WAR OFFICE

ARTIFICIAL HARBOURS

GATES

E. J. Buckton.

A Builder.

A Pump Manufacturer.

A Mechanical man.

G. E. Howorth.

BULK OIL.

Kenyon Bell.

Capt. Algelt, E.T.O.U.S.A.

? one other.

ARTIFICIAL HARBOURS.

Colin White.

J.D.C.Couper.

Aikman Cochrane.

R.D.Gwyther.

Ivor Bell.

Col. Roberts, E.T.O.U.S.A. to be ex officio member of any Committee.

19th July 1943

We are asked to select, on defined sections of coast line, suitable anchorages for 12 coasting vessels and advise how these can best be converted into sheltered harbours.

We should advise on the area available in each harbour selected, and the traffic which can be handled.

Discharge will be by lighters.

Maximum and minimum draft of vessels will be supplied.

The anchorage should be within short distance of road communications, and rail as a secondary consideration.

(1) Selection of site from the point of view of:-

(a) The configuration of coast line.

(b) The accessibility of existing road and rail communications on shore.

(2) Protection required at selected site.

(3) Area of sheltered water, exceeding four fathoms, available.

(4) Nature and extent of works on foreshore required to facilitate landing of cargo.

(5) Number of ships that can be dealt with at one time, or quantity of cargo that can be handled in any 24 hours.

ARTIFICIAL HARBOURS

AIR BREAK-WATER.

First Stage. Try out the effectiveness of a stream of air bubbles to break up and damp oscillatory waves.

(1) It is suggested that this should be done at Garlieston where the Lobnitz pier head and D.Tn. bridge is installed.

Position and details of pipe line can be laid out on a scale plan and sent to officer/charge to instal with instructions to report:-

(a) effect on waves and area of sea affected.

(b) quantity of air used.

(c) effect of varying position so as to obtain optimum effect.

(d) carry out further experiments as Committee and O.I/C. may suggest.

(2) Prepare model reproducing conditions at Garlieston on which experiments can be tried out to ascertain -

(a) Size and length of pipe for best results.

(b) Position of pipe relative to pier head and direction of waves.

(c) Size and spacing of air outlets with a view to economy in air.

Second Stage.

(1) If trials undertaken in Stage One show promise pipe should be taken out to deeper water and suspended say 24 ft. below surface and at least 24' depth of water at L.W. with a view to providing a sheltered anchorage.

(a) Length of perforated air pipe line required to give a definite area of sheltered water.

(b) Ascertain best method of suspension of pipe and anchoring.

ARTIFICIAL HARBOURS

AIR BREAKWATER (Contd.).

(v) Ascertain rapid and safe manner of installation.

Second Stage.

(2) Model.

Experiments as to size and length of pipe

" size of air outlet and spacing.

" depth of air outlet below surface.

Any advantage in going deeper?

11/8/43.

ARTIFICIAL HARBOURS

Note on operations of Messrs. J. Mowlem & Sons at Dover Harbour with compressed air wave breaker.

As requested at the third Meeting of the Committee, contact was made with the above firm and details obtained of the use made of compressed air to assist the operations of their divers at Dover.

The following compressors were used and are in store in London at the present moment:-

5 No. @ 1000 cubic feet per minute capacity.
2 No. @ 850 " " " " "
2 No. @ 610 " " " " "
1 No. @ 555 " " " " "

These are all Bernard Holland machines of the rotary type and are really blowers giving 20 lbs. pressure.

No perforated pipes are now available from this job.

From a description of the experiment carried out by Mowlems it would appear that there is very little to be learned from it.

The perforated pipe used was placed in water where the waves had already broken so that it was hardly a fair test, but it is stated that the action of the bubbles did produce slightly better conditions for the divers.

Four inch diameter pipe was used with ¼" holes drilled at 6" centres, but the total length was very small and it was placed on the bottom in close proximity to the spot where the divers were at work.

No data is available as to the quantity of air used per minute.

Beyond locating certain air compressors which might be useful, very little information was gleaned from Mowlem's representative.

ARTIFICIAL HARBOURS

POINTS IN CONNECTION WITH TOWING.

No. of Tugs and H.P. required to two -

2 Lobnitz Pier Heads 200' x 60'

6 Section D.Tn. Pier of 6 spans

10 American pontoon equipment each 107' x 43'

at say 4 knots.

Time taken to tow from Southampton. How much of tow must of necessity be in daylight.

Any difficulty in towing through Race of Alderney, or would it be necessary to go West of Alderney.

Any difficulty due to navigation of these channels, weather, fog.

ARTIFICIAL HARBOURS.

QUESTIONNAIRE for the Hydrographer in connection with Site 1 (East of Surtainville) and Site 2 (Anse de Sciotat).

Any further information regarding depths *especially inshore & for 2 miles out.* additional to that shown in Chart 2669 so that larger scale plan can be prepared.

Any information regarding direction and strength of currents closer in - say 1 mile from shore.

Note regarding prevalence of fogs during March to September.

" " prevalence of S.W. W. & N.W. gales) and if possible some indication of) March - Sept. force.)

Nature & quality of holding ground

Size of waves (1) Summer
(2) Winter

MOST SECRET

ARTIFICIAL HARBOURS.

Minutes of Meeting of Sub-Committee at 2.30 p.m. on 4th August, 1943, at the Institution of Civil Engineers.

PRESENT: Mr. C. R. White, in the Chair
Mr. R. D. Gwyther
Mr. J. D. C. Couper
Major W. I. Bell.

Mr. C.R.White produced a list (copy attached) of seven possible sites on the 1st Priority as a basis for discussion and these were examined by the Sub-Committee with the following results:-

No.1. EAST OF SURTAINVILLE.

The beach here is about 6½ miles in extent of which about 1 mile at the Northern end has possibilities.

The width of the beach is about 500 yds. and has a slope of about 1 in 50 at low water at the Northern end rising to a slope of about 1 in 20 at High Water.

There are rocky outcrops at low water which rule out all possibility of a landing at low tide but landing at High Water is possible at any point.

The beach is soft sand (See I.S.T.D.)

Road Access - Roads exist but are poor in quality and would require a considerable amount of work to be done on them.

Deep Water - There is deep water (5 fathoms) within 6 cables of the H.W. line.

Current - As far as can be estimated this is in the region of 3 knots, but should be checked by reference to the Hydrographic Dept.

Exposure - The beach is open to South Westerly and North Westerly winds.

No.2. ANSE DE SCIOTOT. This beach appears to be better protected than No.1.

It is approximately 1 mile in length by about 600 yds in width.

The gradient is 1 in 80 at Low Water rising to 1 in 40 at High Water.

Infantry can land at any stage of the tide according to I.S.T.D., but M/T would have difficulty with the soft sand above high water.

Road Clearance - This is better on the whole than in the case of No.1. All roads converge on Pieux but circuits could be arranged.

Current - This is estimated at 3 Knots and the spring range of tide is about 32 feet.

Exposure - There is surf on the beach with westerly winds.

No.3. VAUVILLE. This beach is approximately 2 miles in length and 400 yards wide.

The slope is about 1 in 70 at Low Water rising to 1 in 10 at High Water where sand gives way to shingle.

Road Clearance - There is a stiff climb of 350 feet from the fore shore to join a secondary road.

The main circuit for M/T would be through Beaumont Hague, a round trip of approximately 10 Kilometres, and there is a scarcity of secondary roads to feed dumps.

Current - There is a tidal stream of about 3 Knots, North and South, at Spring tides.

Exposure - Beach is exposed to Westerly winds which produce heavy surf.

No.4. NEAR OMONVILLE. Very little information could be obtained of this beach but it would appear to be rocky, and with no road access.

Current - Tidal stream of 3½ Knots.

Exposure - There is surf on the beach with winds N.West to N.East.

No.5. It was decided to rule out this site on account of its proximity to Cherbourg.

Any anchorage would moreover be untenable during Westerly winds.

No.6. **QUINEVILLE.** There is a good sandy beach 1,300 yds. northwards from Quineville with an average gradient of 1 in 140.

There are rocks exposed at Low Water, however, opposite this village. Distance between High and Low Water about ½ mile.

Road Clearance - Poor, but there are some roads which would require considerable development.

Around Quineville there is marshy land which might be inundated in winter.

Exposure - This beach is protected from Westerly and Northerly winds.

Current - Tidal stream of 2½ Knots.

No.7. Not a very attractive site - I.S.T.D. reports a rocky coast line and absence of roads.

Slope of beach 1 in 13 with steep cliffs behind.

Beach subject to surf in Northerly winds.

It was arranged that the Sub-Committee would meet again on Thursday, 5th August, at 2.30 p.m.

August, 1943

"Y"

General

1. Coast most inhospitable

2. Fog frequent

3. Tidal stream strong
Exposed to winds from between west and north, no anchorage.

P.251 1.8/15

(Exposed to winds from S. to N. through West. Protected S.W. by Jersey, &c.)

Springs 34½' (Die) Extremes H & L.

1. Min. distance of 5 fathom line from shore about 6 cables, but it swings round at S to enclose Bancs de Surtainville with a minimum of 1¾ fathoms. Detached patches Bihard & Caillou 1 fath. and 2 fath. respectively, the whole extending 2¼ miles from shore on S. side of Bay, forming a pocket.

Sandy beach with patches of rock backed by dunes.

2. To N. of I. and separated from it by rocky Point and detached patches of rock.

Min. distance of 5 fath. line from shore about 6 cables.

Sandy beach backed by dunes.

S. and 3 to 4 miles off shore of 1 & 2 Tidal Streams attain rate of 4 kn.

3. N of 2, separated from it by Cap.

Min. distance of 5 fath. line from shore about 5 cables.

Sandy beach backed by dunes. Bordered by a bank, which, with depths of less than 5 fath. extends, in places, over a mile off shore.

Anchorage sand and gravel but holding ground bad.

Tidal streams in middle of Anse attain 3 kns.

4. 5 fath. line between 2 & 3 cables off shore. Rocky beach

N.W & E. outlying rocks. Latter extending a mile off shore in places, some dry.

Tidal streams attain 4 kn.

5. 5 fath. line a minimum of about 1 cable off shore increasing in both directions to 4 cables.

Anchorage exposed to Westward and only tenable with winds between E & South.

Tidal streams 1 m. west of Cap attain 1½ knots.

6. 5 fath. line a minimum of 1½ miles off shore.

Long stand at H.W. (Nearly 3 hr.)

Anchorage. On shore winds cause heavy sea. Sand, mud & Clay.

Tidal streams attain 2½ kn.

7. 5 fath. line about ½ mile off shore. Backed by cliffs.

Tidal streams attain 3 kn. off the Port to the Eastward.

MOST SECRET

ARTIFICIAL HARBOURS

Minutes of second Meeting of Sub-Committee held at the Institution of Civil Engineers at 2.30 p.m. on 5th August, 1943.

PRESENT: Mr. C.R.White (in the Chair),
Mr. R.D.Gwyther,
Mr. J.D.C.Couper,
Lt.Col. L.B. Roberts, S.O.S., E.T.O.U.S.A.,
Major W.I.Bell, Tn.5.

Some discussion took place on the sites investigated at the first meeting and it was agreed that from the point of view of exposure the beach running South from St. Vaast to just South of Quineville was the most desirable.

The Sub-Committee considered it desirable to have in their possession all details of the various types of apparatus proposed for the production of comparatively still water.

Details are also required as to any recent decisions regarding the types of temporary pierhead and approaches it is proposed to use in conjunction with the above.

Major Bell was requested to obtain information under the above headings from Dept. Tn.5. It was also hoped that Colonel Rolfe might be able to obtain from the Hydrographic Department information regarding weather conditions, tidal currents etc. at Beach No.6 as well as Nos.1, 2 and 3.

Any information available as to the behaviour under towing conditions of Floating Pierheads, Pontoon Bridges, etc. of approved design would be useful to the Committee.

Colonel Roberts drew attention to the fact that there was a scarcity of good ports on the West coast of the Cherbourg peninsula and if a suitable site could be found on this stretch it would be of great advantage.

It was agreed to proceed with an investigation of the beaches in the Second Priority at the next Meeting and the Committee adjourned until 2.30 p.m. on 9th August.

MOST SECRET

ARTIFICIAL HARBOURS

Minutes of Third Meeting of Sub-Committee held at the Institution of Civil Engineers at 2.30 p.m. on 9th August, 1943.

PRESENT: Mr. C. R. White, in the Chair,
Mr. R. D. Gwyther,
Mr. J.D.C.Couper,
Col. J.A.Rolfe, Tn.5) Part
Lt.Col.L.B.Roberts, S.O.S.,E.T.O.U.S.A.) time
Major W.I.Bell, Tn.5.

As arranged at the second Meeting, Colonel Rolfe was approached for certain information regarding developments in connection with apparatus for "wave breaking" and he agreed to attend in person to explain the position and answer any questions.

It is understood that all experimental work in this connection is in the hands of the Admiralty and Colonel Rolfe will endeavour to arrange for a visit by the Committee to Shoreham in the near future to witness tests of a "Bubble Breakwater" in course of installation there.

Meantime it is Brigadier Bruce White's intention that Dept. Tn.5 should consider this problem independently and carry out such experiments and tests as may be necessary to arrive at a satisfactory solution in case the work being done by the Admiralty should be unsuccessful or "hang fire" in any way.

This Committee is therefore requested to study all available data and put forward concrete proposals.

Colonel Rolfe and Lt. Col. Roberts produced dossiers containing all the data which has been collected to date, and this is being duplicated for the information of all concerned.

Colonel Rolfe drew attention to the work done by compressed air in reducing wave action at Dover Harbour by Messrs. John Mowlem, and Major Bell was requested to contact that firm in order to ascertain the present position of the plant used by them and other details.

(Note:- This has been done and Mr. Beck of Mowlems is arranging to get in touch with the Engineer who was in charge of the work before the next meeting of the Committee.)

The problem was discussed in the light of the data produced, and the general opinion of the Committee, pending further investigation, was that:-

(a) The most successful results would probably be obtained with the perforated pipe floated at a level of 15 to 20 feet below the surface instead of in deep water anchored on the sea bed.

(b) The estimated horse power required was probably excessive and experience may show that the figure of 12,000 H.P. per 1,000 ft. of pipe given may be an over estimate.

(c) The evidence available all pointed to the possibility that the "Bubble" type of Breakwater was more likely to be successful and was a more attractive proposition than the rubber balloon or "Lilo" type.

Mr. Gwyther was requested to contact unofficially Professor Gibson of Manchester University with a view to obtaining the benefit of his advice on scientific matters connected with the Committee's investigations.

Mr. Gwyther also undertook to prepare a questionnaire for submission to the Hydrographic Department through Colonel Rolfe.

For purpose of record Colonel Rolfe gave the following information:-

(1) D.Tn. Pierhead (Lobnitz type)

on order at today's date	6 Pontoons with spuds.
Further order contemplated	9 " " "
Probable ultimate total	15

(2) Floating Bridge for above
(80' spans with "Beetle" pontoon)

On order at today's date	4 Miles
Further order contemplated	6 "
Probable ultimate total	10 "

(3) Towing 6 spans of Item (2) above will require one Tug of 750 H.P. to attain speed of 4 Knots. - Two such tugs required for speed of 6 Knots.

Colonel Rolfe laid down that 4 days would be allowed for the installation of the artificial anchorage from the word go excluding towage to site.

The depth required would be for vessels drawing 22 ft., say 4 fathoms.

Each pier head intended to take three ships. Three piers, i.e., 9 ships, requiring approximately 1 sq. mile of sheltered water.

The scheme should be able to stand up to all weathers during 3 summer months.

Colonel Rolfe agreed to arrange for the attendance of Captain Mylchreest the towing expert whenever the Committee should require his advice.

The next Meeting of the Committee arranged for Thursday, 12th August, at 2.30 p.m.

Mr. Colin White

MOST SECRET

ARTIFICIAL HARBOURS.

Minutes of Fourth Meeting of Sub-Committee held at the Institution of Civil Engineers at 2.30 p.m. on 12th August, 1943.

PRESENT: Mr. C.R.White in the Chair,
Mr. R.D.Gwyther,
Mr. J.D.C.Couper,
Lt.Col. L.B.Roberts, S.O.S.,E.T.O.U.S.A.,
Major W.I.Bell, Tn.5.

The following matters were discussed:-

Memorandum of points to be raised with the Hydrographer re Site 1 E. of Surtainville.
2 Anse de Sciotot.
6 N. of Quineville.

Memorandum of points regarding towing and it was resolved to leave over for time being as more points may be raised as result of air bubble experiments.

Agreed to request Tn.5 to give instructions for the investigation of the possibilities of the air breakwater making use of the Port Construction Co. and Lobnitz Pier Head and Equipment at Garlieston.

A draft was drawn up to indicate the lines on which investigation No.1 should be carried out. - See Memo attached to Minutes.

It was also decided that one member of the Committee should be in close touch with the progress of the investigation and spend some time at the site so that there should be no delay in obtaining results. It was considered that Major Ivor Bell could best undertake this.

The Committee expressed the opinion that so far as their enquiries went the air break water appeared to offer the simplest method of forming sheltered water and that neither time nor effort should be lost in acquiring information regarding the possibilities of this scheme.

Mr. Gwyther reported that Prof. Gibson could not undertake the work in connection with a model and had suggested the City & Guilds College, where a wave making apparatus had been constructed and might still be available. It was agreed that this should be followed up with Prof. White of the City & Guilds College.

<u>Note:</u> This was duly arranged and Dr. White called on Mr. Gwyther on the 13th instant and from conversation it appeared that Dr. White was already engaged by the Admiralty in connection with experiments at Shoreham.

Possible sites for artificial harbours in the 2nd Priority were examined by the sub-Committee. Although the coast line offered very little in the way of sheltered water, the following were noted as being the most likely sites:

(1) <u>Etretat</u> (35) where there is a break in the cliffs and a beach 650 yards in extent with a slope of 1 in 10.
Deep water 27' is obtainable 450 yards from the coast.
Beach is shingle, which gives way to sand at Low Water.
Road access - by 4 roads, second class.
Current -
Exposure -
Tidal rise -

(2) <u>Fecamp</u> (32) beach 1,100 yards with a gradient of 1 - 14 of shingle; depth 27 ft. at 500 yards from coast.
Flat area of rock exposed at dead Low Water. 4 fathom line at 2,000' from shore.
Roads - several first-class roads serve the port area.
Current -
Exposure - surf with winds from W. through N. to N.E. and holding for anchorage bed.
Tidal rise -

(3) <u>Veulettes</u> (31) break in the cliffs.
About ½ mile of beach - 200 yards wide in middle.
Beach is sand with belt of shingle at High Water.
Deep water 23' at 850 yards from coast. Gradient 1 -24
Road access - 2nd class coast road & road up valley.
Current -
Exposure -
Tidal rise -

No suitable site could be found north of this point as far as Ault, as the coast appears unapproachable.

INVESTIGATION NO. 1.

ABC.

4" pipe, 300' long, 3/16" orifices at 6" intervals on one half (150') and ¼" orifices at 6" intervals on other half (150'). All orifices on underside of pipe with non return valves at A and C and stop valve at B.

Pipe joints may be screwed connections or patent couplings. Care should, however, be taken to ensure that air orifices are on bottom of pipe when in position.

Pipe should be level and about 2 ft. off sea bed. It is proposed that pipe be seated on concrete blocks 9" deep, 9" x 6" on top and 12" x 9" at base, checked for rail, which should be clipped in.

This block can be levelled up with partly filled sandbags of sand or gravel, set by diver from soundings taken at slack tide High or Low Water.

Connections AE & CD.

These can lie roughly in the bottom.

AE & CD.

Are feeders 3" (or 4" if 3" are not available) with flexible connections to Pier Head at E & D, to allow for rise and fall of tide, connected on Pier Head to receiver at Compressor.

Compressor.

It is anticipated that for the first investigation (No.1) 1500 to 2000 c.ft. of air per min. will be required. A battery of compressors should be rigged up to receiver to give this quantity.

The receiver should have a gauge and the air pressure and consumption should be recorded. It is anticipated that 30 lbs.sq.in. will be sufficient at H.W.

Observations & Records.

The purpose of the investigation No.1. is to ascertain the effect of a steady discharge of air bubbles on waves and to form an estimate of -

(1) The amount of reduction, if any, in height of waves.

(2) Area of calmer or still water.

(3) Quantity of air required and pressure to damp down different height of waves. For this purpose a pile or gauge should be established on which the height of wave trough to crest can be measured.

MOST SECRET

ARTIFICIAL HARBOURS

Record of Meeting held at Metropole Buildings on 15th August.

PRESENT: Brigadier Bruce G. White, C.B.E., Tn.5
Colonel J. A. Rolfe, Tn.5
Major Carline
Mr. Colin R. White
Mr. R. D. Gwyther
Major W. I. Bell, Tn.5

The object of the meeting was to discuss plans for putting in hand without delay arrangements for an experiment with compressed air at Cairnhead, Major Carline being the C.O. of a P.C. & R. unit of the R.E. stationed there.

A plan showing the proposed layout for a preliminary experiment together with a description of the work involved was handed to Colonel Rolfe and it is believed there is sufficient information on these to enable Major Carline to proceed as soon as materials are available.

Two prints were handed to Mr. Gwyther giving the results of a marine survey at Cairnhead and it is assumed that these give all det ails of the sea bed required in the vicinity for the time being.

Suggestions were discussed for the trying out of a further experiment with compressed air, the whole of the apparatus being installed in a small coaster or one of the port repair ships available near the site at Cairnhead, but this will presumably await the collection of data to be obtained from the first experiment in the neighbourhood of the Lobnitz pierhead.

It was agreed that every effort should be made without delay to locate suitable air compressors which are not electrically driven.

(Note:- Since this meeting Messrs. Ingersoll Rand have reported that various small units varying from 100 to 250 cubic feet capacity are likely to be available in the Glasgow district, and a further report is expected from them before the Committee meeting on 18th instant.
These units, although small, are all for generating at 100 lbs. pressure.)

Mr. Gwyther reported details of an interview with Dr. White, assistant Professor of Hydraulics at the City & Guilds College.

It appears that Dr. White is already retained by the Admiralty in connection with their investigations at Shoreham and felt compelled to refrain from accepting similar work in an Advisory capacity for the War Office until the situation could be cleared up with the Admiralty.

Brigadier Bruce White undertook to deal with this matter.

Mr. Colin White suggested that an invitation to join the Committee should be sent to Mr. P.J. Unna.

(Note: This has been done and Mr. Unna is understood to be going to attend the next meeting of the Committee on 18th instant.)

Mr. Colin White

MOST SECRET

ARTIFICIAL HARBOURS.

Minutes of Fifth Meeting of Sub-Committee held at the Institution of Civil Engineers at 2.30 p.m. on 18th August, 1943.

PRESENT: Mr. Colin R. White, in the Chair,
Colonel J. A. Rolfe, Tn.5.
Sir Leopold Savile,
Mr. J.D.C.Couper,
Mr. P.J.Unna,
Lt. Commr. Steele, (part time)
Major W. I. Bell, Tn.5.

For the benefit of members who had just joined the Committee some time was spent in discussion of the various schemes suggested for the production of sheltered water.

Colonel Rolfe sketched out the broad lines on which the Committee should frame their report and it was hoped that this would be available for handing to Brigadier Bruce White not later than Friday evening, 20th instant.

With a view to speeding matters up it was arranged to put in hand immediately photostat enlargements of the necessary portions of Admiralty Charts, and also the corresponding portions of the road network on shore in the immediate vicinity of the Beaches selected.

(Note: These are all prepared and submitted to the Committee herewith.)

It was arranged that the next meeting would be held on 19th instant at 2.30 p.m. and further meetings were fixed for Friday, 20th instant at 10 a.m. and again at 2.30 p.m., all at the Institution of Civil Engineers.

Lt. Commdr. Steele produced photographic data concerning certain Beaches and these were apparently the only copies available in London and could not therefore be left in the possession of the Committee.

It would appear that Commdr. Steele's main object in attending the Committee had been to acquire information for the Admiralty regarding the activities of this Committee rather than for the purpose of sharing information with them.

MOST SECRET

ARTIFICIAL HARBOURS

Minutes of the Sixth Meeting of Sub-Committee held at the Institution of Civil Engineers at 2.30 p.m. on 19th August, 1943.

PRESENT: Mr. Colin R. White, in the Chair,
Sir Leopold Savile,
Mr. R.D.Gwyther,
Mr. P.J.Unna,
Mr. J.A.Cochrane,
Major W.I.Bell.

The Committee considered in detail the possibilities of locating artificial harbours at the three sites selected on the West coast of the Cherbourg peninsula, and preliminary notes were made on the charts provided.

Next meeting arranged for 10 a.m. on 20th instant.

MOST SECRET

ARTIFICIAL HARBOURS

Minutes of Seventh Meeting of Sub-Committee held at the Institution of Civil Engineers at 10 a.m. on 20th August, 1943.

PRESENT: Mr. Colin R. White, in the Chair,
Colonel J.A.Rolfe, Tn.5. (part time)
Sir Leopold Savile,
Mr. J.D.C.Couper,
Mr. R.D.Gwyther,
Mr. F.J.Unna,
Major W.I.Bell, Tn.5.

The discussion centred principally round the question of this Committee putting forward any definite recommendations for a particular site without first obtaining the advice of Naval experts on all questions of navigation and seamanship involved.

It was decided to ask Colonel Rolfe of Tn.5 to join the meeting and pending his arrival a memorandum was prepared (copy attached) on this matter for discussion with him.

Colonel Rolfe appreciated the Committee's point of view and agreed that in putting forward any preliminary recommendations they were at liberty to make such reservations as they considered necessary on the lines of the above Memorandum.

He stressed however the necessity for framing a preliminary Report without delay giving an indication of any sites for Artificial Harbours which in the opinion of the Committee were worthy of further consideration and investigation. It was quite understood that the practicability of applying any of the four methods proposed for producing a sheltered area of water depended on the results of experiments already in hand and the collection of a great deal of data which was as yet not available to the Committee.

Colonel Rolfe undertook to make contact with the Naval authorities and ascertain if it would be possible to have the assistance of one of their representatives at the afternoon session.

The meeting then adjourned until 2.30 p.m.

In the afternoon Colonel Rolfe again attended (part time) and explained that on further consideration he had decided that it would be premature to bring in a Naval representative at this stage.

Matters were so urgent in view of the necessity to have a preliminary Report in the hands of Brigadier Bruce White on the following day that it was agreed to postpone discussions with Naval experts and concentrate on a brief report of the sites considered.

The preliminary Report was duly completed and a copy is attached hereto.

In the course of the afternoon the Committee received from the Meteorological Department of the Admiralty a brief report on weather conditions, i.e., fog, prevalence of gales, size of waves, etc., for the various sites under consideration. This information was supplied by the courtesy of Captain Garbett and his assistant Commander Burgess.

Sir Malcolm McAlpine attended the afternoon session of the Committee and placed on the table blue prints showing details of his proposal for the production of breakwaters. The design generally was on the basis of using reinforced concrete monoliths to be floated into position and sunk.

Sir Malcolm stressed the point that his firm were not seeking for any profit or kudos from this proposition but it was merely an effort to help in the successful prosecution of the war. The Committee thanked him and undertook to consider his proposals in the near future.

MEMORANDUM OF SUB-COMMITTEE DEALING WITH ARTIFICIAL HARBOURS.

20th August, 1943.

This Committee have studied various places on the coast as to their practicability or otherwise for use as landing places, but being harbour engineers and not navigators they feel that it would not be sound for them to advise on the adoption of such landing places without first obtaining the opinion of naval experts on the navigational and seamanship point of view. They would not, therefore, be prepared to put forward any recommendations unless they have the benefit of such advice.

In regard to the question of providing protection for such landing places the Committee consider it absolutely essential that they should have the benefit of the advice of the Navy as well as the Army and full information as to what has been and is being done by both Services in the matter and what data has been collected.

SECRET.

	Surtainville Anse de Sciotat	Quineville Etretat Fecamp Veulettes
Max. size of waves in a) Summer b) Winter	a) unlikely to exceed 15 feet b) unlikely to exceed 30 feet and this only on rare occasions, say once or twice a month.	a) unlikely to exceed 12 ft. b) " " " 20 " and this on rare occasions.
Odds against poor visibility, less than 2 miles March to September	March 10 to 1 April 12 " 1 May 9 " 1 June 8 " 1 July 9 " 1 August 10 " 1 September 10 " 1	Somewhat better chances than western side of peninsula except near Le Havre which is a little worse other than in June and July.
Odds against gales, March to September.	S.W. to N.W. gales March 11 to 1 April 30 " 1 May to August 50 " 1 September 16 " 1	N.E. gales. March 40 to 1 April) May) 70 " 1 June to August 100 " 1 September 50 " 1

MOST SECRET

Preliminary Report of Sub-Committee
on
ARTIFICIAL HARBOURS
20th August, 1943.

The Committee has examined the charts of the coastline of the 1st and 2nd Priority viz St. Malo to Caen and from Caen to Le Treport.

In the limited time available it has not been possible to consult the Admiralty regarding questions of navigation and seamanship. The Committee are therefore unable to make any final recommendations but seven sites have been tentatively selected for detailed consideration in conjunction with the Naval Authorities.

The sites selected are indicated on the attached key map and are as follows:-

(1) Surtainville.
(2) Anse de Sciotot.
(3) Vauville.
(4) Quineville.
(5) Etretat
(6) Fecamp.
(7) Veulette.

In addition an enlargement of a portion of the Admiralty Chart covering each site is also attached. On each of these an area is shown where it is considered sheltered water might be provided.

At Quineville (No.4) it is considered probable that discharge of ships could proceed without protection during a considerable proportion of the summer months, but at the remainder of the sites proposed it is considered that some form of protection will be necessary.

Four methods for providing sheltered water have been suggested to the Committee. These are as follows:-

(1) The sinking of a line of ships to form a breakwater.

(2) The construction of a breakwater consisting of ferro concrete caissons which can be towed and sunk in position.

(3) The use of compressed air liberated from a submerged perforated pipe, known as the Brasher system.

(4) The use of the partially submerged balloon known by the

security name of "LILO".

No.1 involves the loss of a number of valuable ships, while the result may or may not be successful.

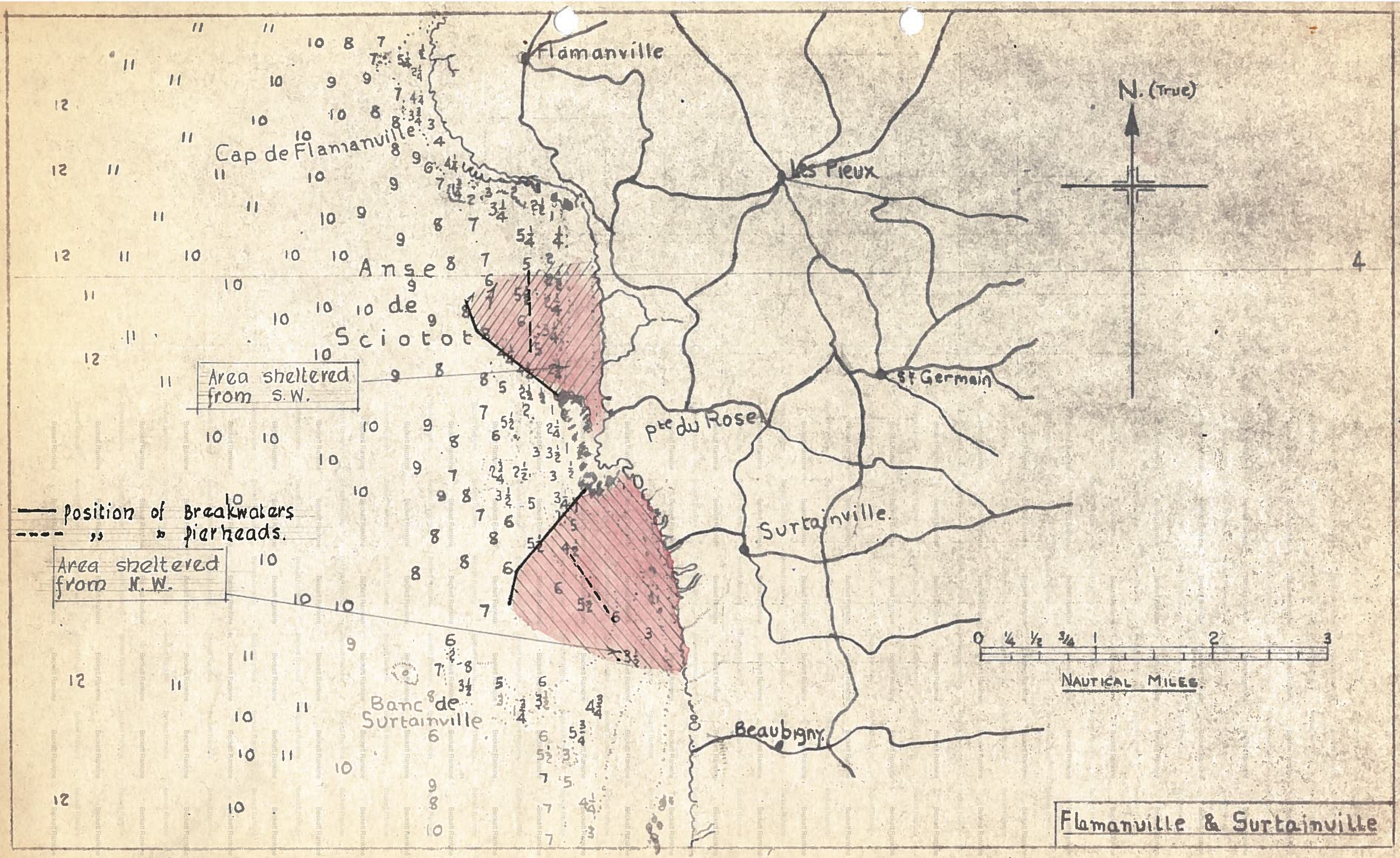
No.2 avoids the loss of ships but would require considerable time and labour to produce.

In the case of Nos.1 and 2 these are both practical propositions but cannot, of course be transferred to another site once they have been sunk in position.

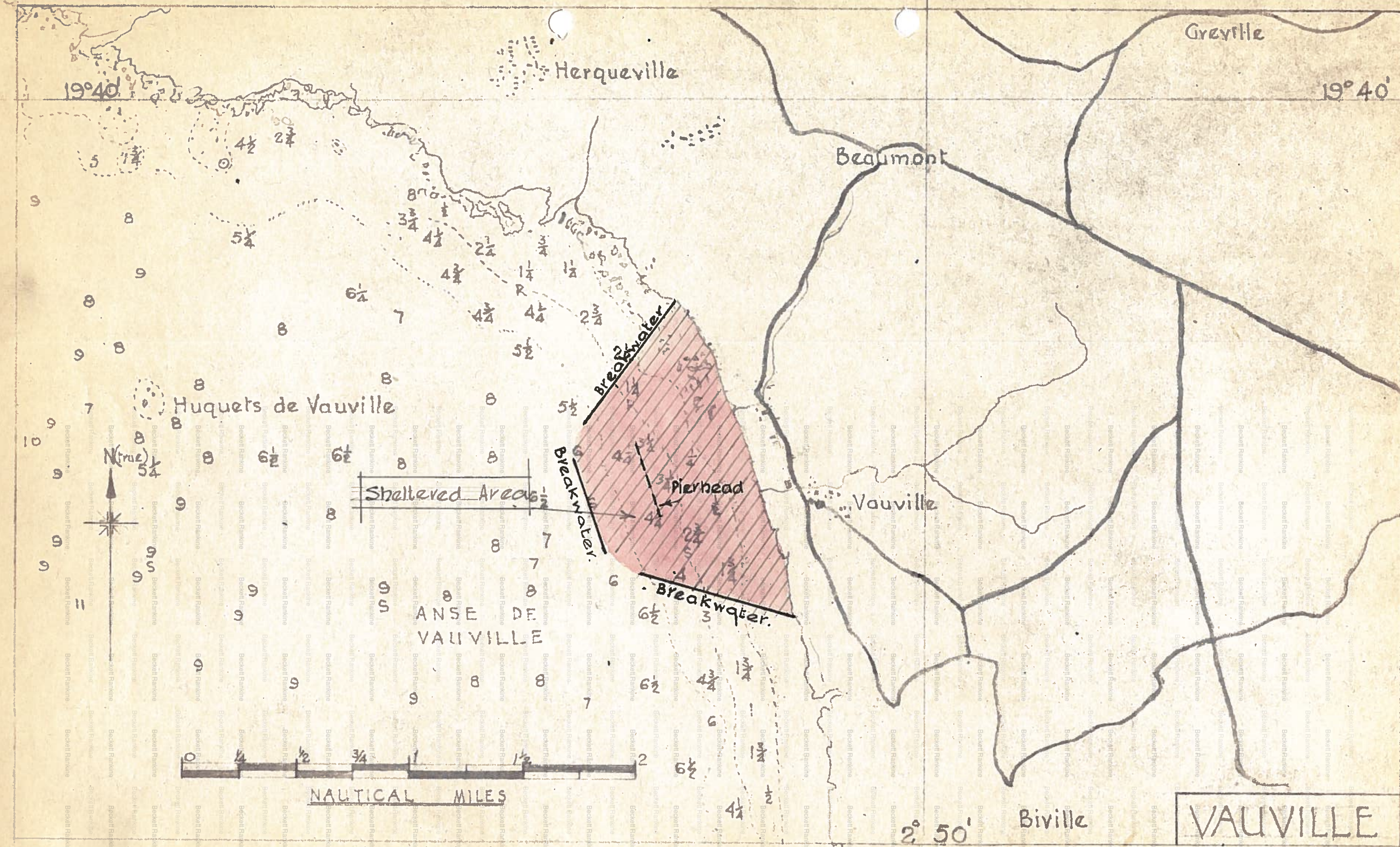
No.3. Although this idea was introduced approximately 30 years ago it has not been as yet fully developed.

It is understood, however, that the Admiralty is conducting further investigation. No opinion can therefore be given at this stage as to the practicability of this scheme.

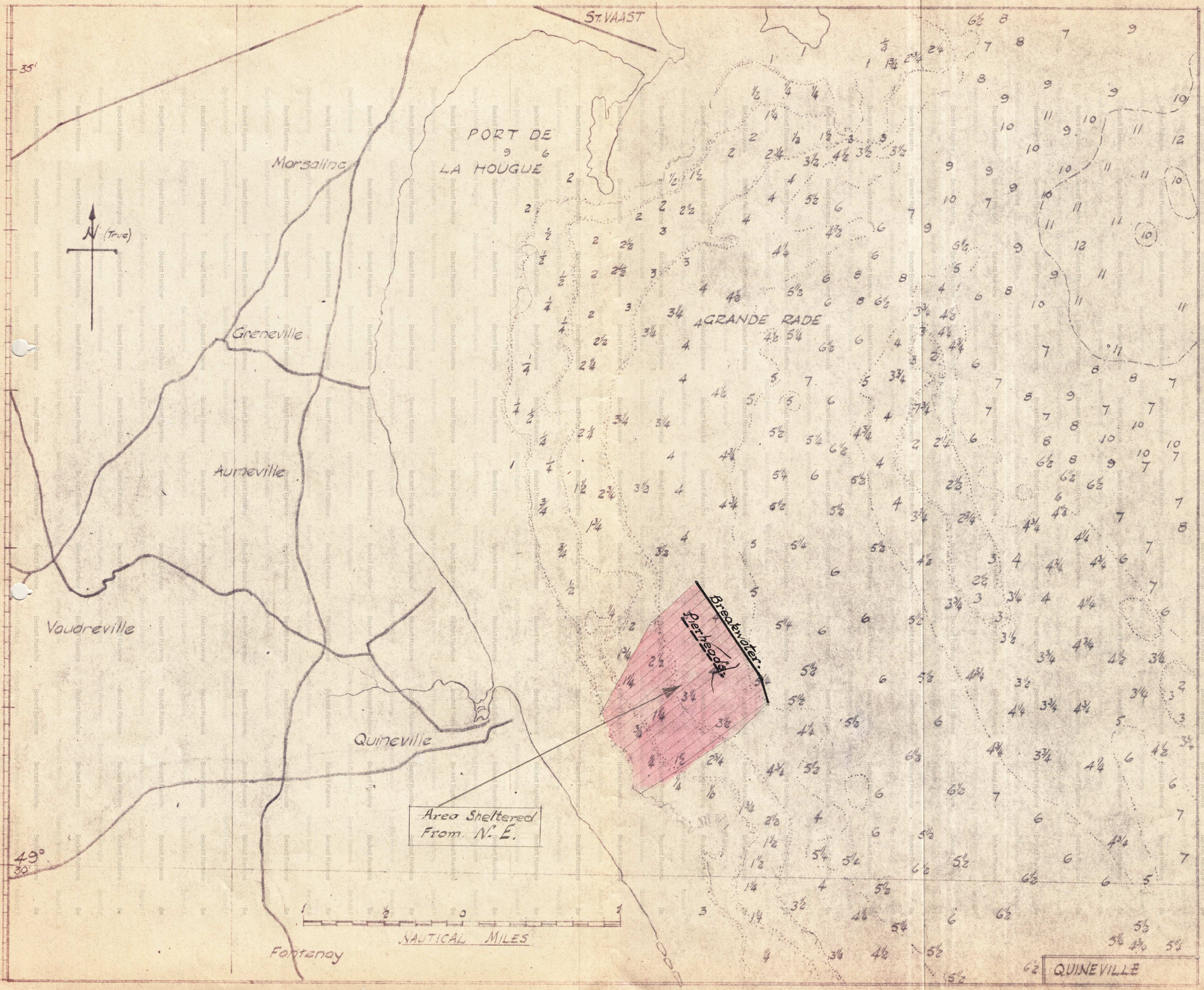
No.4. This system is under investigation by the Admiralty and the Committee must await the result of full scale tests which are at present in progress.

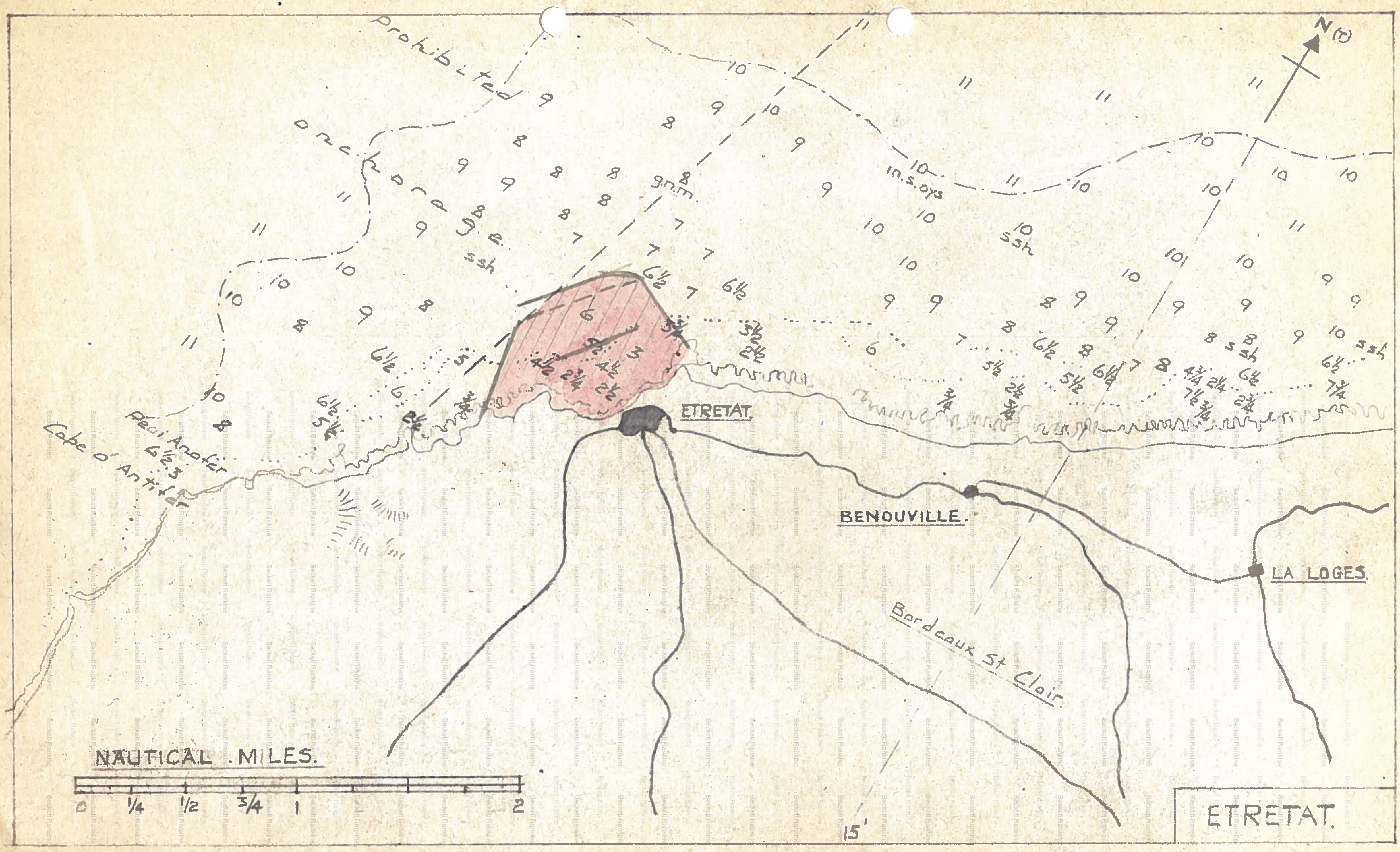


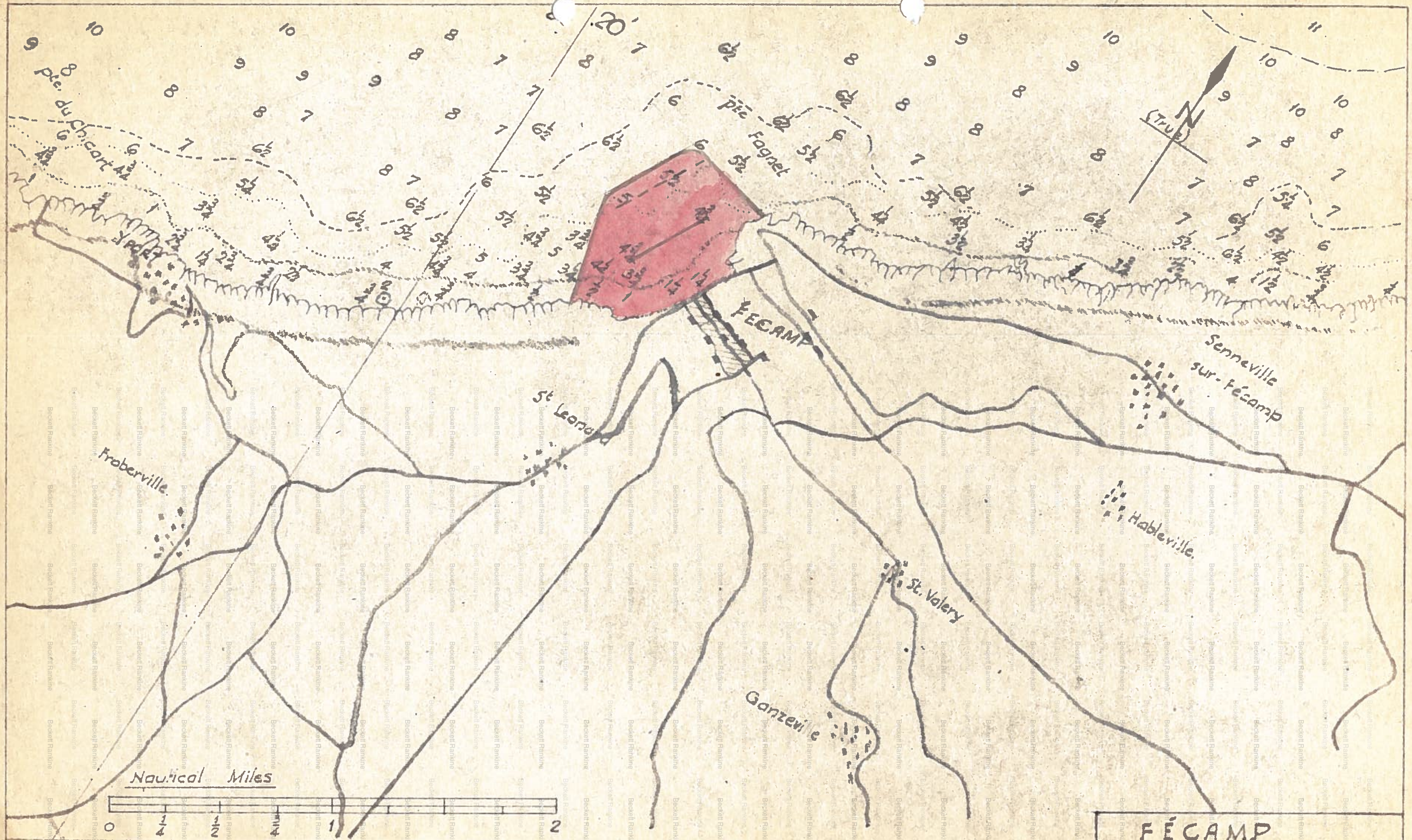
Flamanville & Surtainville

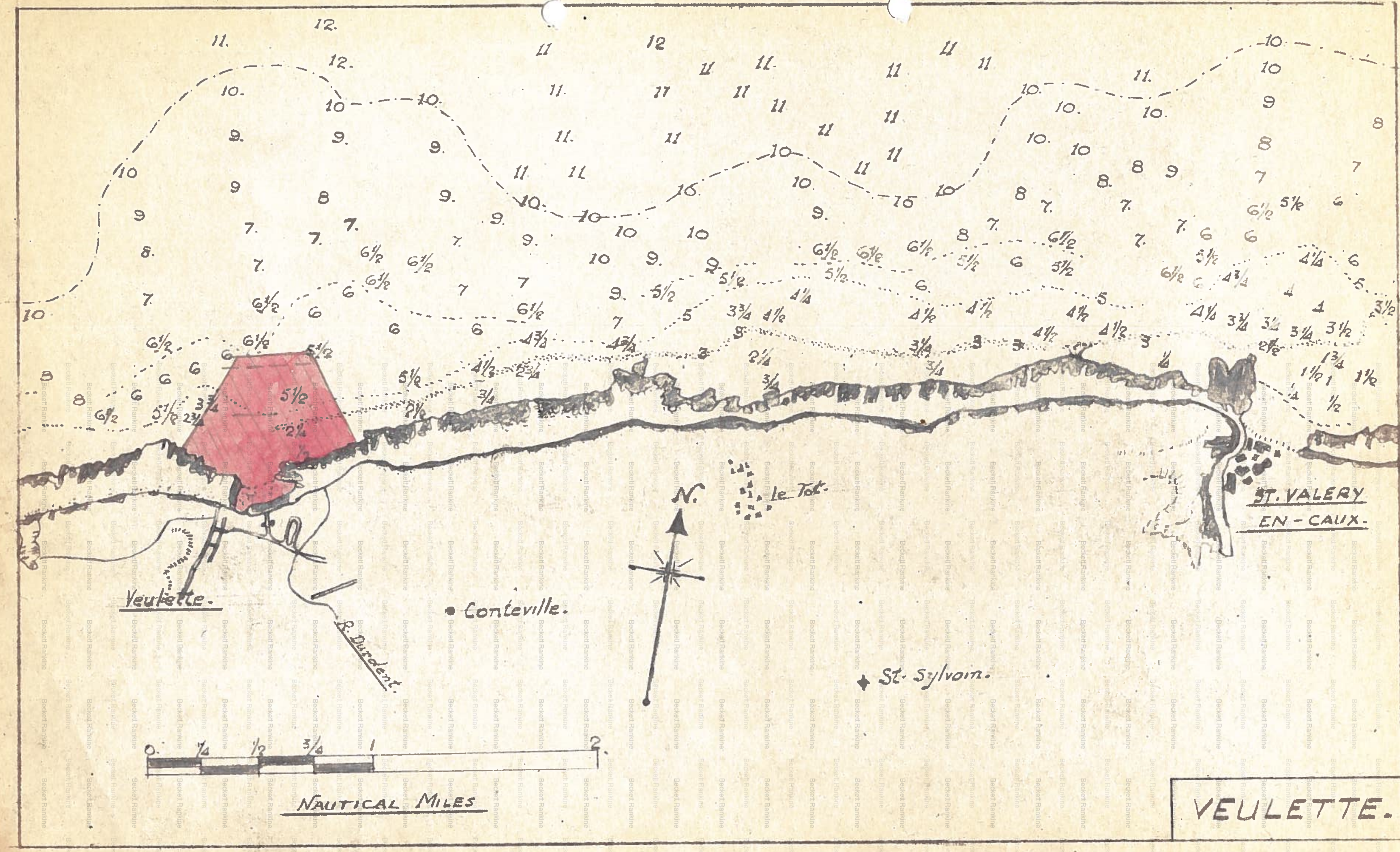


Greville
Herqueville
Beaumont
19°40'
19°40'
Huquets de Vauville
N(true)
Sheltered Area
Breakwater
Breakwater.
Breakwater.
Pierhead
Vauville
ANSE DE VAUVILLE
0 1/4 1/2 3/4 1 1 1/2 2
NAUTICAL MILES
2° 50'
Biville
VAUVILLE


St. VAAST
PORT DE
LA HOUGUE
Morsaline
N (True)
Greneville
GRANDE RADE
Aumeville
Vaudreville
Breakwater.
Pierheads
Quineville
Area Sheltered
From N. E.
NAUTICAL MILES
Fontenay
35'
49°
30'
QUINEVILLE


N(T)
Prohibited anchorage
ETRETAT.
BENOUVILLE.
LA LOGES.
Bordeaux St Clair
Cabo d'Antifer
NAUTICAL MILES.
0 1/4 1/2 3/4 1 2
15'
ETRETAT.


20'
Pte. du Chicart
Yport
Pte Fagnet
(True) N
FÉCAMP
St Leonard
Senneville sur-Fécamp
Froberville
Hableville
St. Valery
Ganzeville
Nautical Miles
0
1/4
1/2
3/4
1
2
FÉCAMP



Veulette.
R. Durdent.
Conteville.
le Tot.
N.
St. Sylvain.
ST. VALERY
EN-CAUX.
NAUTICAL MILES
0. 1/4 1/2 3/4 1 2.
VEULETTE.

MOST SECRET

ARTIFICIAL HARBOURS

MINUTES OF MEETING HELD AT METROPOLE BUILDINGS ON WEDNESDAY 25th AUGUST, 1943, AT 2.30 pm

PRESENT Mr. Colin R. White (in the chair)
Colonel J.A.S. Rolfe
Major J.G. Carline, R.E.
Sir Leopold Savile)
Mr. J.D. Cooper)
Mr. J.P. Unna) Advisory Panel
Major W.I. Bell)

The purpose of the meeting was to discuss certain modifications in the preliminary layout of pipes for the initial experiments at Cairn Head.

Colonel Rolfe explained that he was not in favour of laying the first length of perforated pipe parallel to the pierhead as the prevailing rough weather would run more or less parallel with this.

Instead he proposed, and it was agreed, to lay the first length at right angles to the pierhead and later extend this in the form of an "L" to cover waves coming generally from the south west.

It was also agreed to avoid as far as possible the necessity for opening and closing valves by diver as this could not be carried out in rough weather, and it might be necessary therefore to duplicate supply pipes so as to operate independently the 5/16" and the 1/4" holes.

Two sets of pipes say 10' apart were also suggested one with 1/4" perforation and the other with 5/16" which could be blown separately or together.

It was arranged that Mr. Unna should proceed to Cairnhead on Friday night 27th instant, and inspect the site with Major Carline.

Some time was spent in discussion regarding the experimental work which it was known the Admiralty had already put in hand, and it was generally agreed that from a commonsense point of view this Committee should be put in possession of all data already obtained by them. Colonel Rolfe undertook to endeavour to arrange this.

Colonel Rolfe had definite instructions from Brig. Bruce White to press on with the experiments at Cairnhead with all possible speed and while he had hoped the Committee would be in favour of doing so, he regretted he could not hold up progress pending the conclusion of a satisfactory working arrangement with the Admiralty.

The War Office had already made it quite clear that any data obtained at Cairnhead would be put at the disposal of the Admiralty, and it is understood that when their arrangements are complete the Admiralty will invite the W.O. to witness tests of their plant at Shoreham.

Tn. 5.
27/August/43.

Advisory Panel

TELEPHONE No.: WHITEHALL 4538.

PLEASE ADDRESS REPLIES TO
G. KENYON BELL.

1, GREAT GEORGE STREET,
WESTMINSTER,
S.W.1.

GKB/G **SECRET** DATE 7th Septr., 1943.

Colin R. White, Esq.,
Messrs. Wolfe Barry, Robert White & Partners,
164, Grosvenor Gardens House,
Westminster,
S.W.1.

Dear White

ARTIFICIAL HARBOURS.

I enclose copy of a letter from Ivor Bell containing his remarks on Unna's memorandum. This is for your information, pending Major Bell's return from Scotland.

Yours sincerely
G Kenyon Bell

P.S. Yours is the only copy issued so far.
GKB

C O P Y

CONFIDENTIAL

The Crown Hotel,
Newton Stewart.
1st Sept. '43.

Dear Kenyon Bell,

Many thanks for your letter of 30th August which I received last night on my return from Garlieston.

I got through on the 'phone to your office this morning (on a very bad line!) and learned from Mrs. Gibbs that you were already in Liverpool.

I gathered also that you and Col. Rolfe had agreed that Unna could talk freely to Marshall of I.R. I think it is all to the good that he should do so.

As regards the memorandum prepared by Unna, I have discussed the various points with Maj. Carline at Garlieston today.

The collection of data regarding waves, wind pressure etc. is a sound thing to do and Carline is going to put arrangements in hand forthwith, but this cannot affect or hold up in any way our preliminary experiments.

The data called for by Unna on frictional losses in pipes, coefficients for various sizes of perforation etc. is nearly all contained in the book sent to me by Marshall. I have handed this to Carline to take up to London with him.

I do not agree that we should abandon the suggestion to put the perforations along the bottom of the pipe as it is not practicable to keep these in alignment. I think this could be done quite easily, and have an idea that Unna visualises one length of pipe about a mile long!

I feel sure the ultimate solution will be on the lines of numerous short lengths which will be comparatively easy to handle both in construction and operation.

I agree that it is very desirable to cut out work by divers as much as possible.

This applies as much to the original placing of the apparatus as to adjustments which may be required while in operation during rough weather when it would be impossible to send a man down.

I feel very strongly that, for our initial experiments, we want to be able to vary the depth of the pipe below the surface in order to ascertain the optimum depth.

It should be possible to change the "setting" very quickly so that the effect may be observed of several positions during identical weather and wave conditions, and before the ebb/or flow of the tide has had time to alter appreciably the total depth of water.

I am hoping to have a chance to put something of this sort into practice in cooperation with Carline, but unfortunately our discussions were cut short today by a summons for him to go up to London again tonight.

I was hoping to be able to make good use of my time with him this week in order to get things moving and it is disappointing that Carline has had to push off.

C O P Y

He will be back on Saturday and I am arranging tentatively to travel up to town on Monday night in the hope that this will enable me to get down to things with him during the week end before I leave.

Carline is in a difficult position here as so much of his time is taken up with visits by high personages who, for political reasons, have to be waited on hand and foot. His staff spend much time making all the arrangements for accommodation, sleeper reservations, motor transport etc. and he has no one available to give his whole time to pushing this experiment along. Neither Unna nor I can do this as civilians and what is needed is a young officer with intelligence who could be put in charge and left in peace to get on with the job. Carline is going to press for this but I am not very sanguine that anything will happen quickly.

Unna should be useful on the hydrographical side of the experiments but I think Carline would be better with a free hand to carry out the engineering part of the job if he can get the assistance he requires.

I think it is rather premature to bring in towing experts at this stage as we have as yet no proposition to put to them.

As regards salvage experts, I doubt if they could help very much unless we could find one with actual experience of "Bubbles", which is very doubtful. In any case we are suffering from "too many cooks" already!

Both Carline and I are rather dubious about the "canvas pipe" suggestion. Canvas is very unsatisfactory stuff in rough seas and I am afraid would give endless trouble. We feel that the perforated pipe could be buoyed up by drums attached to lugs welded on to the pipe at intervals.

In this connection I am again visualising short lengths of say 200' or 300' of pipe as a unit and not several thousand feet.

Owing to the thick layer of mud on the bottom at Cairn Head there is something to be said for anchoring the perforated pipe to sinkers and buoying it up to any desired level by means of oil drums.

The objection to this method is that the level of the pipe relative to the surface could be altered only by diver and not at a during rough weather. It is impossible also to alter the level as the tide rises and falls.

To achieve this end the only possible method is to adopt the use of floats from which the perforated pipe would be suspended.

I have discussed these two propositions with Carline, but unfortunately he had to push off to London before we could agree on a definite scheme and get down to details.

I am sending you these rough notes in the hope that you would kindly get Mrs. Gibbs to tidy them up for me and let Gwyther have a copy.

They are intended primarily for your information and his in case there should be further discussion by the Committee before I get back.

I am most anxious to see something moving before I have to leave here and hope Col. Rolfe has been able to get a few hundred feet of 4" pipe on urgent order.

Please excuse this rough draft and let me know if there is anything I can be getting on with to help things along.

Yours sincerely,

(Sgd.) W. Ivor Bell.

At Ingersoll Rand office, 2.9.43.

Present, Mr Wood, managing director of Ingersoll's.
Mr Marshall, engineer do.
Major Carline
Mr J.D.C.Couper
Mr P.J.H.Unna

Couper explained to Wood and Marshall what was wanted -

Data about delivery of compressed air through a perforated pipe under water -

(a) Rate of delivery at given air pressures, against given heads, through holes of given diameters.

(b) Frictional losses for various diameters of pipe, air pressures and rates of delivery.

(c) Output of free air per minute for given compressors, speeds and delivery pressures.

The ~~pxsxixix~~ use of perforated pipes under water, and the possibility of using flexible ones with eyelet holes, was discussed.

Ingersoll's suggested that if steel pipes were to be used, they should have Victaulic joints.

Also that a 300 foot pipe, ~~wxtkxa~~ 4 inch diameter, should be tried with 6 inch feed at centre. But this suggestion was quite tentative.

Handed to me by [illegible].

1. <u>Wave measurements</u> - take daily. If possible at H.W., half tide, and L.W.

Observe T, the period, interval of passage of succesive crests, by timing the passage of, say, 10, and taking average. Take at least three observatiobs. Probably this can be done best near the beach.

Erect a tide gauge in as deep water as practicable, to show W.L. above ground; and note readings at passage of succesive crests and troughs, to give wave height, and mean depth. These readings need not be simultaneous with those of T. Immediately before or afterwards will do. *Note time of day*

The object is to have a record of the extent of sea to be expected at the site.

When taking observations record wind in statute m.p.h., or by Beaufort gauge, and direction.

2. Take Marshall of Ingersoll's into confidence, so that full benefit of his advice may be obtained; and get from him -

(a). H.P. required from commercial for delivery at various gauge pressures.

(b). Data as to delivery through holes of various diameters under various air and water pressures.

(c). Frictional losses in pipes at various pressures and speeds, according to diameter.

(d). Volumetric efficiency of average commercial compressi on - volume of free air per minute to volume swept by piston, at various speeds.

3. Discard idea of holes at bottom only because -

(a). Impracticable to maintain alignment.

(b). Can only effect result in very shallow water such as that in an experimental tank.

4. Experiment with handling now, on assumption that wave quenching experiments are successful, to save time. General principles -

(a). Bring salvage and towing expert in at this stage.

(b). Consider twin pipes - air and flotation.

5. Quenching experiments -

(a). Devise for laying various types of pipe without diver

(b). For this, try canvas flotation pipe stropped on to bubble pipe, ~~from a London dock wall.~~

Garlieston, 6.9.43.

Major Ivor Bell and Mr P.J.H.Unna visited Major Carline.

Tidal data. Springs rise, 22 feet.
Neaps ,, 16 feet.
Neaps range, say, 10 or 11 feet.

Cairn Head, + 29 min. H.W.D.
Garlieston, said to be + 19 min. H.W.D.
Wigtown, do. + 29 do.

One would expect H.W. at Cairn Head to be the earliest.

Pipes on order. 1000 feet, 4 inch dia., in lengths up to 20 feet. Delivery soon - a matter of days. Victualic joints.

Weight of pipe and joints required.

Compressors on order. Thirteen, of which seven have arrived. All about 100 c.ft free air a minute. Major Carline has no weights, but estimates each set at about 2 tons.

Preliminary tests. Major Carline is going to get single lengths drilled with (a) 1/8, (b) 3/16, (c) 1/4, inch holes, quartered × - pitch unspecified and a matter for experiment, it being easy to reduce the number of holes by plugging.

Consumption per hole, for each size of hole, to be measured with pipe at various depths below surface.

This will enable consumption for a long pipe, with holes at 6 inch pitch to be calculated; and will also give the power required, less that used to overcome frictional head between compressor and the holes.

Flattening down tests. The pierhead is at present at right angles to the pontoon approach. It will soon be slewed round, end on to the approach, probably before the flattening down tests are started.

It is proposed to stream 200 feet of pipe line, parallel to the approach, and 200 feet from its centre line, and on its south side. The seaward end of the pipe line will be abreast the seaward end of the pierhead x. The pipe line will be nearly, but not quite athwart the usual direction of the sea.

x after it has been slewed

The pipe line will be in 17 feet of water at L.W.S., but held between sinkers and submerged floats 5 or 6 feet off the bottom.

Air supply by 4 inch flexible to mid length of pipe line.

× At each end of two diameters.

? Are floats capable of standing 40 ft head available?

Garliestown cont., 6.9.43.

It is intended that the pipe line should afterwards be extended to 400 feet total length.

Nature of bottom. $2\frac{1}{2}$ feet of mud and clay, overlying rock. Apparently some weed, but information not definite.

Extent of sea. On 6.9.43 there was a strong S.W. wind - clouds W.S.W. by compass - wind veering.

When driving along the coast road skirting the shore of Fleet and Wigton bays, between 10 and 11 a.m., it was obvious that there was quite a heavy sea running outside.

At midday, the breakers on the beach at Garliestown had periods ranging from 6 to 8 seconds, corresponding to a wave length of about 250 feet in the open.

In spite of this, it was, to all intents and purposes, a flat calm inside Cairn head in the afternoon.

This seems to show that, owing to the shelter from Burrow and Cairn heads, no effective breakwater tests can be made with the wind west of south.

And it was therefore emphasised that unless the experimental pipe lines can be streamed without divers, the trials will take too long.

Note. The available fetches from S.E., S., S.W., are about 35, 85, 95, miles; the Isle of Man offering some obstruction with wind S. or S.W. At a rough estimate, the full effect of these three fetches would not be obtained until the wind has been blowing for 7, 12, 14, hours.

The odds against a gale (from any direction) on any day in the Irish Sea, force 8 and upwards, during Sept., Oct., Nov., Dec., are 14, 8, 5, 5, to one - see The Weather of the British Coasts, p.20, (1918).

These figures were not discussed at Garliestown, but are given here so that the probable intervals between breakwater tests can be roughly estimated.

Tidal streams. Said to run up to 3 or 4 knots off Cairn head. Those in the bay are merely eddies when the flood is running outside. So, although they run for the greater part of the day, they always do so to the south. It is doubtful whether they ever exceed a knot, but no measurements seem to have been taken.

Wave observations. Measurements are going to be taken for reference purposes, whenever a sea is running into the bay during daylight.

Deep water wave length to be ascertained by measuring period of breakers on the beach.

The wave length at the pontoon or pipe line can then be calculated from the usual formulas, which have been confirmed for both deep and shallow water, as the result of many observations.

This is more likely to give accurate results than any attempts to make direct measurements of length.

Wave height to be recorded by measuring height of crests and troughs above the bottom.

Some species of tide gauge will be required for this, but it is not practicable to drive a pile to carry the gauge because -

The pile would interfere with navigation.
The bottom is rock.
There is no gear for driving it.

So it was decided that the most hopeful way would be to rig a long horizontal spar from the pierhead, wherever the hull would least affect the wave height, and let the spar carry the gauge. The pierhead's draught is only 15 inches when the spuds are down, so there should not be much reflection.

It was also decided that the most hopeful way of measuring height to seaward to the pipe line would be to rig a dolphin of steel scaffold tubing, weighted at the bottom with rubble or otherwise, to carry the necessary gauge. There is plenty of tubing available at the site.

Note. Major Carline should be asked to rig the dolphin at once, to make sure that it will not carry away when actually required for use. Besides that, simultaneous readings on the two gauges will afford a check as to the accuracy of the one on the pierhead.

1, GREAT GEORGE STREET,
WESTMINSTER,
S.W.1.

TELEPHONE NO.: WHITEHALL 4538.

PLEASE ADDRESS REPLIES TO
G. KENYON BELL.

WIB/G

DATE 8th Septr., 1943.

Colin R. White, Esq.,
164, Grosvenor Gardens House,
Westminster,
S.W.1.

ARTIFICIAL HARBOURS

I enclose two copies of Minutes of meetings of 19th, 20th and 25th August, together with the various papers referred to therein.

Ingersoll-Rand Company Ltd.

165, QUEEN VICTORIA STREET
LONDON, E.C.4.

TELEPHONE: CENTRAL 5681

OUR REF. DYM/NDC

9th September, 1943.

PRIVATE AND CONFIDENTIAL.

Colin R. White, Esq.,
c/o., Sir John Wolfe Barry & Partners,
Grosvenor Gardens House,
Grosvenor Gardens, London, S. W. 1.

Dear Sir,

Portable Air Compressors
for Experimental Works.

We thought you would like to receive the attached copy of a letter we have addressed today to Major Carline outlining arrangements made for sending one of our engineers to the site to take charge of the air plant.

Yours faithfully,
INGERSOLL-RAND COMPANY LTD.

This arrangement was made with Carline direct by the I.R. people without [illegible] knowledge

D. Y. Marshall

D.Y.MARSHALL.
NDC. 9-9-43.

CHAIRMAN: W. M. TREGLOWN.
DIRECTORS: H. WOOD (MANAGING) S. RHODES, W. G. CORNER, VISCOUNT SUIRDALE.

F.O.M.

COPY.

Ingersoll-Rand Company Ltd.

CHAIRMAN:
W. M. TREGLOWN.
DIRECTORS:
H. WOOD. (MANAGING)
S. RHODES. W. G. CORNER.
VISCOUNT SUIRDALE.

165, QUEEN VICTORIA STREET
LONDON, E.C.4.

TELEPHONE:
Nº 5681 CENTRAL (7 Lines)

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PRIVATE AND
CONFIDENTIAL.

9th September, 1943.

Major Carline, R.E.,
c/o., G.P.O.,
Whithorn,
Wigtownshire.
Scotland.

Portable Air Compressors
for Experimental Works.

Dear Sir,

We tried to get in touch with you today by telephone, but, unfortunately, you were not available, however, we left this message.

Our engineer, Mr. F. A. Ashby, will leave by the 9.30 p.m. train from St. Pancras on Monday, September 13th., and it is understood that he will be met at Newton Stewart when he arrives there the following morning, the train being due in at 10.12 a.m.

Mr. Ashby has had considerable experience on work of a similar nature to that which he will be expected to carry out on the site.

As well as assisting with the layout of compressed air supply between the individual compressors and main supply lines he will take charge of the complete compressor plant, supervise operation and maintenance during the period of your experiments. We feel sure Mr. Ashby can relieve you of all anxiety regarding the supply of air.

With kind regards,

Yours very truly,
INGERSOLL-RAND COMPANY LTD.

D. Y. Marshall.

D.Y.MARSHALL.
NDC. 9-9-43.

NATIONAL SCHEME FOR DISABLED MEN

QUOTATIONS SUBJECT TO CHANGE WITHOUT NOTICE. ALL AGREEMENTS CONTINGENT UPON STRIKES.
ACCIDENTS AND OTHER CONDITIONS BEYOND OUR CONTROL.

Kirklands
St Michaels
Liverpool

TELEPHONE:
VICTORIA 4313 (2 LINES)
TELEGRAMS:
COAXIAL, SOWEST, LONDON.

A. J. BARRY, COCHRANE & PARTNERS.
ARTHUR J. BARRY, C.B.E., M.INST. C.E.
J. A. COCHRANE, M.C., M.INST. C.E.
CIVIL & CONSULTING ENGINEERS.

23, PALACE STREET,
LONDON, S.W.1.

9th. September 1943.

Dear White,

After leaving you yesterday afternoon, I saw Border at the Ministry of War Transport and later telephoned your office but too late to get you.

Unfortunately his knowledge of 'A...' is not extensive and he has no knowledge of the hinterland or adjacent coast. I imagine we could get as much information as I gleaned from any chart of the port.

He suggested however that one Captain Riddel - Marine Superintendent for the B.I. could help me or better the Secretary of that Company who would possibly be able to recommend someone, now or formerly on the B.I. staff, who would have intimate knowledge of the place. Will you arrange for this or shall I make the enquiry when next I am up in town.

I shall be in London and available for meetings on Monday, 13th, from 2.30 - 5.30. and on Wednesday from 2.30 onwards. I am coming up on Sunday and will phone your office on Monday early to ascertain if there is a meeting and when.

Yours sincerely,

J A Cochrane

Colin R. White, Esq.,
164, Grosvenor Gardens House,
Westminster. S.W.1.

10th September 1943

Dear Cochrane,

Thanks for your letter dated the 9th instant. I saw the Brigadier for a short time today, when he told me he was anxious to see you on Monday, but as he had only just returned he could not fix any definite time.

I am pleased to see that you will be in London on Monday and I will try to give you early information on that day as to when he could see you.

I have got a set of Minutes ready for you but as it contains secret names I am not going to risk it in the post, and will give it to you when we meet on Monday.

Yours sincerely,

CHW

J. A. Cochrane, Esq.
Kirklands,
St. Michaels, Liverpool.

At 4 Dean's Yard, 10.9.43, (Friday).

Present, Mr Marshall and Mr Unna.

Mr Marshall and Mr Wood went to Siebe Gorman's this morning, and saw Sir Robert Davis.

Tank 25 feet deep, and not 12 feet as previously stated by Mr Harry Davis. Diameter 6 feet.

Inspection windows half way down and near the bottom.

Pipes, each 5 feet long, 4 inch dia., to be drilled with 1/8, 3/16, 1/4 5/16 holes, and used for tests - (holes in one line - not spiral.)

At various depths.
At various pressures in excess of hydrostatic head.
With the holes at top, bottom, sideways.

Tests should be finished early next week.

Records to be made of -

Air consumption per hole.
Rate of rise of bubbles.
Apparent size of bubbles.
Effect of varying position of holes.

Siebe Gorman's also to experiment with holes and eyelets in a short length of flexible hose. Suggestions -

Holes to be punched, not pierced, through both sides of hose, so that edges may be clean.

Suitable (? rubber?) washers to be inserted between the fabric and each of the two parts of the eyelet, so as to give a fair grip on the fabric.

If necessary, large eyelets to be used, so as to have ample flanges on the eyelets, the final size of the hole being controlled by means of a metal washer punched to required diameter.

Siebe Gorman's have full facilities for all the above,

Mr Marshall asked about Siebe Gorman's charges. Mr Unna said that Mr White would deal with this.

MOST SECRET

SUBJECT: "Civil" Committee's Interim Report on Site "B"

TO : The Director of Transportation.

FROM : The Chairman of the "Civil" Committee

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1. The Committee has been asked to advise on the layout of artificial harbours at sites "A" and "B", on the assumption that suitable breakwaters can be provided. The question of the design and construction of the necessary breakwaters, therefore, has not been considered.

2. The requirements outlined to the Committee were - to provide sheltered water of sufficient area to allow for the discharge of approximately 5,000 tons of cargo per day at site "A" and 7,000 tons of cargo per day at site "B".

3. The accompanying plan shows a suggested layout of breakwaters to meet this requirement at site "B" and provides space for three pierheads, connected to the shore by floating bridges, each having berthing accommodation for three coasters with a depth of 18 feet alongside at L.W. springs.

4. Provision is also made for mooring at buoys four large vessels of 24 feet draught and seven vessels of 18 feet draught.

5. It has been assumed that buoys or other suitable moorings will be provided so that ships may be moored fore and aft.

6. The length of beach available for landing cargo from dukws and other small craft is approximately 5,000 feet.

7. Allowance has also been made on this beach for the landing of other motor transport, either by ferry or by landing craft discharging to a pierhead.

8. The positions of the pierheads, ships moored at buoys and beach alloted to dukws and small craft shown on the plan are put forward as suggestions only and should be discussed with the nautical and operational authorities before being embodied on the final plan.

9. Questions affecting navigation at the entrance and within the harbour must, of course, be considered, and the advice of pilots and navigators, preferably with local knowledge, should be obtained.

10. The contours shown on the plan we have prepared have been taken, with the exception of the 2 and 4 fathom lines, from the Admiralty chart, which provides the latest information we have been able to obtain.

11. No information is obtainable from the chart, and none has yet been obtainable from other sources, in regard to the holding ground where moorings will be required. The presence of rock shown on the chart raises serious doubt in our minds on this point.

12. The site proposed to us has, in our opinion, certain natural disadvantages, but we have been unable to find a better site in the immediate neighbourhood.

13. In order to facilitate the correlation of the chart with the land plan, we have shown the grid reference lines on the plan we now submit.

Colin R. White

21st September 1943.

NOTES ON BUBBLES

Certain preliminary calculations may make things clearer.

d = diameter of pipe, inches.
l = distance of any given point from dead end, feet.
q = discharge, c.ft/min., per foot of pipe line, free measurement.
Q = flow at point l, ditto.
f = friction loss, lbs./sq.in. per foot of pipe.
F = " " " from point l to dead end.
r = ratio of compression.

Value of q. The American report, on protection for oil shipping jetty, visualises pipe lines in triplicate, with q = 3 for each, but it is not clear that more than one of these three lines was ever installed.

The probability is that it was found necessary to increase q to 9 for the single pipe, as it is almost certain that it could be kept as low as 3 in a pipe with $\frac{1}{4}$ inch holes every 6 inches.

2 not

And from the appearance of the water in Siebe Gorman's tank, it did not look as if success would ensure if q were less than about 10, so that figure will be assumed here.

The equation for friction loss in iron pipes is

$$f = 0.1025 \times \left(\frac{Q}{60}\right)^2 / r.d^{5.34}$$

For a 4 inch pipe, and Q = 1,000, this gives

$$f = 173 \times 10^{-4} \div r$$

As Q = ql, f, which is proportional to Q^2, must also be proportional to q^2l^2.

And the average value of l^2, from l = 0 to l = l, is $\frac{1}{3}l^2$.

So, $F = l \times \text{average value of } f = 173\,\frac{1}{r} \times 10^{-4} \times \frac{q^2 l^2}{3\times10^6}$

$$= 5.8\frac{q^2 l^3}{r} \times 10^{-9}$$

And when D = 30 or 60, r should be rather more than 2 or 3

So, in round figures, if q = 10, $F = (3 \text{ or } 2) \times l^3 \times 10^{-7}$

And, for l = 100, 300, 600, F = 0.3 or 0.2, 8 or $5\frac{1}{2}$, 65 or 45.

This seems to show that, with this value of q, the pipe line should not extend more than 300 feet from the supply, that is, it should not be more than a cable in length, if the supply is at the half way point.

Tank Experiments

Tests have been carried out in the tank room at Siebe Gorman's works. The main object was to measure the air discharged through a hole in a submerged pipe, under various conditions.

General Principle. One would imagine that, as water is almost incompressible, the discharge through a hole of given size, compressed measurement, would depend entirely on the excess of the pressure of the air in the pipe, over that due to the water, so that the discharge would not vary at different depths, if that excess were kept constant. The problem was to test this out.

Test gear. The tests were made in a tank 25 feet deep, and 6 feet in a diameter, with a 2 inch pipe, having nine or fewer holes, 6 inches apart.

Results. The results of Mr.D.Y.Marshall's measurements are shown on the diagrams. They show that the above general principle holds good for ⅛ inch holes up to 11 lbs./sq.in.

The same applies to 3/16 inch holes, but the figures are not so consistent. However, the tests have only been made up to 4 lbs./sq.in., and it is probable that better agreement would be obtained with higher pressures.

The two curves would coincide if plotted to show discharge per sq. inch of hole.

Size of hole. The American report states that ¼ inch holes, 6 inches apart, were used to obtain a discharge of 3 c.ft/min. free, per foot of pipe. Mr.Marshall's figures show that even with a 3/16 inch hole, the pressure in the pipe to obtain this discharge would only just be in excess of that necessary to counterbalance the water pressure.

So, as a reasonably large excess pressure is desirable, to ensure fairly uniform discharge throughout the pipe line, it looks as if ⅛ inch holes are imperative.

Uniform Discharge.

Excess pressure. The excess pressure at any point in the pipe line will be the sum of the friction loss beyond that point, and the excess pressure at the dead end of the pipe.

It can, therefore, only be correctly estimated in so far as the equation for friction loss holds good.

Spacing of holes. Having estimated the excess pressure at any point in the line, the total pressure, and so the ratio of compression becomes known, and therefor the discharge per hole. The spacing can then be set out to give the required value of q, at half tide.

Switchback bottom. Where the soundings are below the average the discharge will be high, and where they are above the average the excess pressure will be reduced, and the discharge will be low.

At first sight, it would seem that if the soundings increase above a certain limit, water will enter the pipe. But if it does so, it will merely bank up the air, whose increased pressure will be able to blow it out again. So trouble is scarcely likely to arise from that.

All that seems necessary is to provide for ample excess pressure at the dead end, and to avoid a continuous stretch of deep soundings near that end.

Rising bottom. If the line leads towards the shore, lower total pressure will be called for at the shoal end. So it may then be advisable to supply air only at the deep end, and perhaps to use a smaller pipe, so that the effect of shoaling can be counterbalanced by frictional loss.

Floating Pipe Line.

The above assumes that the pipe line is lying on the bottom, but it has been suggested that it might be slung from buoys, to get rid of the difficulties due to an uneven bottom and range of tide. This may offer certain disadvantages:-

Difficulty in streaming.
Sagging between buoys, though this might be got over by slinging from a continuous floating pipe, perhaps by nets, to give continuous support.
Change in depth of submergence due to stream.
Working of the pipe line, in accorance with the surface water, and not with the stiller water in which it lies below.
Bumping if it takes the ground at low water.
Interference with, and possible damage by, shipping.
Weed.

Fire Hose for Pipe Line.

Another suggestion is to use fire hose for the pipe line, chiefly because it will be easier to stream, but also easier to inspect, and to replace damaged lengths.

An initial difficulty arose, as the makers said piercing the holes would irretrievably destroy the fabric; but eyelets were successfully put in at Siebe Gorman's, and their maintenance foreman, putting all his weight on a cord, could not tear one out.

The eyelets. In fact, it does not seem necessary to use leather washers, to ensure uniform grip on the fabric.

Large eyelets, say ¾ inch, are used, and a plate, with hole of the required size, brazed on.

To close the eyelets on a 50 foot hose, a series of dies would be fixed to a batten, which could be drawn through the hose with a cord, the inner ferrules, if necessary, being lightly gummed to the discs.

Rig. A net, 49 feet long, and 4 feet wide, would be used for each 50 foot length of hose. One half would be folded over, and the edge stopped to the middle line of the net, forming a tube through which the hose would pass.

Each coupling would be stopped to its end of the net, to prevent creep.

The line would be ballasted with old wire rope, or preferably chain, stopped to the foot of the net.

The supply pipe would be buoyed and coupled up at the proper place, and thrown over the side, to be picked up later by the pump ship.

Test. 3 inch hose (no 4 inch available) was tried in the tank.

Calibration of the holes for discharge is not yet finished.

There is no air leakage through the fabric, even at 40 lbs./sq.in.

Friction. Unless data are available for air friction in fire hose, tests would be required. They will require full scale air supply.

Deep water Tests

Siebe Gorman's pressure diving tank has not got the connections necessary for making discharge tests, so if tests in deep water have to be made, a tank, say 12 feet high, and 2 feet diameter, will have to be obtained. So far, efforts to borrow flanged pipes to make the tank have not been successful.

General

Layout of holes. It would be best to drill the holes spirally round the pipe, so as to give water every chance of getting out. Air escaping from holes on the underside, merely shoots downwards for a few inches, and then starts to rise.

Blowing out the water. Experience at the tank shows that quite a small excess pressure does this.

Speed of bubbles. Tests made in 1918 show that the speed depends entirely on the size of bubble, and is steady for any given size, whether they start at 2 or 15 fathoms below the surface. The speeds ranged from $7\frac{1}{2}$ to 30 feet a minute. It is not clear why the speed should not vary as the air expands towards the surface.

A large bubble seemed to be ejected from each hole, when the air was turned on in Siebe Gorman's tank. After that all the bubbles started small. As they rise they may break up, but not the reverse.

The initial bubbles seemed to be about the size of an orange just before breaking surface, but actually all the bubbles are mushroom shaped. The initial ones come up at about 2 feet a second, the latter ones at perhaps a foot a second.

If the bubbles came up uniformly throughout the tank - they do not do so - their average speed could be calculated from the air supply and the rise in water level when the air is on. On that basis, the speed would be $1\frac{1}{2}$ feet a second. Actually, most of the bubbles rise in the centre, creating an upward current there, with a downward tow near the sides.

Course of bubbles. In a seaway, the bubbles would follow a zigzag course, each tack increasing in length towards the surface. The tacks would not be straight, but concave downwards on crests, and convex downwards at troughs; the actual course being determined by rate of rise, period of wave, and depth of water.

Action of bubbles. It would seem that all the bubbles are likely to do is to upset the rhythm of the vertical movement of the water particules. How far that would interfere, and reduce, the pontential half of the wave energy, is a problem that is not solved.

In any case, some of the energy would get through the air screen, and some would pass under it, specially where wave length is large compared with depth, if the pipe line is not on the bottom. Whether this energy would reform waves of appreciable size, is another problem, to be solved by actual test.

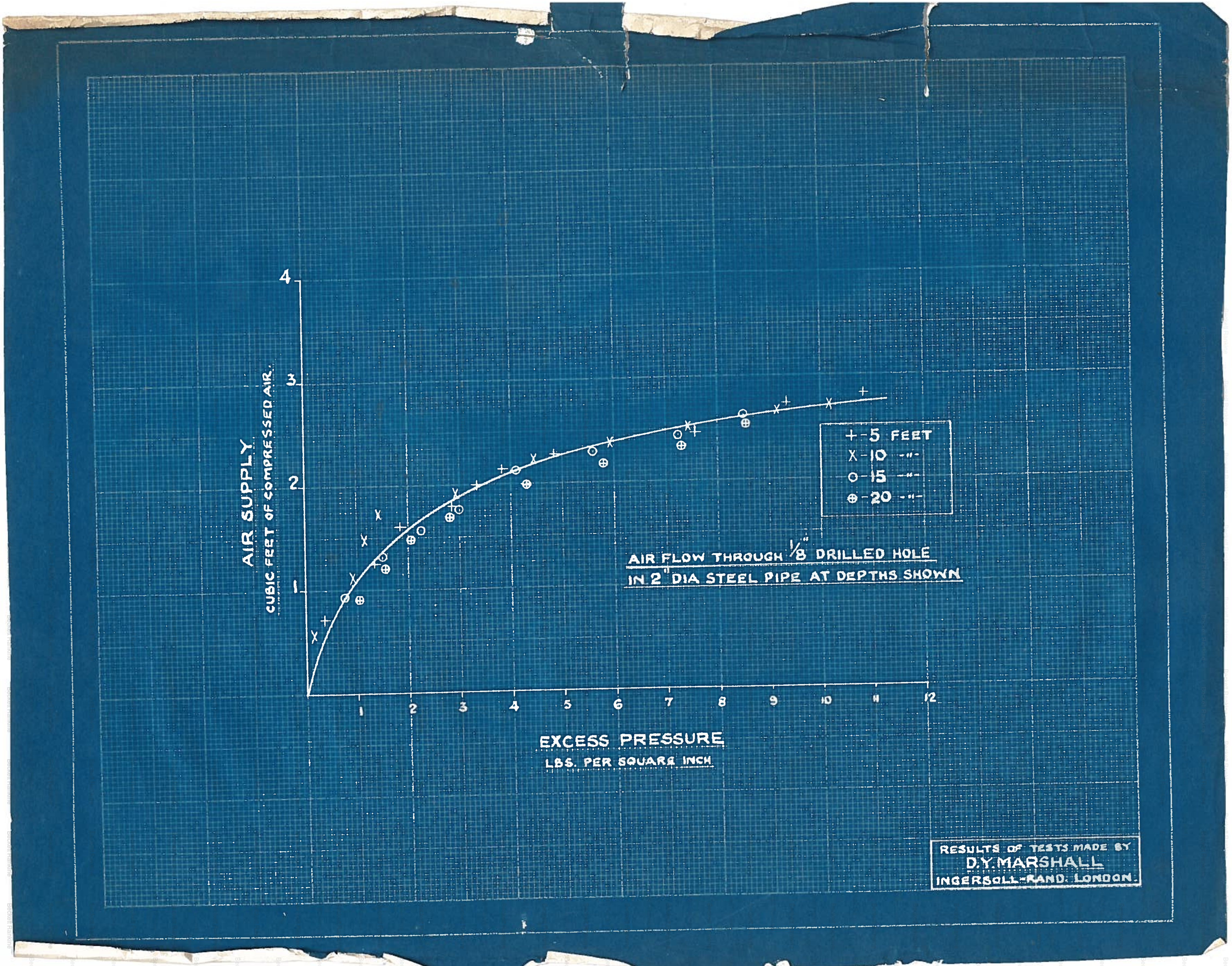
Full scale test. It may be that the waves will reform, but will not do so close up to the air screen. So to prevent interference from waves curling round the ends of the screen, it would be best to make the full scale test at a deep water entrance between solid piers.

Conclusion.

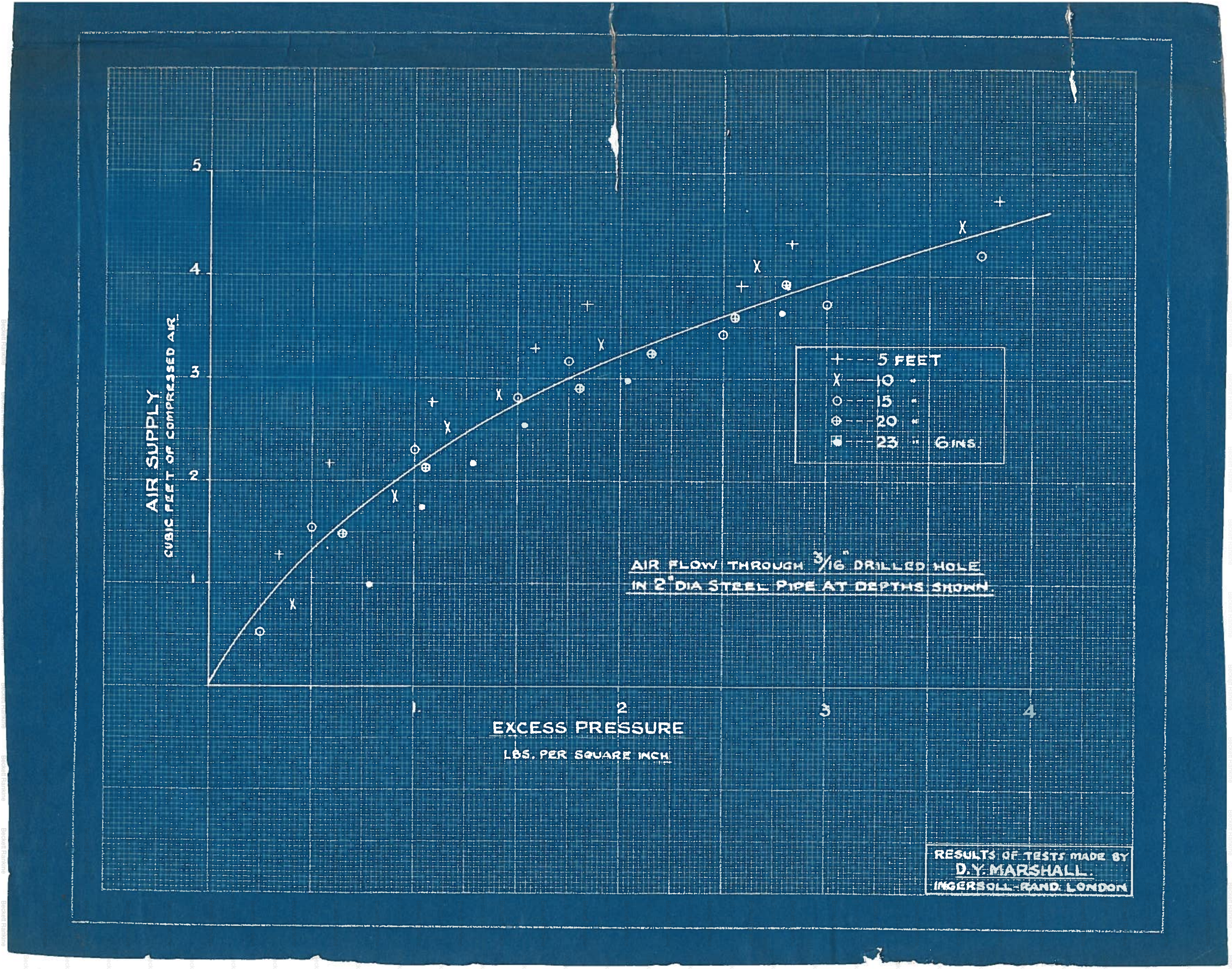
If the bubbles do have the desired effect, the crux will be to space the holes correctly. This will be comparatively simple with a pipe line in a tideless sea, or hung from buoys, but not so if the line is on the bottom and the range is large, as the ratio of compression would vary according to the tide.

Each case would have to be considered on its merits, according to the air supply desired, the depth at low water, and the range of tide. It may be found necessary to use very large pipes, to ensure that the ratio of compression is fairly uniform throughout the pipe line. Alternatively, this might perhaps be attained by using much smaller pipes in duplicate, the second set only being turned on towards low water, when the friction loss would be high. A third possibility would be to have a, large number of short and independent pipe lines, each with its own supply pipe.

In any case, it must be remembered that the power available for supplying air will be much less than that of the waves. The latter = $0.0165\ H^2 L^{\frac{1}{2}}$ H.P. per foot of wave crest, where H and L are deep water height and length. Thus for waves 300 feet long and 10 feet high, the power would be $28\frac{1}{2}$ H.P. per foot of wave crest. So, to ensure efficient use of the limited quantity of air available, it will be necessary to distribute it as uniformly as possible.



AIR SUPPLY
CUBIC FEET OF COMPRESSED AIR.
4
3
2
1
1
2
3
4
5
6
7
8
9
10
11
12
EXCESS PRESSURE
LBS. PER SQUARE INCH
+ - 5 FEET
X - 10 -"-
O - 15 -"-
⊕ - 20 -"-
AIR FLOW THROUGH 1/8" DRILLED HOLE
IN 2" DIA STEEL PIPE AT DEPTHS SHOWN
RESULTS OF TESTS MADE BY
D.Y. MARSHALL
INGERSOLL-RAND. LONDON.



AIR SUPPLY
CUBIC FEET OF COMPRESSED AIR.
5
4
3
2
1
1
2
3
4
EXCESS PRESSURE
LBS. PER SQUARE INCH
+ --- 5 FEET
X --- 10 "
○ --- 15 "
⊕ --- 20 "
■ --- 23 " 6 INS.
AIR FLOW THROUGH 3/16" DRILLED HOLE
IN 2" DIA STEEL PIPE AT DEPTHS SHOWN.
RESULTS OF TESTS MADE BY
D.Y. MARSHALL.
INGERSOLL-RAND. LONDON

SECRET

Naval Meteorological Branch,
Memo.112/42.

FORECASTING OF SEA AND SWELL.

SECRET.

FORECASTING OF SEA AND SWELL.

Introduction.

The forecasting of the state of the sea surface is becoming a matter of increasing importance for Naval Meteorological Officers. The feasibility or otherwise of landing troops and tanks depends almost entirely on the size of the breakers likely to be found on the beaches selected for the landing; the recovery of catapult reconnaissance aircraft from cruisers is likely only if the swell is comparatively small; aircraft can only land with difficulty on carriers if the swell causes an excessive motion of the ship.

But, in spite of its importance, comparatively little of a definite quantitative nature is known about the generation of waves by wind on the sea surface and their subsequent travel and decay. This is partly due to the difficulty of making any accurate measurements of the height and length of waves from a moving ship, and partly to the custom of measuring wind force by the appearance of the sea. Little information can subsequently be obtained as to the relation between waves and wind by examination of the ships' logs, etc., since the measurements of wind and waves are not independent.

It must therefore be appreciated that the figures which follow, in particular those in Tables I, II and III, can only be taken as a guide to the order of magnitude of the waves to be expected under given conditions. Both the wind and the waves produced are far from steady, and considerable doubt often exists as to the exact values of wind strength, fetch and even direction over wide areas of the ocean when ships' observations are few.

Any measurements or fairly accurate estimates of the dimensions of waves would be of value to check the figures herein. Methods of measuring height, speed, period and length of waves are contained in S.561 (Form for Recording Results of Rolling Trials in H.M. Ships). However, as the period, length and speed are not independent, but connected by the formulae

$$\text{Speed in knots} = 3.1 \times \text{Period}$$
$$\text{Length in feet} = 5.15 \times (\text{Period})^2$$

where Period is in seconds, only one of these need be measured. The simplest to estimate is the period - by noting with a stop-watch, the time taken for a patch of foam or small object floating on the water to fall and rise again as a wave passes. Needless to say, the mean of several estimates should be noted. The length can be estimated with tolerable accuracy by noting the simultaneous position of two or more crests along the ship's side, if the waves are shorter than ship's length - due allowance being made for the inclination of the ship's fore and aft line to the direction of the waves. The length of the longer waves can be estimated by comparing them with the ship's length, looking down from Bridge or somewhere well above the water. The tendency is always to underestimate the length of the longer waves, especially if they are high or seen from low down in the ship. If such measurements are noted in the Meteorological log, they should be accompanied by an actual measurement of the true wind from anemometer, if possible.

Section A.

The production of sea waves by wind.

When the wind blows over a sea surface roughened by waves, the air impinges on the windward slope of the wave, and is diverted upwards over the crest to impinge on the windward slope of the next wave. The leeward slope is in comparatively calm air. The type of air flow existing over waves is suggested by figure 1. In the case of very steep waves, there may even be an eddy formed in the lee of each wave, as in figure 2. In either case the effect of the wind is to increase the pressure on the windward side of the crest (points A) and to decrease it on the leeward side of the crest (points B). That this distribution of pressure (suction in front of, and pressure behind, the crest) actually exists has been verified in wind-tunnel experiments on wave-shaped profiles.

The motion of the surface particules of water as each wave passes is circular, in the direction of the wave's motion at the crest, and back in the trough, upwards in front of, and downwards behind each crest - shown by the thick arrows of figure 2. It is at once apparent that both the pressure and suction of the wind tend to urge the surface water in the direction in which it is already moving, i.e. to increase its motion; also friction between air and water is obviously greatest at the crests, and again acts so as to increase the motion, i.e. to increase the height of the waves, provided that the wind is blowing faster than the waves themselves are moving.

Hence, so long as the wind velocity is in the same direction as the waves and greater in magnitude, the waves tend to increase in height. They also increase in length, and, since the speed of a wave is proportional to the square root of its length (in deep water), this means that the speed of the wave also increases as the wind continues to blow. But the process does not continue indefinitely; after a time which is small for light winds and of several days for winds of gale force the difference between the speeds of wind and wave becomes so small that the pressure and suction effects described above can only supply sufficient energy to the waves to replace that lost by viscosity in the water. Thus to every wind strength corresponds a maximum size of wave, whose wave-length is such that its speed is slightly less than the wind speed. The rate of loss of energy due to viscosity is proportionately much larger for the short waves raised by light winds than for those raised by strong winds; hence the difference between maximum wave speed and speed of wind diminishes from 2 knots for the lightest wind that can raise waves at all (about 3 knots) to a mere fraction of a knot for strong winds.

Table I below gives an estimate of the length, speed and height of waves produced by constant winds of given strength acting for a known time.

TABLE I.

Wind Speed		L. Wave Length (ft.) C. Speed (Knots) & H. Height (ft.)														
Beaufort	Knots	6 hours.			12 hours.			1 Day			2 Days			MAXIMUM		
		L.	C.	H.	L.	C.	H.	L.	C.	H.	L.	C.	H.	L.	C.	H.
3	9	25	7	2½	25	7	2½	25	7	2½	25	7	2½	25	7	2½
4	13	60	10	5	70	11	5	75	12	5	75	12	5	75	12	5
5	18	120	15	8	140	16	9	150	17	10	150	17	10	150	17	10
6	24	230	21	12	270	22	14	280	23	15	280	23	15	280	23	15
7	30	320	24	17	410	27	21	470	29	23	480	30	23	480	30	23
8	36	410	28	23	560	32	29	680	35	33	690	36	33	690	36	33
9	43	550	32	30	740	37	38	900	41	42	950	42	44	1000	43	44
10	51	670	35	37	900	43	50	1150	46	55	1200	47	56	1400	51	56

The figures of Table I relate to the waves that would be produced in a limitless ocean over the whole of which the wind was blowing with the given constant strength and direction. In practice, fortunately, this state of affairs does not exist (except possibly in the Southern Ocean, where a westerly wind might conceivably blow round and round the Earth). If one goes along a great circle to windward from the area in which one wants to know the dimensions of the waves, sooner or later land is reached, or one comes to a point where the wind is considerably less in strength, or where it is blowing from a different direction. The distance upwind throughout which the wind is blowing roughly in the same direction with roughly constant force is the "fetch" of that particular wind; it is the distance over which the wind has been able to pump energy into the train of waves at present in the area.

In the case of stationary, or only slowly moving isobaric systems, this distance is easy to estimate with sufficient accuracy; in figure 3, it is the distance AB to shore, in figure 4 it is the distance AB to the point where the wind veers and decreases. If the isobaric system is moving, the estimation of fetch is more difficult, but a satisfactory estimate can usually be made from a study of consecutive isobaric charts.

The size of the waves produced at point A depends on the time the wind has acted on these waves. In figures 3 and 4, this cannot exceed the time the waves, starting as short (and therefore slow) ones at B have taken to reach A. However long the blow may have persisted, the wind cannot have acted <u>on the individual train of waves now at A</u>, longer than the time taken for these waves to get from B to A. Thus the possible size of the waves at A is limited by the fetch as well as by the wind strength; if the fetch is small, the waves will be considerably below the dimensions given in Table I for the wind strength and duration of blow.

The maximum waves produced by given wind acting over given fetch for unlimited time are given in Table II below

<u>TABLE II.</u>

<u>Wind Speed.</u>		<u>FETCH (nautical miles).</u>														
<u>Beaufort</u>	<u>Knots</u>	L. Wave length (ft) C. Speed (knots) H. Height (ft)														
		10			50			100			500			1000		
		L.	C.	H.	L.	C.	H.	L.	C.	H.	L.	C.	H.	L.	C.	H.
3	9	25	7	2½	25	7	2½	25	7	2½	25	7	2½	25	7	2½
4	13	40	9	3	65	11	4	75	12	5	75	12	5	75	12	5
5	18	75	12	5	125	15	7	150	17	10	150	17	10	150	17	10
6	24	110	14	7	210	20	12	260	22	14	280	23	15	280	23	15
7	30	140	16	10	260	22	15	350	25	19	480	30	23	480	30	23
8	36	180	18	13	330	25	20	450	29	25	690	36	33	690	36	33
9	43	210	20	16	420	28	25	560	32	32	880	40	44	940	42	44
10	51	250	21	19	500	30	31	650	35	40	1100	45	56	1200	47	56

The dimensions of the waves produced at a given point on any given occasion may be limited <u>either</u> by the fetch available or by the time for which the wind has blown; i.e. the height and length of the waves is the <u>smaller</u> of the appropriate entry in Table I or in Table II.

For example, a wind of force 8 blowing for a day over unlimited fetch will produce waves 680 ft. long and 34 ft. high (Table I). If the fetch is 500 miles or more, this answer is still correct. But if the fetch is only 100 miles, the resulting waves will only be 450 ft. long and 25 ft. high (Table II). If the blow only lasts 6 hours, the waves will be 410 ft. long and 23 ft. high for a fetch of 100 miles or more.

It will be observed that the steepness (Height ÷ Length) of the waves decreases as the fetch and time increase.

Section B.

Production and Travel of Swell.

In preceding paragraphs it has been shown how the size of the waves that will be produced in a storm area under given conditions of wind force, duration and fetch may be estimated; the tables given also enable the speed of the waves to be estimated. The train of waves thus raised by the wind in a storm area continues to travel along the great circle in the direction of the wind that produced it long after the wind has died down or the waves have moved out of the storm area. The speed at which the front of the group of waves raised by the storm (which is now SWELL) advances into the comparatively calm water outside the storm area is equal to HALF the speed of the individual waves as given in Tables I and II. It appears probable that the wave-length (and hence the speed) of this swell remains roughly constant at the value attained in the storm area. But as the forces mentioned in the first paragraph as acting on the surface now act against the motion of the water, energy is continuously removed from the waves and their height diminishes. The rate of diminuation of height is greater for the shorter waves; it appears, from such evidence as is available, that the waves lose roughly $\frac{1}{3}$ of their height each time they travel a distance in miles equal to their length in feet. E.G. a swell 600 ft. long and 30 ft. high is 20 ft. high after 600 miles, 13.3 ft. high after 1200 miles, 9 ft. high after 1800 miles, 6 ft. high after 2,400 miles, and so on.

i.e. if H is the original height and L the original length in ft. of a swell, its height after travelling D miles will be F.H. where F is a factor given by the table below.

TABLE III.

D/L	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
F	.67	.44	.30	.20	.13	.09	.06	.04	.03	.02

The following deductions immediately emerge:-

(a) The height of any swell diminishes rapidly to begin with and more slowly afterwards. As the length is assumed not to change, the swell is thus a wave with small H/L ratio except in the immediate vicinity of the storm area, i.e.it is rarely a steep wave.

(b) The shorter waves are of less height to begin with, and lose their height at a much greater rate - they therefore are unable to travel far before becoming inappreciable, as compared with the long waves which can go vast distances. E.G. Table III shows that a 150 ft. wave 10 ft. high is reduced to 2 feet after 600 miles travel, while a 600 ft. wave 30 ft. high is still nearly 2 ft. high after 4,000 miles.

(c) The only winds which can produce swell capable of travelling great distances are those of gale force, as inspection of Tables I and II shows that only such winds, sustained for at least 6 hours (over a fetch of 200 miles or more) can raise the necessary long waves. The 600 ft. wave mentioned in (b) above requires Force 8 at least to produce it.

(d) As stated above, the train of waves produced in the storm area travels out of it at HALF the speed given by Table II or I. The interval between the storm and the arrival of appreciable swell from it on a distant shore may be considerable. E.G. a N.W. 600 ft. swell train starting 30 ft. high off Newfoundland moves at about 16 knots. It will arrive off the Moroccan coast (2000 miles distant) about 5 days later still about 8 ft. high, and, if more northerly in direction, may reach St. Helena (3,600 miles) 9 days later, though now less than 3 ft. high.

It must be realized that the wind blowing over the sea area traversed by the swell on passage may have some effect on the latter. A wind behind the swell should retard its rate of decay, while an opposing wind should tend to accelerate its decay. Little evidence is available on this point; but it would appear that winds appreciably less in velocity than the wave-speed (C) of the swell itself have no great effect. In the same way, cross winds have little apparent effect on a long swell, which travels through the cross-sea produced by the wind with the normal rate of decay. A head or cross wind of speed equal to or exceeding the speed of the swell appears, however, to destroy the original swell and to set up a swell in its own direction in a comparatively short time. Herein one finds an additional reason for the fact that only the long swells travel far; a long swell set up by a gale is unlikely to run through another gale on its travels, while the short swell set up by a wind of force 4-5, say, does not usually get far before a wind approximately the same speed from another direction destroys it.

If two trains of swell-waves pass through the same area, they do so without disturbing one anothers' length or speed. Two crossing swells have frequently been reported from the Doldrum area of the Atlantic, the one set being comparatively short waves set up by the SE Trades, the other set being produced by the NE Trades when the latter are strong, or by depressions far to the North which produce a long northerly or northwesterly swell. The two swells pass through each other; where two crests coincide, the amplitudes of the two waves add together; the result is the unpleasant 'pyramidal sea' characteristic of this area and of others where such crossing is common.

Section C.

Effect of waves running into shallow water.

As each wave passes, a surface particle of water describes a circle of diameter equal to the height of the wave in a time equal to the period of the wave (period = time between successive crests = L/C). In deep water particles beneath the surface also describe circles whose diameter decreases rapidly with depth; at a depth equal to half the wave-length, the motion is less than a hundredth part of that at the surface. I.E. the wave disturbance affects, for all practical purposes, only the top layer, of depth L/2 of the sea, beneath this the water is practically at rest. The speed of a wave in deep water (i.e. in water whose depth is greater than about L/2) is equal to $1.36\sqrt{L}$ knots, if L is in feet. If, however, the depth of the water is less than L/2, the motion of the water is affected by the presence of the bottom, and this rule ceases to apply. The motion below the surface is now elliptical, the ellipses getting flatter and flatter until close to the bottom the water moves to and fro in a straight line parallel to bottom. The speed of the wave in water shallow compared with the length of the wave is about $3.4\sqrt{D}$ knots, where D is the depth in feet. This is less than the original speed, and since the number of waves passing a fixed point in unit time (i.e. the period of the waves) is the same in the deep or the shallow-water, it is clear that the waves must be telescoped together in the same way as traffic on a main road on entering a speed limit - i.e. the wave-length (distance between successive waves) becomes less. But the shorter waves in shallow water still possess the same energy per wave as they did when they were longer in deep water; this they can only do by getting higher. Thus waves running into shallow water get shorter, higher and steeper as the water shoals. Obviously this process cannot continue indefinitely; as soon as the height of the wave becomes roughly equal to the depth of undisturbed water the wave becomes unstable and breaks.

The magnitude of these effects may be estimated from Table IV below, in which:

H, L) denote height and length of waves in deep water.

h, l) denote their height and length when they have run into water of depth D <u>feet</u>.

TABLE IV.

D/L	0.1	0.08	0.06	0.04	0.02	0.01	0.005
l/L	0.77	0.71	0.61	0.5	0.35	0.25	0.18
h/H	1.08	1.14	1.28	1.41	1.7	2	2.4

Example 1.

Thus a 100 ft. wave 6 ft. high such as might be produced by a local wind of force 5 would be about $6\frac{1}{2}$ ft. high in 10 ft. of water,(where D/L = 0.1, hence h/H = 1.08) $6\frac{3}{4}$ ft. in 8 ft., and $7\frac{3}{4}$ ft. high in 6 ft. But it breaks when D = h, viz when it is about 7 feet high in 7 ft. of water.

Example 2.

A 600 ft. swell also 6 ft. high, such as might have come from a considerable distance, would be $6\frac{1}{2}$ ft. in 100 ft. of water, $6\frac{3}{4}$ ft. in 80 ft., $7\frac{3}{4}$ ft. in 60 ft., $8\frac{1}{2}$ ft. in 40 ft., 10 ft. in 20 ft., and 12 ft. in 10 ft - obviously it breaks about 12 ft. high in 12 ft. of water.

It may be taken as a rough working rule that a low swell (i.e. a wave whose height / length ratio is small) will break at a height about double its open sea height in soundings of the same depth.

The reduction in speed of the swell as it runs into shallow water tends to cause the waves always to approach the beach with their crests parallel to the fathom lines (i.e. in general, parallel with the beach). This is clear if one imagines a swell approaching a N - S beach from N.W. The N.E. end of the swell gets into shallow water first and its speed is progressively reduced, while the crest of the same wave further offshore is still in deep water and moving at full speed. The wave obviously wheels left and finally approaches the beach with its crest parallel to it.

Section D.

The forecasting of swell.

From what has been said in sections A and B it should be apparent that the forecasting of swell likely to affect any particular area of sea or length of coast is a matter of some complexity, due primarily to the distance in space and time at which the cause of the swell may be found. To simplify the problem Table V below has been constructed from Tables I and III given previously. It gives roughly the maximum distance from an extensive area of wind of given strength at which the swell will still be 3 ft. high, also the time the swell train will take to cover this maximum distance. Similar figures are also given for a swell 10 ft. high.

TABLE V.

Wind Force		4	5	6	7	8	9	10	Beaufort.
3 ft. Swell.	Distance	100	500	1200	2400	4000	7000	10,000	miles
	Time	½	2	4	7	9	14	18	days
10 ft. Swell.	Distance	-	0	300	1000	2000	3000	4000	miles
	Time	-	0	1	3	5	6	7	days

Thus, assume it is required to know now (28th p.m.) whether a swell exceeding 3 ft. in height is to be expected at point A A.M. 29th (i.e. in 12 hours time) assuming one has available a series of synoptic charts at 12 hourly intervals.

Inspect the last chart (28th P.M. i.e. 12 hours before the time one is interested in) to see if a wind of force 4 or more is reported within 100 miles of A, or is expected to spring up within the next 12 hours within this radius. If so, it can cause a swell exceeding 3 ft. at A on 29th A.M. if the fetch, duration and direction of wind are right. If the direction of the reported or expected wind is towards A, the fetch and probable duration of this wind must be examined to see whether it will, in fact, produce a swell exceeding the critical value by using the principles and tables of sections A and B.

Then proceed to examine the charts of A.M. 28th, P.M. 27th, and A.M. 27th, (i.e. up to 2 days before the time one in interested in) for winds of force 5 or more within 100 and 500 miles of A. If such winds are directed towards A, it is possible that they may produce a swell exceeding the critical value - their fetch and duration must be looked into to see whether they will, in fact, do so.

Next proceed to examine the charts of A.M. 26th, P.M. 26th, P.M. 25th, and A.M. 25th, (i.e. up to 4 days before A.M. 29th) for winds of force 6 or more within 500 miles to 1200 miles of A. Again, if suitably directed towards A, they must be examined to see if their fetch and duration are sufficient for their swell to reach A with a height exceeding the critical value.

Similar examination of charts 4 - 7 days before A.M. 29th for winds of or exceeding force 7 and directed towards A between 1200 and 2400 miles from A, of charts 7 - 9 days before 29th for winds of or exceeding force 8 and directed towards A between 2400 miles and 4000 miles from A and so on must be made until the boundary of the ocean in which A is situated is reached.

The problem is, however, somewhat simplified if actual observations of swell from ships are available. These should give an estimate of its height, length and direction. From the reported length the speed can be estimated (Speed of train in knots $= \frac{2}{3}\sqrt{\text{length in feet}}$), or, if the ordinary code is used, a short swell (less than 300 ft.) advances at about 10 knots, a medium length swell (300-600 ft.) advances at about 15 knots and a long (over 600 ft.) swell train advances at about 18-20 knots. If from the observations, an estimate of the time of onset and cessation of swell directed towards A can be formed, its time of arrival and duration at A can be forecast; its approximate height at A may be estimated from reported height (low = less than 6 ft., moderate = 6 to 12 ft., high = over 12 feet) by use of Table III.

In either case, an eye must be kept on the winds the swell will experience on passage from the storm area or observing ship to A - the effects of such winds are mentioned in Section B.

Example.

The 4 charts (a), (b), (c), (d) of figure 5 show the synoptic situation in Mid-Atlantic at successive 12 hourly intervals from, say, A.M. 1st (5 (a)) to P.M. 2nd (5 (d)). Before and after these times the synoptic situation was radically different. The area outlined indicates where, throughout the 2 days, the wind was approximately constant in direction (NNW) and of gale force (average about force 8); and this is the only area on the chart where a strong wind persisted for such a considerable time. The fetch was about 800 miles, duration of blow about 2 days; wind force 8: - Tables I and II indicate that the waves at the southern end of the storm area (in about 35° N) would have attained almost the maximum size for force 8, viz. roughly 700 ft. long and 33 ft. high, towards the end of the gale. The waves earlier and later than this would be shorter and lower; but a reasonable assumption is that for at least 2 days, from A.M. 1st to A.M. 3rd, waves approximately 600 ft. long and 30 ft. high were crossing 35° N. south of the storm area, travelling towards SSE. This train of waves would advance at about 16-18 knots and should reach the vicinity of the Equator in about 20° W. (a distance of 2,300 miles) a matter of 6 days or so after leaving the storm area. As the earlier and later waves to be formed are shorter and slower, they take longer to travel the distance, and hence an observer near the Equator would experience a swell lasting for rather longer than the two days or so of the original gale.

The average waves are 30 ft. high and 600 ft. long to start with. After 2300 miles (D/L = 3.8) Table III gives their height as slightly over 0.2 x 30 i.e. 6-7 ft. high.

Actually, a ship in 1° N. 20° W. reported swell from direction 30 (NNW) of 4 in code (moderate height, moderate length) from P.M. 8th to P.M. 11th, rising to 5 (moderate height, long) A.M. on 10th.

Naval Meteorological Branch,
Hydrographic Department,
Admiralty.

(H.M.79/38) September, 1942.

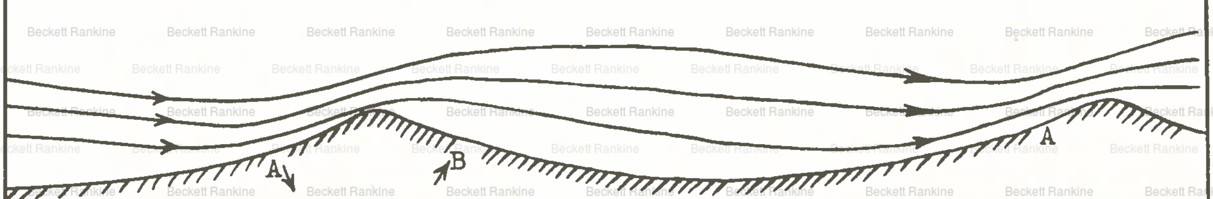


Figure 1.

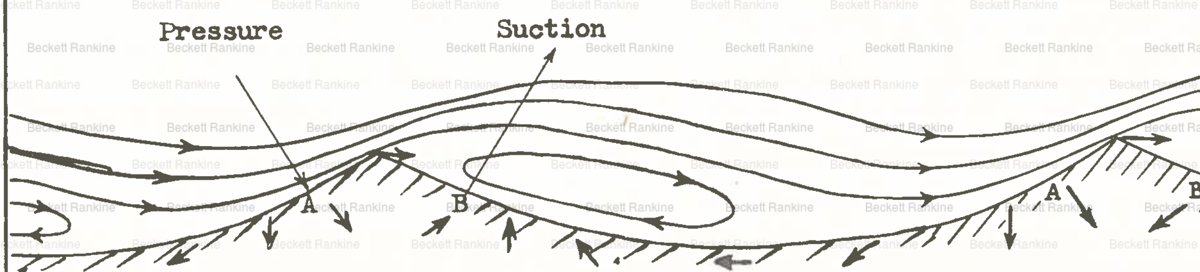


Figure 2.

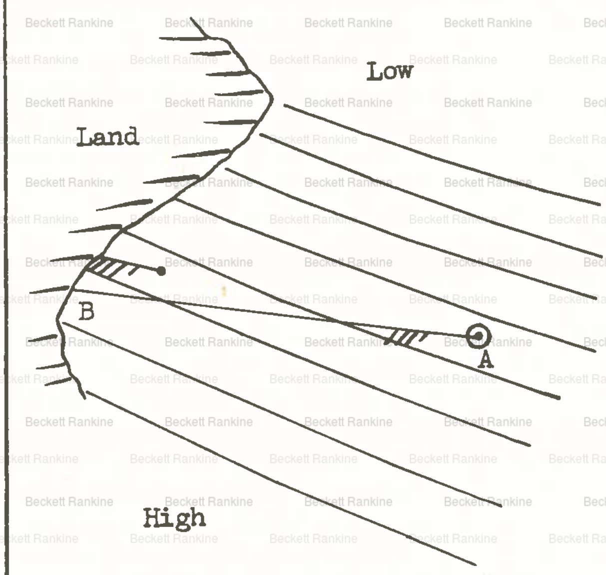


Figure 3.

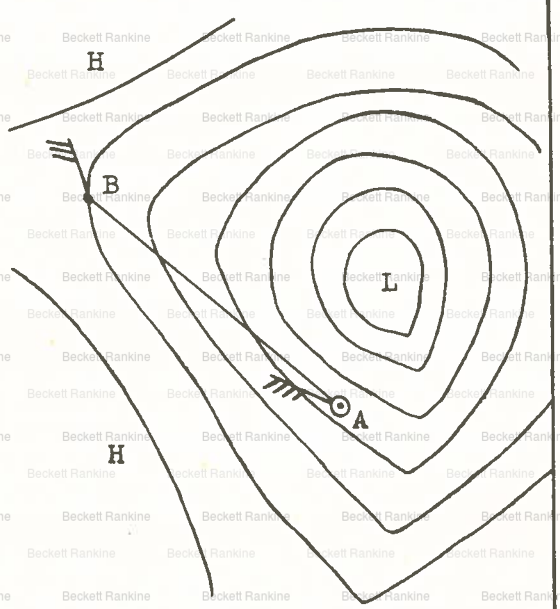
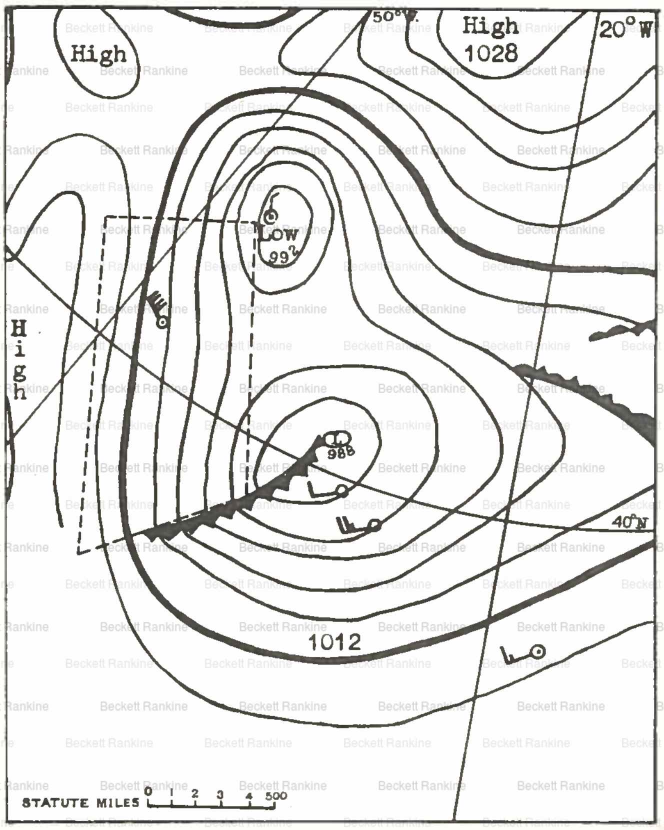
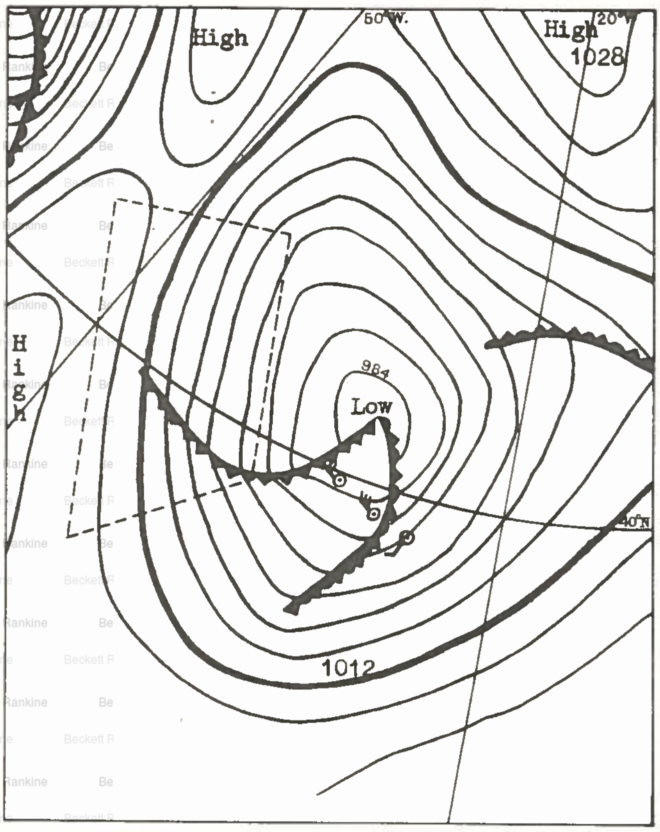


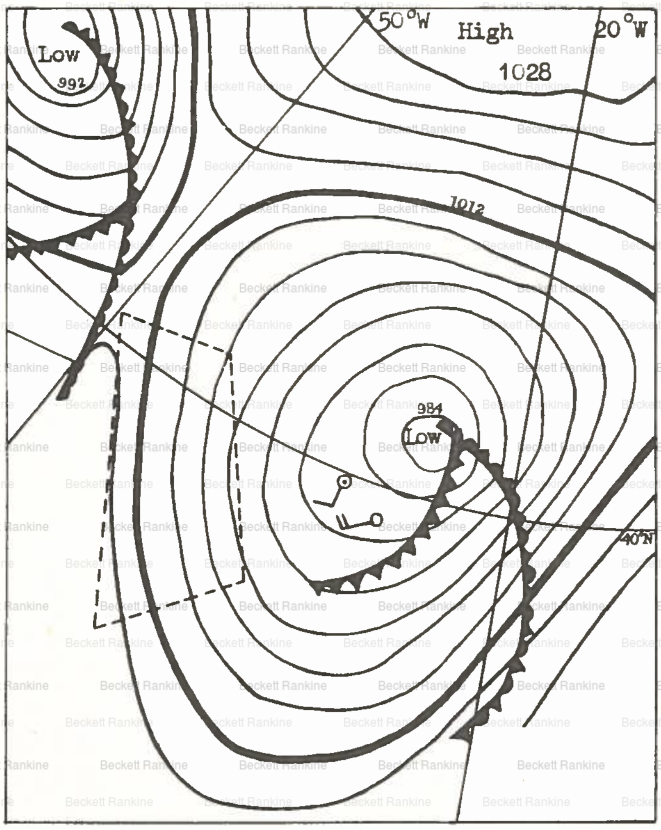
Figure 4.



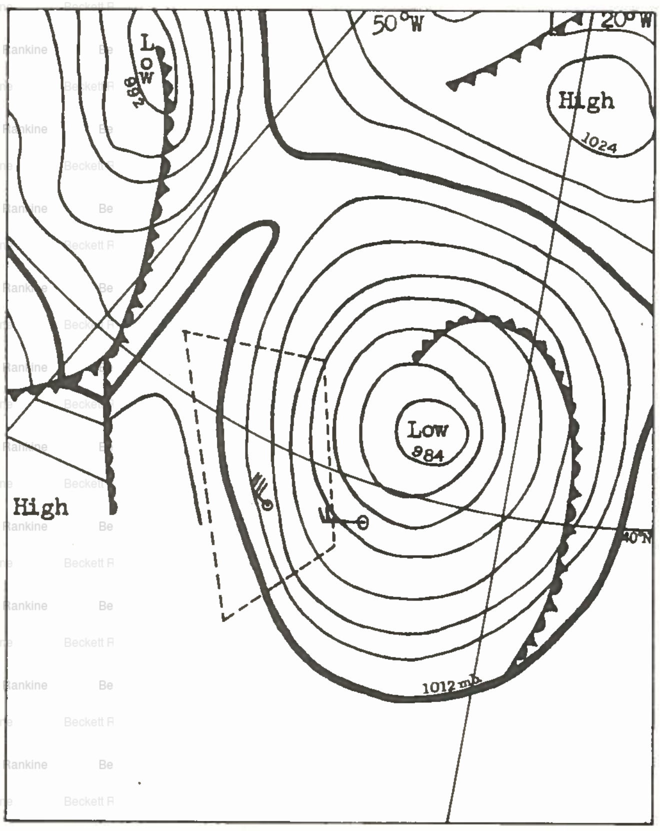
5(a). A M. 1st



5(b). P M. 1st



5(c). A M. 2nd



5(d). P M. 2nd

MOST SECRET.

From: Chairman, "Civil" Committee.
To: The Director of Transportation.

Subject: Plan "B".

Three copies of Plan "B", No. 29/9

Print No. 1.
" " 2.
" " 3.

are forwarded to you.

The layout indicated in this plan has been discussed and agreed with Rear Admiral Benn, Director of Navigation, who has asked that a copy should be supplied to him.

signed R.D. Gwyther.

for Chairman.

30th September, 1943.

MOST SECRET.

MEMORANDUM.

MULBERRY 'B'.

The "Civil Committee" comprising Mr. Colin White, Mr.J.D.C. Couper, Mr.R.D.Gwyther with Lt.Col.Bell attending, met on 10th February 1944 to consider a fresh proposal regarding site 'B' and after discussion the following notes were made.

(1) The middle entrance faces N.W. which was considered less satisfactory than facing N.E.

(2) Bombardon if effective covers the middle entrance but the western entrance is exposed.

(3) With both entrances facing Westward ships may have to enter and leave with the tide instead of stemming the tide.

(4) Any sea coming in from the N.W. will give very disturbed conditions at the Pier Heads and probably on the landing beaches, though this might be somewhat diminished by further development of the Western Shore Arm.

(5) The layout appears to envolve more turning within the harbour area.

(6) The available area inside the West outer breakwater is restricted at L.W. as the traffic lane is encumbered by moored vessel.

(7) As regards the effect of Bombardon we have no data on which we can express an opinion as to its efficacy in damping out wave action sufficiently to allow override discharge of Liberty ships at anchor. Nor have we any information with regard to the practicability of mooring the thing in 7.1/2 Fathoms of water with a 24 feet rise of tide.

(8) **Blockships.** Their chief advantages are that they are self propelled and may possibly be placed more quickly than caissons, though in the Committee's opinion they could not get themselves into correct position without the assistance of tugs.

Unless very much strengthened they will break in two.

Broadly, apart from the sacrifice of ships, we doubt whether they offer any advantage over concrete caissons either from the point of view of rapidity of construction or effectiveness.

MOST SECRET.

From: The Chairman "Civil" Committee.

To: The Director of Transportation.

Subject: Diagram No. 3112

1. We have examined the layout shown on the above diagram and, as requested, we now beg to offer the following remarks, which we trust will be of assistance to you. We would welcome an opportunity of discussing with the Officers concerned those points on which we are in some doubt, and any other matters in connection with this problem which may arise.

General

2. We find that the layout shown is on very much the same lines as those we adopted in the case of War Office plan "B".

West Island Breakwater

3. The West Island Breakwater is further inshore than the position we selected, which in fact was moved out from the five fathom line at the request of Naval Officers in order to increase the area of sheltered water seaward of the three fathom line.

4. It would seem better to align this breakwater on one straight line to facilitate placing the Phoenix units in position, unless there is some good reason for introducing the bend near the eastern entrance.

5. The object of the double Units at the ends of the breakwaters is not clear to us. We anticipate that there would be considerable difficulty in sinking two Units close together or attempting to lash the Units together before sinking.

6. We should like to know the reason for staggering the Units. If this has been done with a view to one Unit affording support to the next, little reliance should be placed on such support. It will not be practicable, even in the calmest weather, to sink the Units with the degree of accuracy necessary, and any attempt to do so might result in serious damage being done to their ends. Further, it is likely that the staggered formation may induce considerable scour.

7. Unless there is some special reason for the 200 ft. opening in the middle of the breakwater, we think this opening should be omitted. It could only be used by small craft in calm weather, and in rough weather would tend to increase the swell inside the Harbour.

East Island Breakwater

8. We note that the eastern entrance has been increased to 700 ft., which we consider to be unnecessarily wide for the size of vessels using the Harbour.

9. We endeavoured to follow the contours in siting the East Island Breakwater, but we see no objection to the straight alignment now selected, which has advantages in facility of construction.

10. It is not evident to us what advantage is gained by bending the western end of this breakwater inshore, as this appears to have the definite disadvantage of making the entrance difficult for vessels leaving the pierheads and also obstructs the swinging area inside the Harbour.

11. The 200 ft. opening in the centre of this breakwater appears objectionable to us, as the shoal outside makes it of little use as an entrance and it could only serve to admit swell to the Harbour, especially off the landing beach.

12. We note that it is proposed to construct this East Island Breakwater of blockships. The only advantage of this form of construction known to us is that the various ships could be taken to the site under their own power, but we believe that they still could not be sunk with the degree of accuracy required without the assistance of tugs. We are of the opinion that a blockship will be more difficult to place in position than a Unit which has been specially designed for the purpose. Further, that a ship is less likely to remain upright and may break up through the void of the machinery spaces.

13. Without knowing the size of ship that it is proposed to use, it is difficult to ascertain the amount of protection they would afford.

14. Ships masters would hesitate approaching near a sunken ship and the navigable area in the Harbour would be curtailed in consequence. Whereas, they would not have the same fear in closing a Unit, the position of which is clearly defined.

15. We observe that the eastern end of this Island Breakwater does not extend as far to the eastward as we provided with the result that the length of working beach under its protection is reduced by one third of the length of beach shown on plan "B"

West Shore Arm

16. As placed, this arm leaves an entrance 1000 ft. wide, fully open to the north west. After considerable thought, the western arm in plan "B" was kept under the shelter of the island breakwater, in order to provide more protection for the Harbour from the north west.

Pierheads

17. These are placed on the three fathom line, as in the case of plan "B".

Contours

18. The contours obtained from the recent soundings appear to show rather more water inside the Harbour than was indicated on the original French chart.

2nd March 1944

COLIN R WHITE
Chairman "Civil" Committee

MOST SECRET

To:- The Director of Transportation.

Subject:- Storing Phoenix Units.

I visited Southend with Lt. Col. Wakefield and Mr. Hughes on the 7th March 1944 and called on Commodore Champion, R.N.

2. The Commodore was expecting us but he had no definite proposals to make for storing the units, beyond putting them on the sands above low water line, and he evidently thought that we would put forward proposals to him.

3. He had not been advised of the drafts of the various types or the numbers that have to be accommodated.

4. Off Southend the rise at neap tides is 14 ft. 9 ins., so the least water necessary in which to ground an A.1 unit and be able to float it off at any high tide is 1 fathom.

5. The Cant Sand, which is situated just to the eastward of the Boom Defences and south of the main channel, has a large expanse of water 1 fathom deep and Commodore Champion suggested that this area might be suitable. There are, however, technical difficulties in sweeping water of this depth, and it would take some weeks to clear a sufficient area.

6. The northern side of the Cant, however, has more water up to 2½ fathoms and Commodore Champion has selected an area south of the main channel between the East Cant Buoy and Outer Bar Buoy and north of 51°27'48", where units might be stored.

7. The soundings throughout this area are very even, varying between just under 2 up to 2½ fathoms, and the bottom is shown to be sand and shells.

8. The units would take and leave the bottom without bumping, even in bad weather.

9. It would be advisable to check the nature of the bottom, and if this proves to be sand and shells throughout, this area is suitable for storing the larger units.

10. The spring tidal rise is 18 ft. 3 ins., so there is too much water for the C and D units in the above area. These units must be stored about low water mark and sites would have to be found for these inside the Boom.

10th March 1944