

CHAPTER 152

ENVIRONMENTAL PROBLEMS ASSOCIATED WITH A PIPELINE LANDFALL IN COASTAL DUNES AT CRUDEN BAY, ABERDEENSHIRE, SCOTLAND.

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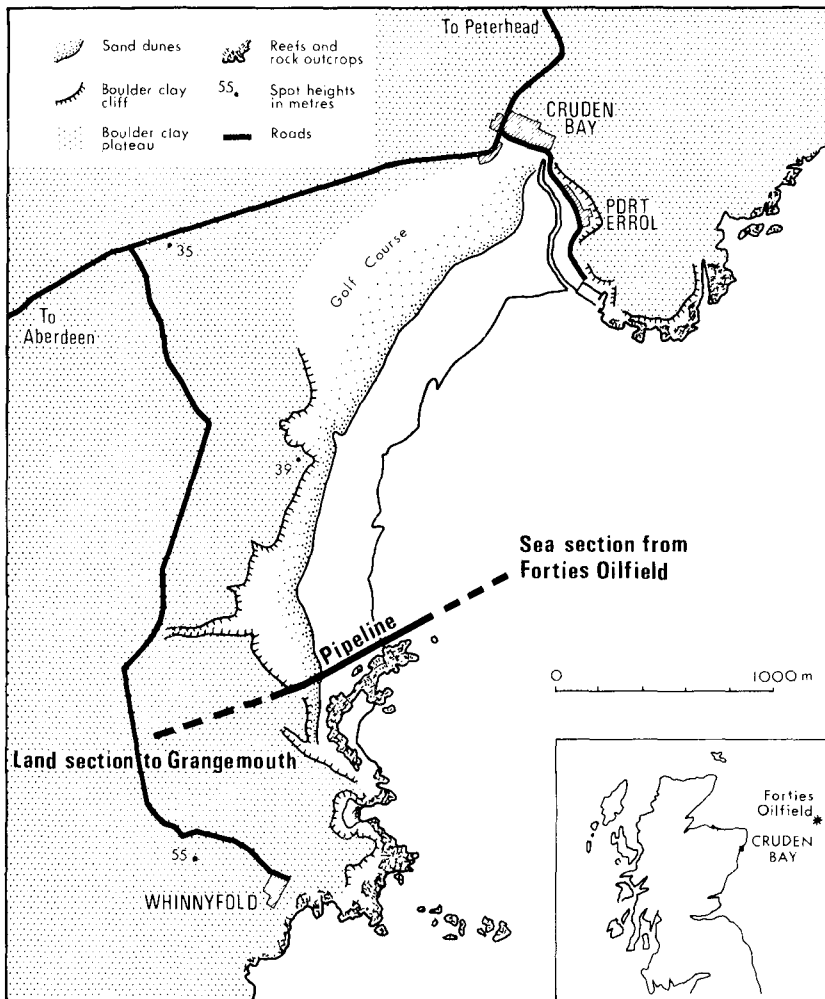
Abstract

The first oil pipeline from the North Sea area reached Scotland in 1973. The landfall, at Cruden Bay, Aberdeenshire, is a sediment-filled, bay-head beach with coastal dunes. Environmental and landscaping problems arose with the trenching of the beach and dune areas. Various methods, including flexible fence construction, spraying with a bitumen compound and spreading of soil over vulnerable areas, protected the site successfully. Full revegetation took place later and the beach and dune area are now restored to their original condition. Environmental management techniques were designed to preserve the high amenity and ecological status of the site and minimise the risk of side-effects, both during and after engineering work.

The General Situation and Problems

Since 1965, at an accelerating rate, several of the deep sedimentary oil and natural gas bearing structures in the Scottish sea area are being explored and exploited. Although the greater number of proven reserves appears to lie near the Shetland Islands, one of the earlier oilfields, the Forties Field, lies 150 km. north-east from the Northeast "shoulder" of Scotland, Aberdeenshire. Although undersea technology is developing rapidly to meet the

problems posed by working in depths of 100 to more than 200 m., the problem of bringing the oil and gas ashore is currently solved by conventional seabed pipelines. The 81 cm. diameter, coated steel pipeline from the Forties Field reached the coast at Cruden Bay in May 1973 and the regional and local site of the landfall is shown in Figure 1. This pipeline is the first to reach Scotland from the North Sea but will be followed within the next few years by several



more. The observations made on the problems of coastal conservation and rehabilitation associated with the pipeline landfall at Cruden Bay may therefore be regarded as occurring in a prototype situation.

The engineering and environmental management issues raised by pipeline landfalls around the Scottish coastline must also be seen against a background of considerable public interest and a growing awareness of environmental issues. The point where the pipeline emerges from the sea to join the land is the location where public and conservational interest tends to be concentrated. Thus, it is not only during the phase of rehabilitation but also during the period of site work that protective measures have to be carefully undertaken.

At the interface of the dune/beach complex and the sea, aeolian, marine and other geomorphic processes interact to produce a relatively sensitive morphological and biological zone. Contemporary pipe-laying techniques require that the pipeline is buried in the nearshore zone, the beach and the dunes. The location must therefore be a sediment-filled, gently shelving offshore area. The re-entrant, sediment trap of a bay-head beach is ideal, whereas the more dynamic, higher energy open coast beach is a more difficult landfall.

The engineering technique employed is essentially a form of trenching. The pipe is pulled onshore from a lay-barge, through the trench by a powerful winch. The sides of the trench in the dune zone are retained by a sheet pile coffer structure. This trench of variable depth (4-10 m.) cuts through the beach, dunes and landwards areas and remains partially open until the pipeline is tested. It is then subsequently backfilled. The exact time of pulling is con-

trolled by wave conditions a few hundred metres offshore where the lay-barge is moored. Around the coastline of northeastern Scotland the wave climate is highly variable and unpredictable, and delays can occur. Again the bay-head situation is preferable since it affords some level of shelter.

The crucial issue of site selection is therefore that of the existence of excavable materials in the immediate coastal area. A sufficient depth of sediment over the rock head profile, both offshore and onshore, is a prerequisite of current techniques. Bay-head sites where these conditions are satisfied are therefore at a premium around the Scottish coast if they are within the economic radius of sea bed pipe-laying from the producing area.

The beach and dune complex, which is the type of coastline that satisfies the physical requirements as outline above, has, until recently, formed an empty zone for human use. Settlement, industry and commerce have tended to prefer other sites. As agricultural land, the dunes and links have a low value. Recreational or leisure pursuits have filled the unoccupied space, as for example, in the form of golf courses. A high proportion of these coastal zones have also achieved considerable ecological, ornithological and conservational status levels. The areas sought by the pipeline constructors are devoid of the more permanent physical artifacts of a modern society but are high on qualitative and intangible resources such as scenic value, recreational potential and scientific interest. Thus, although the technical and physical problems facing the engineer are of a low order, the wider environmental issues aroused may be considerable.

Specific Environmental Problems at Cruden Bay

The landfall at Cruden Bay consisted of a low gradient sand beach, approximately 240 m. wide between low and high water spring tide levels, with a 22 m. wide area of sand between the base of the dune and high water mark (sand nourishment zone). The coastal dune was low and mature, and in a condition of occasional erosion as a result of wave undercutting. It had a gentle dune backslope to a low area in front of a steep abandoned cliff line cut in boulder clay. The profile and planimetry are shown in Figure 2. Of major concern was the proximity of the golf course a few metres north of the site and the high amenity value of the Cruden Bay coastal area.

The specific problems were therefore:-

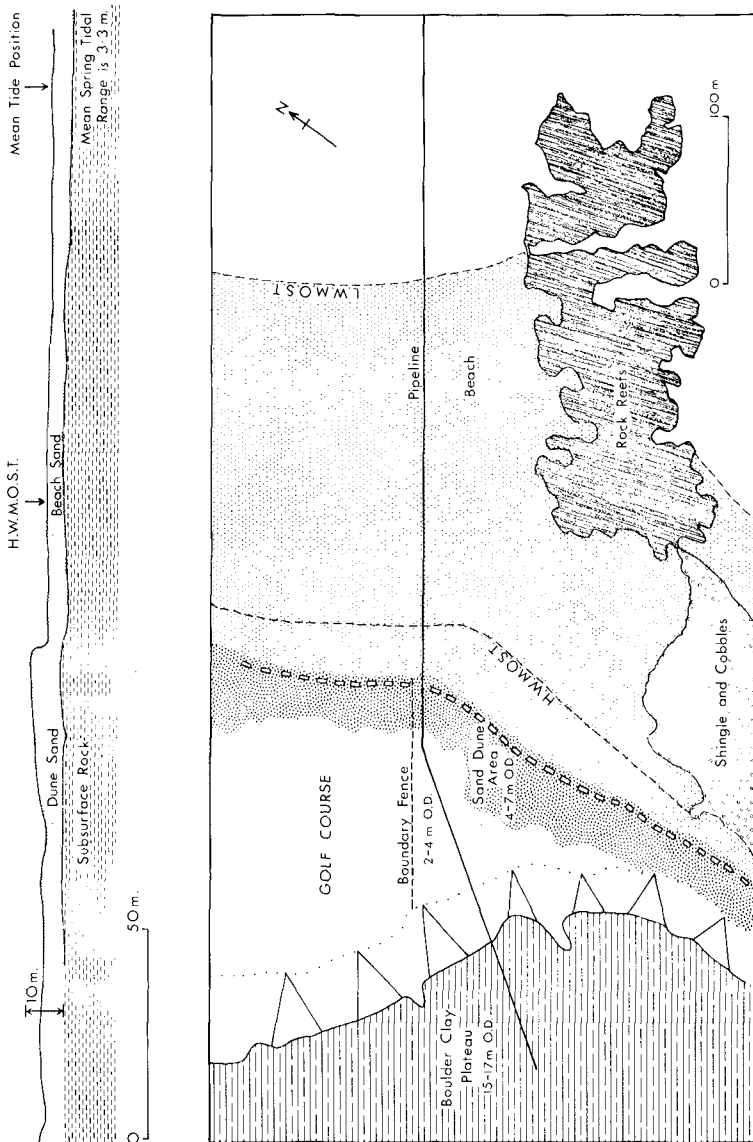
1. Do not introduce geomorphic side-effects such as beach drifting, blowout development, sand deposition on adjacent surfaces or radically alter drainage conditions.
2. Ensure complete and permanent restoration in a short period of time with an appearance and condition as similar as possible to the pre-existing condition and ecological status.
3. Keep the area appearing well-managed throughout the period of site work.

There were therefore two time scales operating; during site work and the longer term planning for site rehabilitation. It was clearly necessary to minimise costs and work by designing day-to-day protection and the temporary movement of spoil materials so that they would be compatible with the final restoration scheme.

Beach Protection

The danger of dune undercutting and the initiation of beach drifting was never a major threat since the site was in a bay-head location and protected by a tombola and reef configuration offshore (Figure 2). The beach trench was only open for a brief period and

coincided with low wave energy conditions. In addition, excess sand from site work was fed into the small bay south of the rock reef below low water mark to artificially nourish the low sand tombola and ultimately feed the beach backshore. Both results were



achieved and the backshore sand has continued to strengthen the formerly eroding dune face by natural accretion.

Coastal Edge and Dune

The coastal edge was slightly undercut. There was little evidence of accretion and mature vegetation reached the edge of the dune. Marram (*Ammophila arenaria*) was present as old mature tussocks with the intervening spaces filled with a varied mosaic of dune and non-dune plants. The dune was not the normal active coastal dune barrier but an old, low gradient, mature feature resembling dune pasture. There was little sign of sand movement and the complete cover of vegetation assured stability. Since a major breach would be cut through this dune to bedrock level (Figure 2) and considerable adjacent areas would be stripped of vegetation, the risk of deflation was considerable. Three devices were used to minimise sand blowing:-

1. All susceptible areas were sprayed with a commercial bitumen compound "Crelawn". This is a water-based, bitumen emulsion and is easily and cheaply spread by a hand sprayer.
2. Larger sand spoil heaps (most of it required for back filling) and bare surfaces were covered by a 5-10 cm. layer of soil. This was the overburden material from the access road. It was not topsoil. The material was clay rich and intended as a temporary cohesive, water retentive cover. Since it contained the seeds of grasses and agricultural weeds, vegetation grew spontaneously, and rapidly hid the visually unattractive appearance of these wasted areas.
3. Brushwood fences were built using standard fence posts and 3-strands of wire with coniferous branches interwoven by hand. The brushwood was obtained locally. Some attempt was made to achieve a 40% porosity; a value suggested by the research literature of tree shelter breaks as being the ideal wind screen. These fences acted as a barrier between the golf course and the site. They were approximately 1 m. high. Other fences were placed along the dune crest and short sections were placed in the dangerous corridors created between the sheet pile walls of the trench and the pre-existing sand surface. The sheet

piles were cut down to their minimum height to reduce their channelling effect on wind flow.



Pipe-pulling through the dune trench in May 1973. Note bitumen spray on trench sides.

These three devices effectively held the entire site area stable from February 1973 until pipe pulling in May 1973 (Plate 1) and the final restoration work which took place in two phases, June 1973 and July 1974. As a result of these devices, there was no wind erosion, no deflation and absolutely no sand deposition on the golf course. Since the bitumen spray as will be described below encourages vegetational growth, the appearance of the site also remained reasonable throughout the period.

Full Rehabilitation

After pipe-pulling the sheet piles were removed and the trench filled with sand to the pre-existing level. The dune face

was restored but set back approximately 0.5 m. and the slope angle reduced to 20° . Other site work such as pipe-testing delayed final restoration and the work was therefore done in two separate stages.

Protective fences were retained for more than one year to inhibit sand movement and protect reseeded areas. In addition to the brushwood fences some fences were constructed of an indestructible, fine screen plastic material. This material was found to be less efficient than brushwood since its porosity was less and offered too much wind resistance, but was easier and quicker to erect. Split chestnut paling is also suitable but was unavailable locally.

All damaged and restored surfaces were revegetated using a seed mixture specified by an agricultural grassland expert to germinate successfully and to be compatible with pre-existing species. Soil which had been used as a protective covering was re-used but additional higher quality topsoil was imported and spread on the surface. The topsoil was seeded and slow release nitrogen fertilizer pellets were added at a calculated rate. The area was then lightly sprayed with bitumen. The bitumen held the surface physically, retained surface moisture (this was particularly important since re-seeding took place in the dry month of June) and by acting as a 'black-body' retained heat and thereby promoted almost incredible vegetational growth. Within weeks the area was carpeted in vegetation. The bitumen will also hold sand slopes stable at an angle greater than the normal angle of rest. Almost one year later, after a single cutting to promote tillering, the area is under lush, mixed grasses and other plants. The bitumen layer has disappeared after first disintegrating into discreet patches and finally granules.

This disintegration is an advantage since many other alternative forms of surface protection are not biodegradable.

During winter gales some sand was trapped on the crest of the new dune face by the brushwood fence. This "edge accumulation"



Dune face showing low-cost thatching in July 1973 and the same area in May 1974 with Marram and Sea Lyme grass coming through the branches and hessian cover.

was hand planted later with Marram grass, and, in time the edge will build-up to a natural configuration. If conditions are suitable Marram and other dune species will gradually take-over from the planted species and there are signs (in late summer 1974) that this is taking place.

All fences, except the one along the coastal edge, were removed in summer 1974 unless they were required to demarcate ownership limits. Hitherto the fences had an important function in restricting public access. The coastal edge fence remains to protect the still fragile crest above the dune face.

The dune face posed a special problem in that it is parti-

cularly difficult to revegetate this edaphically difficult zone.

As shown in Plate 2, low cost thatching was used to physically protect the slope and encourage accretion. This thatching included a cover



A general view of the site area in August 1974.

of hessian to bind-down the tree branches. There has been considerable sand accretion and strandline, and dune species have started to recolonise the dune face. Hand planted Marram and Sea Lyme grass (*Elymus arenaria*) were planted in Spring 1974 to increase the rate of colonisation and the appearance of the dune face in July 1974 is shown in Plate 3. The general appearance of the site can be seen in Plate 4 and compared with Plate 1.

Conclusion

The problem of environmental management of the landfill site at Cruden Bay consisted of maintaining physical stability and assuring the restoration of vegetation. It also had a wider function in ensuring that the sometimes neglected aspect of coastal engineering, the initiation of side-effects was minimised. At Cruden Bay, the chances of this happening were low since the site was particularly well chosen in a sheltered locality, nevertheless an awareness of the linkages in a natural system such as a dune/beach system is an essential part of environmental management associated with engineering work. There was also a public relations function in that the public are increasingly and properly conscious of the need to preserve the aesthetic, scientific and amenity value of any semi-natural area, which is being disturbed by engineering projects.

For similar future projects the following might be considered useful suggestions:-

1. Commission a vegetation survey before work begins. Vegetation is the best single index of environmental conditions.
2. Commission a geomorphological survey of the local site in the context of the wider physiographic system. Note the process/form relationships in the area.
3. Commission a large scale gridded topographical survey of the site. This is an invaluable reference document and avoids ambiguity in carrying out instructions.
4. Protective and restorative devices should emulate local natural conditions, e.g. keep a moist, cohesive surface on all bare sand areas, use flexible, permeable barriers, avoid rigid structures: the essence of beach/dune stability is movement within a framework of dynamic equilibrium principles.
5. Unless there are high value areas near the dunes, it is not necessarily right to be obsessed by preventing some wind erosion and sand blowing. Although this condition

was not satisfied at Cruden Bay, it is normal for coastal dunes to have erosional features such as blowouts. Sporadic wind erosion is the natural state of most dune systems and is essential to their function within a coastal system.

6. Sea Lyme grass is a more effective dune and coastal edge plant than Marram. Its replanting and growth rates are better. It can tolerate some salt water. It spreads rapidly and does not appear to be any less resistant to disease than other 'traditional' dune-fixing species. Sea Lyme grass has been noted as spreading spontaneously and rapidly under natural conditions in many parts of Scotland.

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