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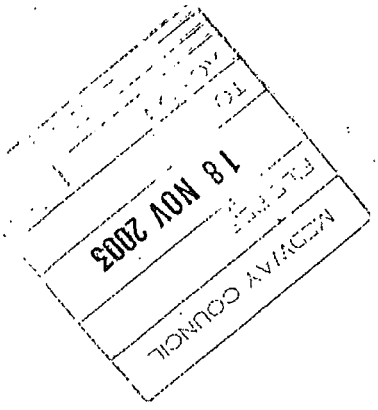
NORTH KENT GRAVEL Deft.

THE GRAVEL RESOURCES OF NORTH KENT

The study considers the River Terrace and Buried Channel deposits of the Isle of Grain, Allhallows Peninsula, and Thames-side.



November 1987

It is now clear that sandstone-based gravels of Upper Medway are generally of an inferior quality which cannot satisfy many construction requirements. Extensive resource areas with no strategic planning constraint have nevertheless been identified in the Upper Medway Valley. It seems right to consider that the identified resource is disproportionately large in relation to the ability of industry to use gravels of lower quality.

This situation focuses attention on our remaining areas of higher quality gravel. Without doubt the Beach Gravel deposits of Dungeness represent a major part of these resources, but are heavily constrained by nature conservation and aquifer protection issues, and by MoD occupation.

The deposits of North Kent, being geologically down-dip from the North Downs, offer flint and chert based gravels of good quality. The deposits of Allhallows, Grain and Thames-side lie second only to Dungeness in their significance as a county resource.

These deposits offer certain attributes compared with Dungeness in that

(a) sand contents are consistent with commercial requirements, whereas Dungeness is deficient in sand;

(b) some deposits could be worked and restored to a dry floor.

Gravels in the main river valleys of Kent are largely worked out, or are sterilized by other development. The remnants can no longer offer the same significance to the county as the deposits of Dungeness and North Kent. These two resource areas are geographically well separated. Commercially they would tend to serve different market areas, and are therefore complimentary.

Two broad types of deposit are identifiable in the North Kent study area:-

(a) terrace gravels that can be worked and restored to a dry floor in relatively shallow workings;

(b) buried channel gravels, usually under deep alluvium, but often offering substantial thicknesses of gravel deposit, which would require some less conventional working methods for deep underwater extraction.

Each type will be dealt with in a separate part of this study. In September last a memorandum suggested that 16 million tonnes of gravel was not sterilized by built development in the terraces of Grain and Allhallows, although much of this is constrained by strategic planning policy.

PART A - TERRACE GRAVELS

1. An attached Map 'A' locates some twenty spreads of terrace gravel in the Grain and Allhallows areas, and substantial expanses of brickearth which in part are known to cover gravel. Many of the spreads are constrained within the Area of Special Significance for Agriculture, or by the designation of a Special Landscape Area with an Area of High Nature Conservation Value.

   In general the Low Terrace is likely to be the most productive, typical depths being:-

   4th Terrace up to 6 ft. (1.8m)
   3rd Terrace up to 6 ft. (1.8m)
   2nd Terrace up to 10 ft. (3.0m)
   1st Terrace up to 35 ft. (10.6m)

2. The geological memoir covering the Chatham geological sheet contains much useful comment on the terrace gravels and on gravel under brickearth:-

p.118 The most extensive brickearth deposits in the Medway Valley border the west bank of the river for a distance of about 3 miles, from Hoo to North Street, with an average width of about three quarters of a mile. These rest on low terrace gravel near the river, and on London Clay on the landward side, the surface levels rising gently from about 20 ft. OD near the alluvium to over 100 ft. due north of Hoo.

Brickearth has been excavated from a considerable area south of Hoo and in 1938 a face about 500 yd. south-west of Hoo Church showed 4 ft. to 5 ft. of red-brown brickearth on 4ft. to 5 ft. of bedded yellow sand; this latter passed down into evenly-bedded sand and gravel seen for 10 ft.

p.119 In the area south-east of Hoo the brickearth appears to be not more than 4 ft. thick, all of the red-brown type, and to rest directly on gravel.

At Lower Stoke, south of Allhallows, surface indications show that the brickearth may here be only a thin layer over gravel.

p.136 The chief areas of river gravel are on the peninsula of Allhallows, and on the Isle of Grain.

To the north-east and east of High Halstow, Lodge Hill, and Chattenden Farm, the surface slopes gently towards the Medway and the main spreads of gravel mantle the slopes from the highest point (240 ft. at Lodge Hill) down to about 50 ft. The higher spreads seldom exceed 5 ft. or 6 ft. in thickness, and appear to have been laid down as a series of terraces of river origin, as indicated by even bedding, a uniformly ochreous character, and high contents of cherts from the Lower Greensand.

The following terraces have been recognised:-

4th Terrace	150 ft. to 210 ft. OD or higher
3rd Terrace	90 ft. to 150 ft. OD

2nd Terrace	40 ft. to 100 ft. OD
Low Terrace	up to 50 ft. OD
Burried channel	down to minus 99 ft. OD

p.137 4th terrace gravels occur only around High Halstow and near Chattenden Farm, W.N.W. of Hoo. 1000 yd. north of High Halstow Church are two small patches, remnants of a wider spread that has been largely removed by land slipping. They cap Northward Hill at a height of 209 ft. OD.

At High Halstow Village a spread sloping eastwards from 200 ft. level at the church contains ochreous sand and gravel with flint and chert, seen in a pondside exposure to a depth of 4 ft.

Separated from it to the east a slightly lower patch slopes eastwards to a hill below 150 ft.

In the Clinch Street Farm spread of 4th terrace gravel the highest point is at 190 ft., and the surface falls gently eastward to 150 ft. at Newlands.

p.138 3rd terrace gravels are extensively spread over the area between High Halstow and Allhallows and tend to extend down the hill slopes.

The largest spread of this terrace, around Dagenham Farm, slopes gently from a central level at 135 ft. OD to the 100 ft. contour southwards, eastwards and northwards. Old pits are about 6 ft. deep. The deposit consists of evenly bedded sand and gravel, the upper 3 ft. being contorted.

A mile west of Stoke, in a spread with a level surface at 120 ft. OD, old pits showed 5 ft. of ochreous gravel and some sporadic iron pan.

p.139 2nd terrace gravels are fairly extensive between Allhallows and Hoo, and eastwards on the Isle of Grain.

A very small patch about a mile N.E. of St. Mary's Hoo, at the 50 ft. level, has been excavated to a depth of 6 ft. The top half of the exposure shows contortions but below the gravel and sand are more or less evenly bedded.

Slough Fort, half a mile north of Allhallows, is on a small spread at the confluence of the Thames and Medway. At the fort the gravel appears to be about 12 ft. thick.

A large spread of the 2nd terrace almost covers the Isle of Grain. It has a fairly flat surface between 40 ft. OD in the central and northern parts, but sloping southwards and westwards to about 25 ft. On all sides it is separated from alluvium by a slope of London Clay. Old gravel pits north-west of Grain village are 8 ft. deep in ferruginous sand and flinty gravel with chert, vein quartz and quartzite pebbles. At the Royal Naval Flying Station, south-east of the village, a well proved 6 ft. of gravel on London Clay.

South-west of Allhallows, gravel 4 ft. to 5 ft. thick lies higher than the general level of the 2nd terrace, i.e. between 60 ft. and 75 ft. OD.

On the north side of Lower Stoke a small patch at about 45 ft. OD has been worked in pits up to 8 ft. deep.

The elongated spread on which the village of Stoke is situated is mainly above the 50 ft. contour. Old pits near the church and near Tudors are 3 ft. to 4 ft. deep.

p.140 Low Terrace gravels border alluvial tracts, and pass beneath alluvium, appearing to merge with deposits of the Buried Channel, while landwards their surface level may rise locally to 50 ft. OD or more.

p.141 At the foot of the steep, northern, London Clay slopes of the High Halstow ridge and bordering St. Mary's Marshes, the gravel may be 4 ft. to 5 ft. thick.

East of Allhallows the small thin spread, with surface level about 25 ft. OD, which caps the low hill of Binney Farm may belong either to the Thames or to the Medway.

Low Terrace gravel underlies the Hoo brickearth. Gravels occur from Kingsnorth westward to beyond Hoo, occupying about half the width of the brickearth area on its riverward side.

A well proved 10 ft. of ballast, clay and sand, on London Clay, and below 8 ft. of brickearth, some 300 yd. south-west of Kingsnorth and about 800 yd. south-east of Beluncle.

Between Eshcol and Abbots Court gravel underlies brickearth at depths from 2 ft. to 8 ft., and just west of Abbots Court there is 6 ft. of brickearth on 8 ft. to 10 ft. of gravel.

It is not known whether the brickearth at North Street is underlain by Low Terrace gravel.

p.142 In 1938 a section 800 yd. south-east of Hoo Church showed:-

red-buff clayed brickearth		4'0"
roughly false-bedded gravel		4'0"
buff loam		4"
dark brown compact ferruginous gravel		1'0"
buff loam		2"
compact red-brown gravel	seen to	7'0"

A section 500 yd. south-west of Hoo Church showed:-

brickearth		4'6"
even-bedded sand		4'6"
even-bedded sand and gravel	seen to	10"

The sub-brickearth surface of the gravel in the area south of Hoo varies from 15 ft. OD near the margin of the alluvium, to about 40 ft. near the village. On the western margin of the deposits, about 750 yd. east of Hoo Lodge, the upper surface of a deposit of evenly bedded sand and loam underlying brickearth rises to a little over 50 ft.

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p,148 The Low Terrace gravel deposits are comparitively important sources of sand and gravel.

Gravel pits about a quarter-mile west of Queens Farm, west of Higham or Church Street, expose up to 20 ft. of gravel. Near the Uralite Works another pit is 15 ft. deep, while east of this a third pit is 22 ft deep, and its floor is 12 ft. below the level of the adjacent alluvial tract.

Extensive gravel deposits in the Low Terrace at Hoo are worked beneath brickearth.

Most of the Terrace Gravels above the Low Terrace are thin, and are only worked in shallow pits, as are pits up to 8 ft. deep in the Isle of Grain.

3, Each resource area will now be considered in some detail. It is only the gravel terrace on Grain, and some sections of brickearth between Hoo and Kingsnorth, that are not constrained by strategic planning policy. In planning terms these areas must represent the best options for future workings.

The ouline of the Grain terrace is shown on Map 'B'. Three areas permitted to Clubb and BP for mineral extraction are lined in red. The remaining resource that is potentially workable is outlined in blue and covers some 89 hectares (38 ha. at Perry's Farm and 51 ha. in the Wallend area). Southern Water Authority (3rd June 1987) have expressed concern about the lowering of ground levels behind their counterwall at Perry's Farm. It should be said, however, that potential areas of excavation seem to be well removed from the counterwall. In terms of the local environment the northerly part of the Wallend area is clearly sensitive in it's proximity to housing of Grain Village.

The geological memoir identifies the Grain resource as a 2nd terrace deposit. Gravel depths of 8 ft. and 6 ft. are referred to.

Recent boreholes in the Perry's Farm area have shown that the gravel is significantly thinner to the west of a north-south line through the buildings of Perry's Farm. To the west an average gravel thickness of 1.40m is proven with a 57% sand content. To the east an average thickness of 3.46m is shown from six holes, with a 43% sand content.

In the northern part of the Wallend area, in the area near to housing, Clubb boreholes have shown an average gravel thickness of 2.65m with a 42% sand content.

The total remaining resource in the 2nd terrace at Grain is likely to equate to:-

89 ha. x 10.000 x 2.60m mean depth x 1.53 tonnes/m^3
= 3.5 million tonnes

It is additionally interesting that there is impressive evidence of large quantities of gravel in a buried channel in close proximity to Perry's Farm under the alluvium to the west. This deposit will be discussed in a later section of this study.

4 Two brickearth deposits which lie outside the ASSFA are outlined on Map 'C'. Three areas permitted for mineral extraction, to Brice, and Newington Bricks, are lined in red. The geological memoir records that the brickearth rests on low terrace gravel "near the river". It gives details of an exposure some 500 yd. S.W. of Hoo Church (i.e. in the vicinity of Cockham Cottages) with 4 ft. of brickearth on 5 ft. of sand, which rested on 10 ft. of exposed gravel. It also states that S.E. of Hoo (assumed to be in the vicinity of Church Farm) 4 ft of brickearth rests directly on gravel.

The westerly deposit at least in part covers proven gravel. The local environment close to Hoo is seen, however, as being somewhat sensitive for gravel extraction. There is an undeveloped area of about 30 ha. which could yield up to 1.0 million tonnes.

The geological memoir is fairly clear in indicating gravel to the S.E. of Hoo in the area designated an ASSFA.

The easterly area of brickearth on Map 'C' carries no positive reference to gravel deposits, but the parcel of land between Jacobs Lane and Abbots Court must be seen as a gravel prospect. An available area of approximately 57 ha. could yield up t 1.9 million tonnes of gravel.

5. The gravel tonnages referred to in (3) and (4) above are the only prospects in the Grain and Allhallows area which are not covered by a policy objection. If it were deemed necessary to set aside some part of policy to release gravel it is likely that this would be within the SLA rather than in the ASSFA. Reference to Map 'A' shows that four prospects with gravel terraces would then arise.

Map 'D' outlines the deposit of 4th terrace gravel at Newlands Farm near High Halstow. The western part of the deposit lies within the ASSFA. The geological memoir records that the spread of gravel falls gently eastward from 190 ft. OD at the high point to 150 ft. at Newlands, and that the higher spreads seldom exceed 5 ft. or 6 ft. in thickness. The available area of 29 ha. is outlined in blue. The likely yield would be:-

29 ha. x 10,000 x 1.68m mean depth x 1.53 tonnes/m^3
= 0.75 million tonnes

6. Map 'E' outlines the deposit of 3rd terrace gravel at Moat Farm near St. Mary's Hoo. It abuts the Ratcliffe highway and the Welham and Thompson consent, although there is no continuity of gravel between the two sites. The recent application (ME/86/795) provides the only evidence of gravel depth, claiming a mean of 2.93m plus additional hoggin. An available area of 19 ha. is outlined in blue. The likely yield would be:-

19 ha. x 10,000 x 2.93m mean depth x 1.53 tonnes/m^3
= 0.85 million tonnes

7 Map 'F' outlines the deposit of 3rd terrace gravel at Dagenham Farm to the west of Allhallows. It abuts the Welham and Thompson consent and is a continuation of that terrace. The geological memoir refers to old pits about 6 ft. deep, and surface levels which range from 135 ft.

to 100 ft. OD. The eastern end of this terrace lies within the ASSFA. An available area of 29 ha. is outlined in blue. The likely yield would be:-

29 ha. x 10,000 x 2.00m mean depth x 1.53 tonnes/m^3
= 0.89 million tonnes

8. Map 'G' outlines the deposit of 1st terrace gravel at the edge of St. Mary's Marshes. It lies at about 25 ft. OD, and might well extend northwards under the alluvium. There is no evidence of gravel depth. A wet working would be more likely here. The area of exposed terrace is about 23 ha. The likely yield would be:-

23 ha. x 10,000 x 2.00m mean depth x 1.53 tonnes/m^3
= 0.70 million tonnes

9. There are, apart from the sites reviewed above, about nine available areas or combinations of areas that could offer viable workings in spreads of 2nd, 3rd, and 4th terraces. All fall within the ASSFA. Their total resource could amount to 5.00 million tonnes over 180 ha. as follows:

1.	Newhall Farm/Cuckholds Green	30.0 ha.	0.83 m.t.
2.	Middle Stoke/Stoke	27.2 ha.	0.74 m.t.
3.	Tunbridge Hill/Cold Arbour	25.8 ha.	0.70 m.t.
4.	Beluncle	19.3 ha.	0.53 m.t.
5.	Sharnal Street	18.1 ha.	0.50 m.t.
6.	Walnut Tree Farm	16.2 ha.	0.45 m.t.
7.	Parkers Corner	15.2 ha.	0.42 m.t.
8.	Tudor Farm	15.2 ha.	0.42 m.t.
9.	New Barn	15.0 ha.	0.41 m.t.

The scale of resources listed above would have to be verified by borehole survey. With the present state of knowledge the estimates seem valid.

10. Spreads of terrace gravel in the Thames-side area occur to the north of Dartford and to the east of Gravesend. The latter extend from Chalk to Church Street and are outlined on Map 'H'. Much of the deposit is covered by an ASSFA designation (lined in blue), and most that is not so covered was consented to White and Killick (lined in red).

The Chatham memoir (p.141) comments in some detail on these spreads:-

> Low Terrace gravels border the alluvial tracts and, passing down beneath alluvium, appear to merge with deposits of the Buried Channel, while landwards their surface level may rise locally to 50 ft. OD or more.
>
> An extensive spread north of Shorne, with a general surface level of between 15 ft. and 30 ft. OD, rises to 50 ft. south of Queen's Farm. Between the road and the southern margin of the gravel at 1000 yds. west-north-west of this farm, a large pit, in 1920, showed up to 20 ft. of gravel.
> In 1937 some 15 ft. of gravel was exposed at the same distance north of the farm.

In 1945 trial boreholes put down between these two pits proved ballast with sandy and clayey seams to a maximum thickness of 34½ ft., resting on chalk, but Thanet Beds were reached 15-17 ft. down on the north side of the site.

Two wells at the nearby Uralite Works proved 16½ ft. of drift (272/74a) and 18 ft. of ballast on clay (272/74b).

Gravel excavations, 1¼ miles north of Shorne, carried to below the level of alluvium, from a surface level of 25 ft. OD, showed, in 1937, a section with:-

10 ft. clayey alluvium on
23 ft. Low Terrace river deposits with
6 ft. yellow sand
12 ft. sand and gravel
3 ft. loam
2 ft. gravel
all resting on London Clay.

From the memoir information it is clear that significant thicknesses of gravel were encountered in this spread, with a likelihood that deposits extend northwards under alluvium beyond the mapped occurrence. It is clear that the area of Filborough Marshes offers a good prospect for gravel extraction from an area with no strategic planning constraint. The matter will be covered more appropriately as a Buried Channel deposit in part B of this study.

Within the terrace some areas around and to the south-west of Queens Farm are not sterilized by built development, but are covered by the ASSFA. Relaxation of this constraint could yield perhaps 25 ha. with a mean depth of 4.5m to yield 1.7 million tonnes.

11. The spread of terrace gravel at North Dartford is outlined on Map 'I'. All eastern parts were consented to the CEGB and southern parts are sterilized by housing development. Future intentions for the Joyce Green hospital land therefore govern the gravel resource that could be available.

The Dartford geological memoir records that the old Marsh Street pit was worked to a depth of 25 ft. without reaching the base of the gravel. A variety of boreholes in recent years have indicated that on average 7m of gravel could be worked, about one third being below water.

In the event of hospital demolition a working area of about 70 ha. would be available, indicating a resource of 7.5 million tonnes. In addition some Buried Channel gravel beneath alluvium occurs in near proximity, and will be considered in Part B of this study.

There is no strategic constraint on the terrace areas.

12. In summary, therefore, the various estimates above predict a total gravel resource in terrace deposits as follows:-

with no strategic constraint				
Perry's Farm	38 ha.		1.80 m.t.	} MEDWAY.
Wallend	51 ha.		1.70 m.t.	
Hoo	30 ha.		1.00 m.t.	
Abbots Court	57 ha.		1.90 m.t.	
Joyce Green	70 ha.	246 ha.	7.50 m.t.	13.90 m.t. PARTFORD
with SLA designation				
Newlands Farm	29 ha.		0.75 m.t.	
Moat Farm	19 ha.		0.85 m.t.	
Dagenham Farm	29 ha.		0.89 m.t.	
St. Mary's Marshes	23 ha.	100 ha.	0.70 m.t.	3.19 m.t.
within ASSFA designation				
Queen's Farm	25 ha.		1.70 m.t.	
nine Allhallows areas	180 ha.	205 ha.	5.00 m.t.	6.70 m.t.
		551 ha.		23.79 m.t.

PART B - BURIED CHANNEL GRAVELS

1. The variations in sea level, brought about by the recurring growth and dispersal of ice sheets in Pleistocene times, brought not only the deposit of gravel terraces at varying levels in our river valleys, but also some cutting of deep river channels during periods of maximum glaciation with low sea levels. In places a channel was cut with a floor as low as 100 ft. below OD. With the return to a warmer climate and a rising sea level gravels amassed in these channels. They sometimes reached a height above the level of our present-day alluvial flood plain, to give continuity with some now-remaining Low Terrace deposits.

2. The Buried Channel Gravels are now covered by some often-deep alluvium. Substantial thicknesses of gravel have been proven in many boreholes. The ratio of overburden to gravel is often much higher than that traditionally acceptable. Groundwater levels reach well up into the alluvial overburden.

3. To exploit these gravel resources would involve an acceptance of the cost of removing high ratios of overburden, probably using unconventional methods for the excavation of difficult alluvium from below water, and posing the question of how to place the spoil. Gravel dredging at appreciable depths would then follow. If these considerations could be satisfied there seems to be a good prospect that very substantial tonnages of gravel are to be found.

4. Map 'J' taken from the Chatham geological memoir locates boreholes that have reached the floor of buried channels under alluvium of the Thames and Medway. 8 provings occur in the Shorne, Cliffe, and Cooling Marsh areas, and 9 occur on the Isle of Grain.

5. The Chatham memoir comments as follows:-

p.144 These records give a general idea of the extent of the buried channels, but are insufficient to give a clear view of the form of their cross-sections. The available evidence suggests that gravels of the Low Terrace pass beneath the alluvium and merge with those of the Buried Channel.

The greatest depth at which river drift is proved is on the south-east side of the Isle of Grain (277/218) where London Clay was reached at 99 ft. below OD overlain by 98 ft. of alluvium and 6 ft. of sand and gravel.

p.146 In the Buried Channel of the Thames the greatest depth of drift proved is in Halstow Marshes where a trial bore passed through 99 ft. of alluvium with sand and gravel and into Woolwich Beds at 90 ft. below OD.

The drift as recorded in most of the well and trial-bore records is sufficiently differentiated to show that the amount of river gravel covering the floor of the Buried Channel is very variable.

The greatest thickness of Buried Channel gravels proved is 37 ft. at Cliffe Fort (272/22) and again at Rose Court Farm (272/36) on the Isle of Grain. The gravel is sandy in both places.

Beneath Halstow Marshes 34½ ft. of partly silty sand and gravel was proved.

Beneath Allhallow Marshes (272/1) the lower 31 ft. of drift consisted of 20 ft. of yellow sand on 11 ft. of gravel.

In the Cliffe area as a whole thicknesses of gravelly drift up to 35 ft. are recorded.

Thicknesses of alluvium around 50 ft. are common in the Thames and Medway estuaries generally, and the greatest thickness proved is 98 ft. on the south-east side of Grain, the mud and silt resting on a gravel bottom.

At Cliffe Marshes (272/23) mud and silt beds are 48 ft. thick resting on gravel.

At Cliffe Fort (272/22) mud and silt beds are 39 ft. thick resting on gravel.

6. The Dartford memoir on p.111 reportes that at Cliffe the alluvium attains a thickness of about 48 ft. and the underlying gravel a thickness of 35 ft.

7. Additional to the published information above a communication of 28 September 1979, from the Institute of Geological Sciences (now BGS), comments as follows:-

(a) in the wide northern area of the Dartford salt marshes the spread of alluvium would be expected to consist of up to 12m. of mostly clay and peat on sand and gravel probably up to 7m. thick. Southwards along the River Darent it is possible the thickness and coarseness of the sand and gravel will decrease, but this is speculation that could only be tested by drilling. IGS hold no borehole records for this area. From present knowledge it must be considered as potentially including sand and gravel resources.

(b) The area of Stone Marshes has Thames alluvium on Upper Chalk. IGS holds three borehole records near the western boundary:-

TQ57NE/2 shows	11.28m overburden on	7.31m gravel
/3	10.67m	4.42m
/4	0.76m	6.56m

Undoubtedly this is an area of potential sand and gravel resources with up to 11m of clay with peat on up to 7.5m of mineral.

(c) IGS hold no borehole data for Swanscombe Marshes but say that the area must be considered to have potential for sand and gravel. Something in the order of 10m clay with peat on up to 7m of sand and clay is probable.

(d) The Eastcourt and Filborough marsh areas must all be considered to have potential sand and gravel resources. IGS boreholes near to the area suggest probably some 8 to 12 metres of alluvium on gravel at least 5 metres thick.

(e) The Cliffe Marshes area has high potential for sand and gravel resources. Borehole TQ77NW43 in The Poplars area showed 13.1m alluvium on 10.45m sand and gravel. Borehole TQ77NW41 showed 14.17m of clay on 26.5m of sand and gravel, although some of this could be Thanet Beds.

8. Test drilling by KCC Highways, on the route of the Dartford Northern Bypass in the vicinity of Joyce Green Hospital, has penetrated buried gravels under the alluvium. At chainage 23 and 50 there is 3.2m of alluvium on 9.0m of gravel. At chainage 31 and 20 a second hole shows 3.7m of alluvium on 7.3m of gravel.

Test drilling by ARC Ltd. on their land holding in this vicinity has similarly shown a workable deposit of buried gravels under the alluvium.

9 Southern Water Authority have commissioned a considerable number of test borings along the shoreline areas of the Thames Estuary in connection with flood defence works. Three holes near the mouth of the River Darent have shown up to 6.6m of gravel. Eight holes to the north of Cliffe have shown up to 10.4m of gravel, and eleven holes in the vicinity of Yanlet Creek have shown gravel with more than 7.3m in the best case.

10. Four holes drilled by B.C.I. in their land holdings at Cliffe have at best shown 6.4m of gravel.

11. Ten holes in the vicinity of Grain Refinery for British Petroleum and British Gas have at best shown 7.0m of gravel.

12. In total from the sources mentioned some forty-nine holes have penetrated gravel under the alluvium. In some instances the depth of gravel is very substantial by comparison with that available in remaining terrace deposits. The ratio of overburden to gravel in the holes varies from 0.4 to 15.0. The selection of areas with ratios that are not too adverse, and an ability to handle difficult overburden from below water, must be key factors in determining whether the extraction of some of this gravel is viable.

The data provided by the forty-nine boreholes is brought together and summarised in a table attached. Map K locates these holes.

13. The best prospects for exploiting the buried channel gravel resource will lie where geological conditions are most favourable i.e. where overburden is thin, gravel is thick, overburden to gravel ratios are low, and where good concentrations of tonnage that meet these criteria are located.

There is no assurance that this appraisal can identify all of the better prospects for gravel extraction. It can only assess the prospect in areas where borehole records are available.

An analysis of the record of the forty-nine holes focusses attention on four areas where the overburden to gravel ratio is not worse that 2 to 1. These areas are now discussed briefly:-

Area 1 To the west of Joyce Green Hospital three KCC holes on the bypass line suggest that 3 to 4 metres of alluvium lies on 7 to 9

metres of gravel. ARC land holdings to the north of these holes are considered to be workable for gravel. A buried channel may continue northwards under the salt marsh to the mouth of the Darent. There is no strategic planning constraint on these areas.

Area 2 Holes 4 and 5 near the mouth of the Darent show more than 6 metres of gravel with an overburden to gravel ratio of 0.9 - 1.3. Hole 6 has thicken alluvium, but does not confirm the full depth of gravel.

Area 3 In Cliffe Marshes near Lower Hope Point the Holes 16 and 17 indicate 10 metres of gravel under 12 metres of alluvium with a ratio of 1.2. IGS correspondence and The Chatham memoir give similar indications. The area is SLA and HNCV.

Area 4 (Map L) to the north of Grain refinery between Newlands and Perry's Farm. Eleven holes show an overburden to gravel ratio no worse than 2 to 1, and gravel from 3.8m to 7.3m in thickness, under alluvium between 5m and 10m deep. These holes are shown in red on the map. There is no borehole evidence to show whether the buried channel extends to northwards, but it probably does. The ten more southerly holes in yellow all have some thinner gravel, producing a less acceptable ratio of overburden.

The evidence currently available suggests that an area of 65 hectares, which might extend northwards, could yield an average 5.6m of gravel under a mean 8.6m of alluvium to yield 5.6 million tonnes of high quality gravel.

The area is partially within the SLA and HNCV and is partly without constraint. Flood-tide defence issues would be likely to arise with SWA and no attempt is here made to suggest solutions to this question.

The near proximity to an estimated 3.5 million tonnes in the 2nd terrace deposit (see Part A paragraph 3 of this report) indicates a total resource of high quality gravel in excess of 9 million tonnes on the Isle of Grain. It would be technically possible to work the whole of this resource through ground conveyor systems to the existing Clubb plant.

14. A clear conclusion emerges that Buried Channel Gravel Deposits occur in a number of areas in North Kent. This gravel is undoubtedly of high quality. Some deposits offer a much greater depth of gravel than do most terrace deposits, giving a much greater yield per hectare. Substantial deposits with an overburden to gravel ratio not worse than 2 to 1 can be found. Exploitation would involve the introduction of working methods that could excavate and handle between 5 metres and 10 metres of alluvial overburden from below the goundwater level.

Buried Channel Gravel deposits undoubtedly extend more widely under the alluvium of North Kent than is identified by currently available borehole data. At present there are three areas that seem to stand out as the better prospect:-

(a) West of Joyce Green Hospital and northwards to the mouth of the River Darent.

(b) In Cliffe Marshes near to Lower Hope Point.

(c) Between Newlands and Perry's Farm on the Isle of Grain.

15. There is an obvious need for further exploration of these Burial Channel deposits, so that planning issues and the viability of workings could be properly considered.

In 1982 such exploration was unsuccessfully proposed to the DoE as an item for their Minerals Planning Research Programme. A geophysical survey with some supporting boreholes would be the economic approach to this exploration, probably using an electrical resistivity method.

Borehole Recordings of Buried Channel Gravels

Map ref	Grid ref	Source of information	Surface level	Thickness of alluvium	Proven depth of	Overburden to gravel
1	538.756	KCC No. 6	+ 3.7	5.7	above 2.8	below 2.0
2	539.755	KCC 23 & 50	+ 1.6	3.2	9.0	0.4
3	541.755	KCC 31 & 20	+ 1.7	3.7	7.3	0.5
4	543.775	SWA W/1/13	+ 1.5	5.8	6.6	0.9
5	542.778	SWA Z/1/1	+ 1.0	8.5	6.4	1.3
6	544.778	SWA B/1/14	+ 2.6	11.0	above 3.0	below 3.7
7	707.749	IGS No. 5	+ 1.3	14.9	3.7	4.0
8	703.753	IGS No. 9	+ 1.4	13.1	6.7	2.0
9	709.759	BCI No. 5		24.0	4.0	6.0
10	708.765	BCI No. 3		23.1	2.4	9
11	706.767	Chatham Memoir	+ 3.0	11.9	11.3	1.
12	707.768	IGS No. 7	+ 1.2	18.3	5.8	3.2
13	715.768	BCI No. 8	+ 3.6	20.0	5.0	4.0
14	722.770	BCI No. 9	+ 2.1	18.1	6.4	2.8
15	718.785	IGS		13.1	10.5	1.2
16	718.785	SWA 24/1	+ 2.4	12.9	10.4	1.2
17	719.785	IGS No. 12	+ 2.1	11.6	10.4	1.1
18	719.785	Chatham Memoir	+ 2.4	14.6	8.2	1.8
19	723.785	IGS		14.2	26.5	0.5
20	715.788	SWA 4/3	+ 2.5	13.2	above 3.0	below 4.4
21	717.789	SWA 4/2	+ 2.1	13.7	above 2.9	below 4.7
22	720.791	SWA 4/1	+ 1.9	13.6	above 3.0	below 4.5
23	722.792	SWA 3/11	+ 2.0	14.1	above 3.1	below 4.5
24	724.793	SWA 3/10	+ 2.5	12.0	above 3.5	below 3.4
25	726.794	SWA 3/9	+ 2.2	13.0	above 3.0	below 4.3
26	728.794	SWA 3/8	+ 2.4	14.4	above 3.0	below 4.8
27	765.785	Chatham Memoir	+ 2.7	19.8	10.4	1.9
28	846.780	Chatham Memoir	+ 2.7	12.8	3.4	3.7
29	858.755	SWA 11/8	+ 5.0	13.8	1.1	1
30	859.756	SWA 11/1	+ 3.1	7.5	2.4	3.
31	861.756	Segas No. 1	+ 2.0	7.3	0.9	8.1
32	861.757	BGas No. 5	+ 3.0	7.5	2.0	3.8
33	861.758	BGas No. 3	+ 3.2	8.8	1.6	5.5
34	860.760	Segas No. 7	+ 2.0	6.1	2.6	2.3
35	861.761	SWA 11/2A	+ 5.1	9.6	2.8	3.4
36	859.763	BP 30	+ 2.4	9.3	6.3	1.5
37	861.762	SWA 11/9	+ 2.1	8.0	above 5.9	below 1.4
38	862.762	SWA 11/10	+ 2.2	7.0	above 1.9	below 3.7
39	863.762	BP 29	+ 2.5	8.1	7.0	1.2
40	862.764	BP 3	+ 2.6	9.7	5.1	1.9
41	862.765	SWA 11/3	+ 2.2	9.0	5.0	1.8
42	865.765	SWA 11/4	+ 4.7	10.4	above 7.3	below 1.4
43	866.764	BP 28	+ 2.3	8.8	1.8	4.9
44	867.764	SWA 11/6A	+ 2.1	7.5	3.8	2.0
45	868.764	BP 6	+ 2.4	9.0	0.6	15.0
46	866.767	SWA 11/5	+ 2.8	9.6	above 5.9	below 1.6
47	870.765	SWA 11/11	+ 1.9	5.7	3.8	1.5
48	872.763	SWA 11/7	+ 1.5	0.8	1.1	0.7
49	869.761	BP 24	+ 2.1	7.2	3.8	1.9

PART C - WORKING METHODS

The exploitation of buried channel gravels would involve working methods which differ from those which are commonplace in Kent.

It is shown in Part B above that a typical deposit might contain 8 metres of gravel under 10 metres of alluvial overburden. In the areas of such deposits the groundwater level would undoubtedly be near to the surface, so that both overburden and gravel might have to be excavated from under water.

It is possible that an excavation could be dewatered, at least to the base of the overburden, so that overburden could be removed by normal earthmoving methods. This practice would have it's problems, and it is considered on balance that methods not involving dewatering should be devised.

A dragline excavator of reasonable size can satisfactorily dig alluvium from under water to a depth of 10 to 14 metres. Probably the major consideration is how best to handle and store the excavated alluvium with efficiency and economy.

A dragline excavator of reasonable size cannot reach gravel at a depth of 18 metres. It is therefore thought that gravel could best be excavated by floating dredge after removing overburden by dragline excavator.

The dredging of gravel at 18 to 20 metres below water presents no particular problems. It may be unusual in Britain, but in Germany there is a wealth of experience in dredging for sand and gravel at greater depths than are normally found in Britain, and deep dredging to below 20 metres is commonplace.

The depth of below-water overburden is probably the one unusual feature in the Kent deposits.

A floating gravel dredger can be equipped in any one of a number of ways to lift deep gravel, as follows with either:-

(a) centrifugal gravel pump
(b) jet pump
(c) air lift pump
(d) cutting head and suction pump
(e) bucket wheel
(f) bucket ladder
(g) grab bucket

In addition an on-shore mounting of a drag scraper is an option which offers limited flexibility in a variable deposit.

Reports of German experience lean heavily towards a dredge-mounted grab which is adopted in this proposal. A 2.5m^3 grab bucket could raise about 4 tonnes of gravel in each digging cycle, and feed it into a dump hopper, from which it would be carried by floating conveyor to a trunk conveyor on the lakeside. Under-water sand is excavated currently at Greatness quarry near Sevenoaks by this method, which was also used at Bradbourne Vale in days gone by.

A sequence of overburden removal by dragline, and gravel excavation by grab-dredge, is illustrated in a series of diagrams attached. The use of a medium-sized dragline is necessary to give the requisitive reach and depth of dig. The size proposed could excavate 65m^3 per hour, which matches the rate of advance needed for 150,000 tonnes/annum of gravel output. A bulldozer is needed initially to push overburden from the dump point and on to the initial stockpile of overburden. Thereafter a continuing sequence of dredging gravel, followed by the excavation and dumping in the lake of overburden, can take place along a 30 metre wide section of the deposit. A bottom-dump barge is needed to move overburden in this sequence (Stage 5 onwards). Overburden from the initial stockpile can be used progressively to finish filling the lake behind the barge stage.

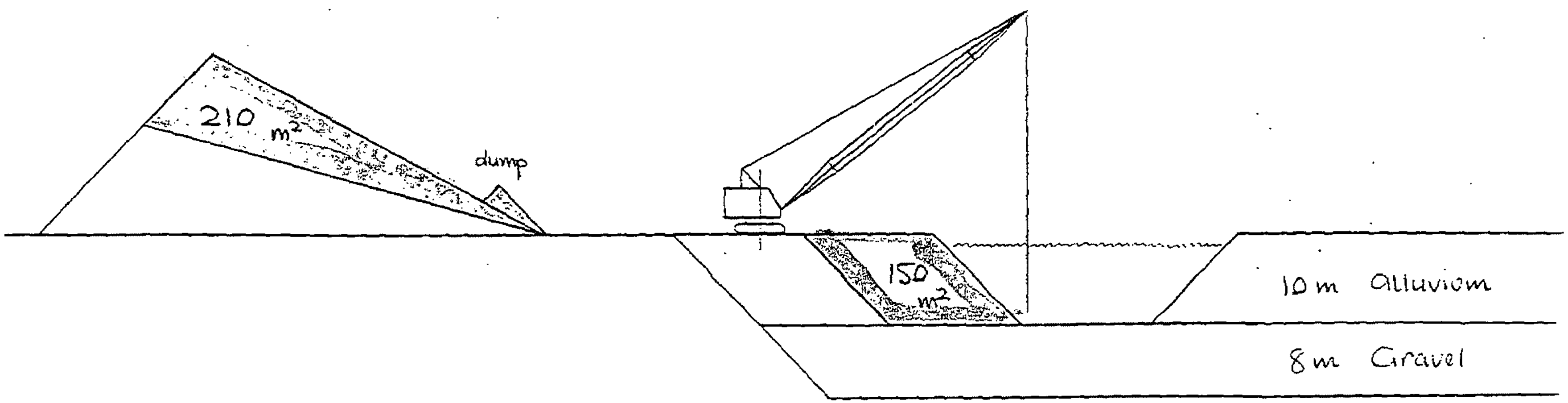
By the methods described the under-water deposits of thick alluvium on buried channel gravel could be worked in an efficient and economic manner, with restoration of the void on a truly progressive basis.

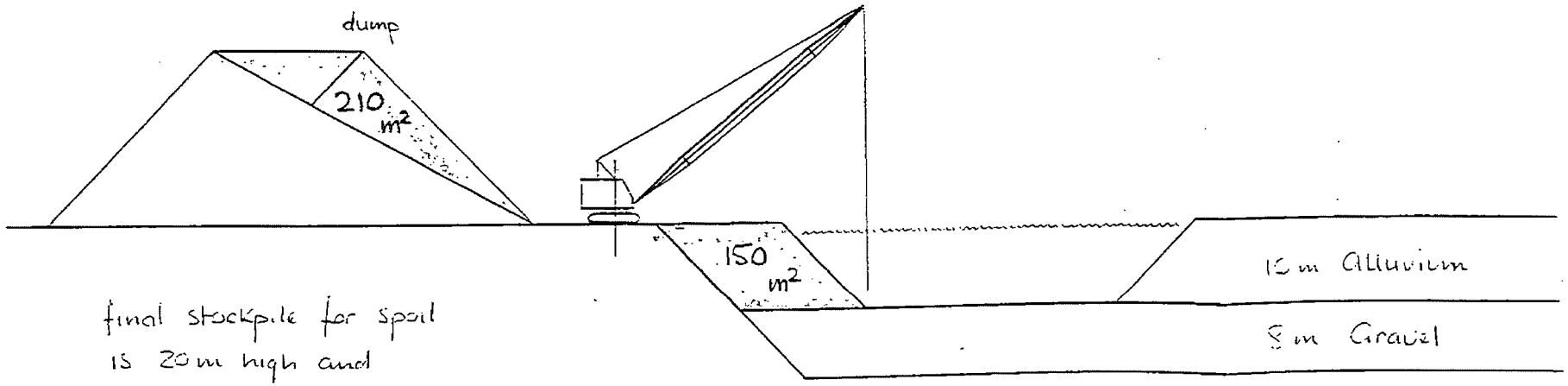
T3GRNK1-17,J8

STAGE 2

pull back dragline & water [illegible] by 15m.

raise stockpile by bulldozer as shown





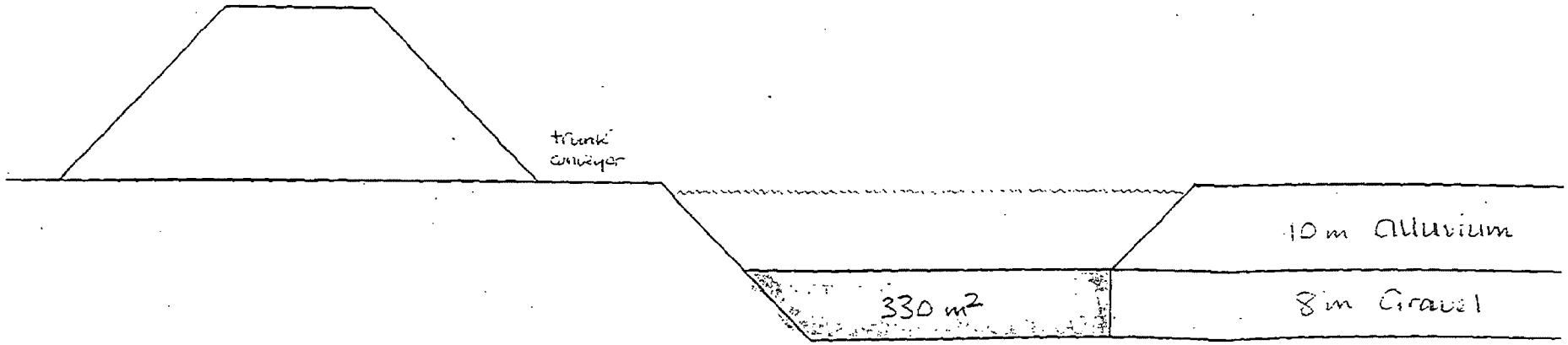
final stockpile for spoil
is 20 m high and
58 m wide at base

SITE 1

Excavate gravel by floating grab.

Floating conveyor will discharge to trunk conveyor and onwards to processing plant.

A 15 m³ grab with conveyors of 150 tph capacity would give an output of 150 000 Tonnes/annum



Gravel yield is 510 tonnes per metre of advance

6 metres advance per week will give 150 000 Tonnes/annum

Move dragline around lake.

Excavate 15m strip of alluvium into backhoe-dump barge

Discharge into lake as shown.

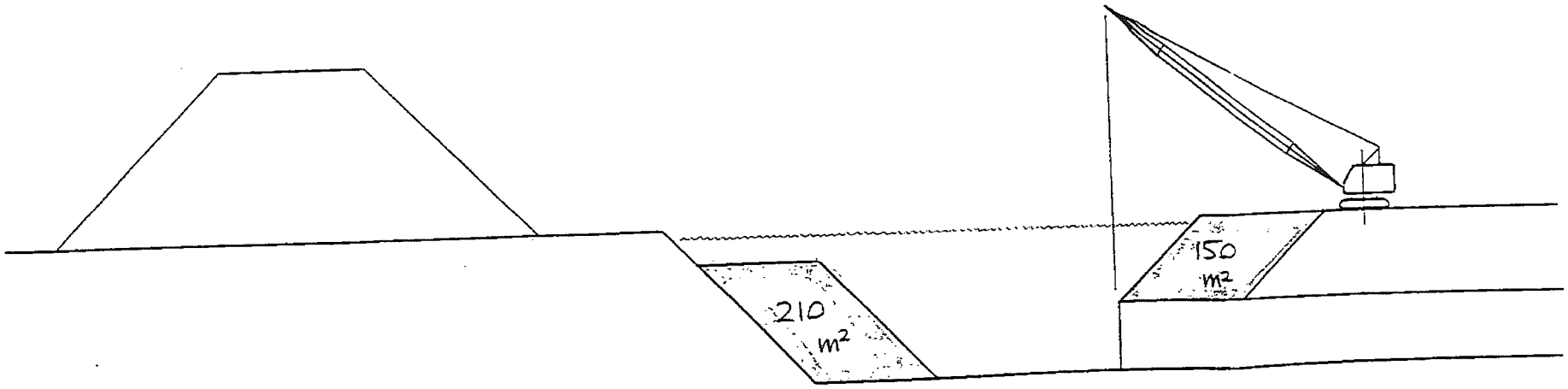


FIG 6

Excavate a second 1 m strip of alluvium

Discharge into lake as shown

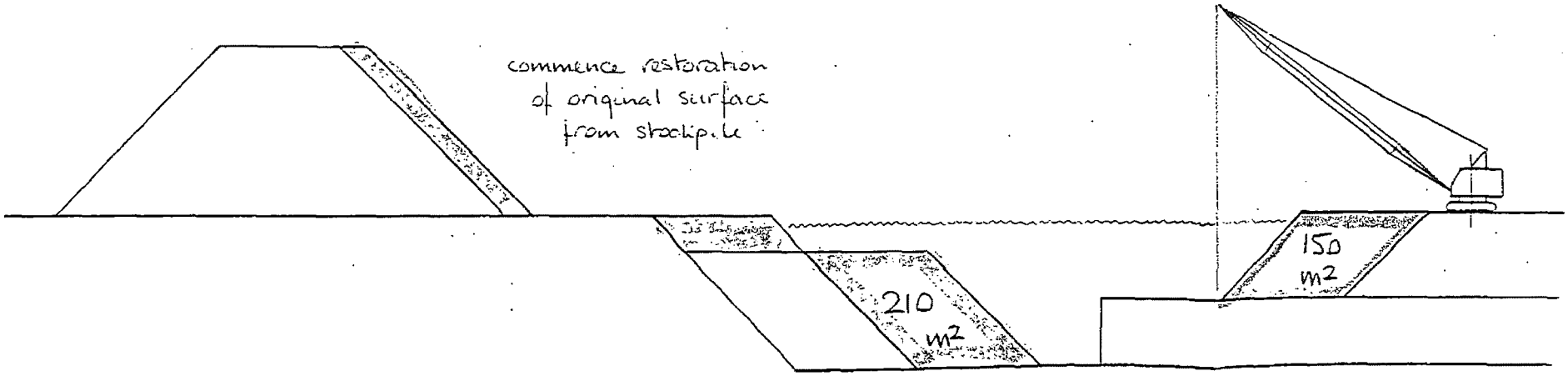
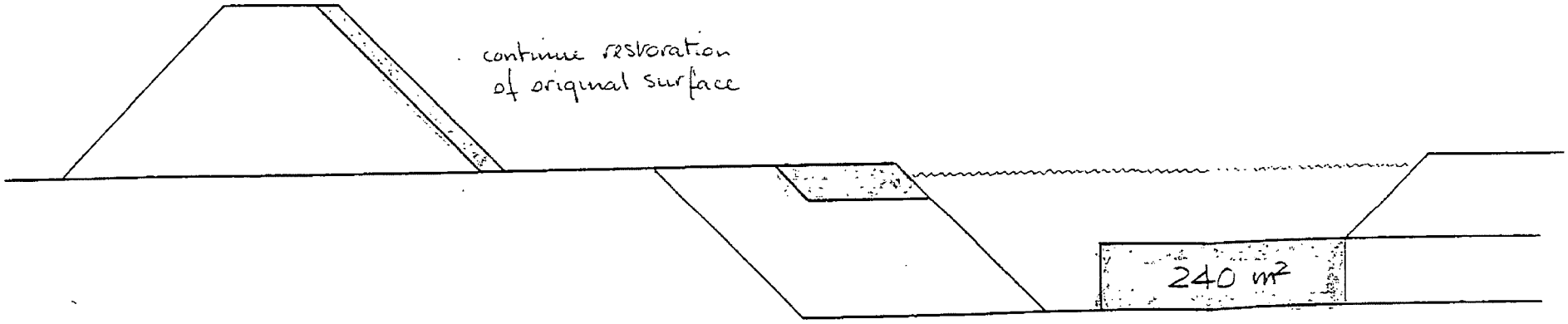


FIG 7

Excavate gravel up to mining limit

Thereafter repeat the sequence from Stage 5 onwards across the deposit



Gravel yield is 370 Tonnes per metre of advance

About 8 metre advance per week will give 150.000 Tonnes/annum.