 = £9,850 per acre

Reclamation in Stages

7.08 The effect on the cost of development by undertaking the reclamation works in stages would be additional mobilisatiom and demobilisation charges for the plant which could add say £25 to £30 per acre. If there should be a considerable lapse of time between the stages there would be also of course increases in costs resulting from normal rises in labour rates and in the costs of any imported materials such as stone for the causeway and roads.

8.00 COSTS OF DREDGING AND RECLAMATION

8.01 As there has been a great deal of discussion regarding the basic rates which should be used for estimating reclamation schemes, we have made special reference to this matter in our dealings with the Contractors and have asked them to provide us with rates which they consider appropriate having examined the materials to be handled in the Nigg Bay area and also in the Moray Firth outside the Sutors. The Contractors have indicated that the circumstances are not comparable to the large reclamation schemes undertaken in Holland, but we understand that they have discussed the scheme for Nigg Bay with their Dutch colleagues. The rates provided to us which vary according to the nature of the materials, and with the locations, are as undernoted: -

Based on an output of 80,000 to 100,000 cubic yards per week per dredger unit in fine to medium sands, the rate per cubic yard is 3/9d. to 4/6d. for a maximum pumping range of 2500 yards.

Rate used in estimates 4/- per cubic yard.

Extra per cubic yard for distances over 2500 yards - 1/4d. per cubic yard for each increment of 100 yards.

For coarse sand and medium gravels the production drops to 50,000 to 70,000 cubic yards and the cost per cubic yard becomes 5/8d. to 7/7d. for a distance of 1500 yards.

A rate of 7/6d. per cubic yard has been used in the estimates for obtaining gravel to cover surfaces of reclaimed areas. The higher rate is used because of surface plant required for spreading.

Extra per cubic yard for distances over 1500 yards - 2/3d. per cubic yard per 1000 yards.

For gravel and cobbles the production is estimated at 40,000 cubic yards per week and the rate of 8/- to 11/- per cubic yard for distances of 750 to 1000 yards would apply.

Extra for distances over 1000 yards, 2/3d. per cubic yard.

The rate used in the estimates is 10/- per cubic yard for gravel and cobbles necessary for protecting sand slopes and which would require some spreading.

A trailer dredger would be used for dredging the entrance channel and for winning the sand from the areas outside the Sutors. This type of dredger is used in more exposed waters where the cutter suction dredger would require to stop working. The trailer dredger does not pump to a reclaimed area but would deposit the material for redredging and pumping by a cutter suction dredger. The rate for this material would be 2/6d. per cubic yard and for redredging and pumping a further 3/- per cubic yard must be added, giving a total rate of 5/6d. per cubic yard which has been used in the estimates for all materials obtained from outside the Sutors.

9.00 DRAINAGE OF RECLAIMED LANDS

9.01 Rainfall over open areas reclaimed with sands would percolate through to a water table which would form in the reclaimed material at a level which would vary with the tidal conditions. Surface water from roads, buildings, etc. would be dealt with by normal drainage systems consisting of main drains of large diameter pipes laid to fairly flat gradients with feeder drains as required. The outfalls for the surface water drains would be fitted with flap valves where these drains discharge into tidal waters and sufficient storage capacity in the form of ponds, culverts, etc. would be necessary to cater for the run-offs during storms which occur coincident with the period when the flap valves are inoperable due to the tide level. Where the discharge is to the fresh-water lake no flap valves will be required.

9.02 A separate sewage drainage system will require to be provided depending upon the requirements of the sites developed and the effluent treated before discharge.

9.03 Costs of surface water and sewage drainage systems have not been included as these would be dependent upon the nature and the extent of industrial development for any area, but a nominal allowance has been made in the costs for the provision of storage ponds or alternatively a pumped system to deal with high flows during high tides when the flap valves are closed.

10.00 NIGG VALLEY DRAINAGE AND BALNAGOWAN RIVER

10.01 We have studied the preliminary report prepared by the Geography Department of Aberdeen University who carried out a separate study on the effect of reclamation of Nigg Bay on the Valley drainage system and the Balnagowan River. The University report indicates that by undertaking relatively minor dredging and embankment works the reclamation schemes for Nigg Bay as proposed in our Feasibility Study would not interfere with existing conditions in the land area fronting the Bay.

10.02 We note that the University would not recommend a shallow fresh-water reservoir and suggest that reclamation of the west side of the Bay, where the bed consists of silts and muds, might be reclaimed to avoid shallow water conditions in a fresh-water lake.

10.03 In our proposals for Scheme II, the deep layers of sand at the head of the Bay would be dredged and used for reclamation of Areas 2 to 5, thus forming a very deep section of the fresh-water lake which would be formed behind the weir. This deep section would be in keeping with the University's recommendations for deeper water and it would also form a natural deposit area for materials carried down by the Balnagowan River.

10.04 To avoid the shallow water conditions at the west side of the lake it would be necessary either to proceed in the early stages with a polderisation system of reclamation for agricultural development which would have a pumped drainage scheme, or alternatively, to dredge out the silts and muds to provide deeper water. In our opinion, the latter method would be grossly uneconomical and we would imagine that polderisation would also prove a costly scheme for agricultural development. We consider that the fresh-water lake should be formed as proposed in our Scheme II, the west side of which being shallow would encourage vegetable growth and could become an area where wild life would develop and the east side together with the deeper waters close to the causeway bounding the reclaimed areas could be used for recreational purposes. At some stage in the future if it is considered advisable to undertake a scheme for agricultural development on the west side by polderisation methods, these works could then be put in hand.

11.00 PORT AND HARBOUR FACILITIES

11.01 An industrial area on reclaimed land in Nigg Bay should have harbour facilities nearby, and assuming that the areas at the East Side of the Bay were developed in the first stage the Harbour would require to be at the South West corner of Area 1 in Scheme I and Area 2 in Scheme II. This area is not as suitable for a harbour as the more sheltered waters further up the Firth. Wave heights of up to 10 feet can occur in the vicinity of Nigg Point but, the berths could be designed with gravity fenders or other efficient fendering to withstand the conditions likely to be encountered.

11.02 The berths for large vessels such as 200,000 Ton Tankers would be on the deep water channel and berths for smaller vessels up to say 50,000 Tons and 60,000 Tons would be sited in the Big Audle which would be dredged in any case to obtain the gravel for protection of slopes. The large bulk carriers and tankers arriving laden would preferably berth at the deep water berths with bow west and turn in the Cromarty Firth after leaving the berth unladen. All movements of vessels within the Firth should be assisted by tugs.

11.03 The possible positions for berths are indicated on the plans of the schemes but no costs are included for harbour works.

11.04 Although marine conditions further up the Firth are better for handling of ships than conditions at Nigg Bay a harbour development within the reclaimed areas would be practicable, if the reclamation scheme were to proceed. It is possible that the equivalent harbour works within the reclaimed areas could be constructed at less cost than at Invergordon. However, more detailed site investigation would be necessary in any area chosen for harbour works to consider foundation conditions, the effects of winds, waves, currents and possible siltation.

12.00 CONCLUSIONS

12.01 The investigations carried out have shown that the reclamation of Nigg Bay for industrial and agricultural development is feasible, but for most of the area substantial settlement of the ground surface would occur and in some cases would in our opinion be excessive. Except for the areas reclaimed on sand all foundations of structures would require to be piled, but the need for piling should not be looked upon as a serious objection to the reclamation of the area as piled foundations are a common construction nowadays for large industrial works, and at Nigg Bay the piles should be relatively short.

12.02 The cost of reclaiming land from tidal waters is high, compared with the cost of existing lands at present used for other purposes, and this factor may weigh against reclaiming Nigg Bay for immediate industrial development. If it is envisaged that development in the Cromarty Firth area is likely to expand, because of the proximity of deep water facilities which could be provided, it may be prudent to proceed at an early date with the formation of an Authority which would control the reclamation works and govern the use of reclaimed land and water areas. It is possible that because of increased demand in the future the cost of existing industrial land may rise to such an extent that the capital costs at present quoted for reclamation works may prove a sound investment, especially as the availability of reclaimed land produced in conjunction with channel improvements could also be attractive to industries seeking areas for development. It is interesting to note that after 10 years of development in Milford Haven it is now necessary there to embark on a £12 million channel improvement programme.

12.03 A Cromarty Firth Authority with powers to levy dues on tonnage using the Firth, and with borrowing powers for future investment could greatly increase the speed of development of a marine based industrial area.

Prior to any works being undertaken it would of course be necessary to deal with the various Authorities concerned including the Crown Commissioners who govern the sea bed in the Nigg Bay area and who presumably would impose some charges for the use of the land.

Yours faithfully,

Babtie, Shaw & Morton

SMM