

Photographic Analysis of Water Quality Changes

Changes in water quality in the Rambler Channel of Hong Kong were analyzed using aerial photography taken in 1956 and 1975.

INTRODUCTION

POLLUTION OF THE environment is a universal problem which accompanies growth and urban development. In the small but over-crowded city of Hong Kong, the problem is even more acute with the lack of space for expansion as a result of its inherent topographical restrictions. Coastal reclamations have been the solution ever since 1841 when this British Colony was established. On the land acquired from the sea spring up the

scale reclamation project has and is still being undertaken by the Government along the surrounding coastal areas.

METHOD OF ANALYSIS

The use of aerial photographs has been found to be the most efficient way of detecting the sources of water pollution and mapping the outfall patterns in the sea (Strandberg, 1964, 1966; Scherz, Graff and Boyle, 1969; James and Burgess, 1970;

ABSTRACT: Black-and-white aerial photography for 1956 and true-color aerial transparencies for 1975 at 1:10,000 scale are used to study the impact of a changing environment on the water quality of Rambler Channel in Hong Kong. The extensive reclamation in the area undertaken by the Government has significantly transformed the land use of the coastal areas and inevitably has led to man-made pollution of the sea water. The aerial photography has been found to be an efficient tool in detecting sources of pollution and in identifying the types of polluting substances, especially with the aid of the true-color transparencies. All these are shown on two maps prepared directly from the aerial photographs with the aid of a Zoom Transfer Scope.

commercial center, factories, and housing estates. This type of coastal reclamation is usually on a very large scale and has inevitably caused great changes to the natural environment. The most notable effect of these is the pollution of the sea water within the harbor area of Hong Kong. In order to examine more precisely the impact of these environmental changes on the coastal waters, the Rambler Channel area, which is located to the northwest of Kowloon Peninsula just outside the main urban residential belt, is selected for study (Figure 1). This Channel is formed between the Tsing Yi Island in the west and the Kwai Chung district on the mainland in the east. It is ideal for this study because a large-

Welch, 1971). By comparing results of photographic analyses of the same area at two periods of time, the impact of a changing environment on the water quality of the harbor can be evaluated. Fortunately, old aerial photographic coverage of the Rambler Channel area is available. These are "split-vertical" aerial photographs taken by the British Royal Air Force on December 27, 1956 with a reconnaissance camera (focal length = 50.8 cm) at a height of 5090 m, thus giving a nominal scale of 1:10,020. The time of photography is not known but its absence of shadows indicates that it must have been obtained near noon. They are good quality contact paper prints and admirably serve the

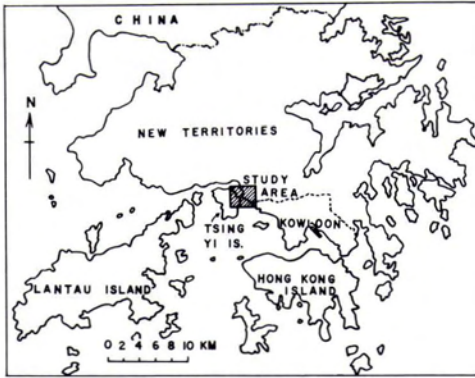


FIG. 1. Location of the study area.

purpose as a standard datum for comparison with later changes. The up-to-date photography of the area was specially taken by the Flying Unit of the Crown Lands and Survey Office, Public Works Department, for the Department of Geography and Geology, University of Hong Kong on January 5, 1975 at 10:25 a.m., using a Wild RC-10 camera (focal length = 152.53 mm) at a height of 1524 m, thus giving a nominal scale of 1:10,000. The film employed is true-color Kodak Ektachrome Type 2448 processed to reversal transparencies for use in the analysis of water

quality. Black-and-white contact prints also are made from these color positives to aid in the analysis. Thus, the two photographic coverages of the area are compatible in time, and a detailed comparison of the environment changes in 19 years' time in the area is feasible. Basically, the procedures involve interpretation of the land use in the area and mapping of the sources of water pollution from aerial photographs with the mirror stereoscopes. A working definition for water pollution employed is that given by Strandberg (1964): "the adding to water of any substance, or the changing of water's physical characteristics in any way which interferes with its use for any legitimate purpose." In addition, the different types of water-polluting substances can be identified more specifically. The Bausch and Lomb Zoom Transfer Scope has been employed to map the land use and outfalls in the sea from the aerial photographs at a common scale of 1:10,000.

CHANGING ENVIRONMENTAL CHARACTERISTICS

The results of the photographic analysis are shown in the two maps, Figure 2 and Figure 3, respectively for 1956 and 1975. The following environmental changes can be noted:

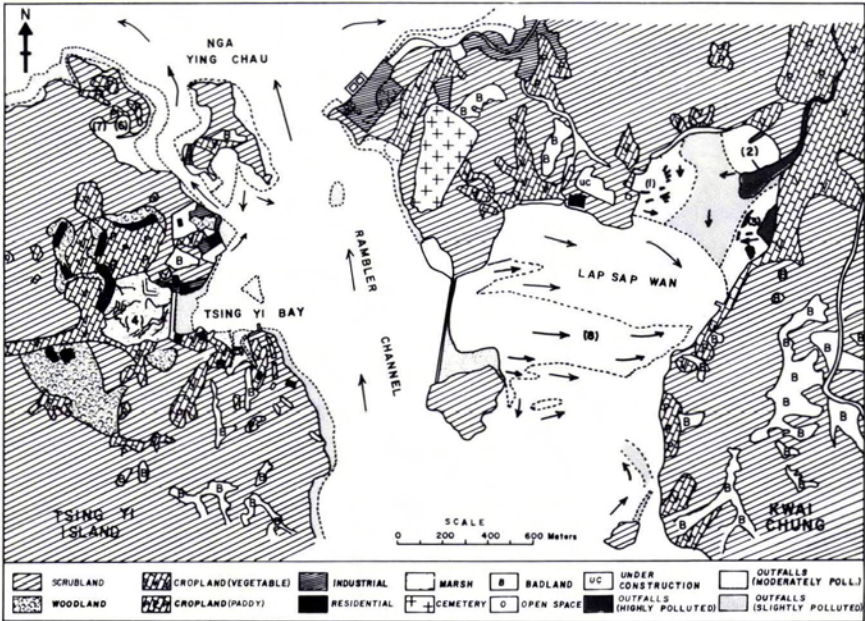


FIG. 2. Land use and water quality in Rambler Channel 1956 as interpreted from the aerial photographs.

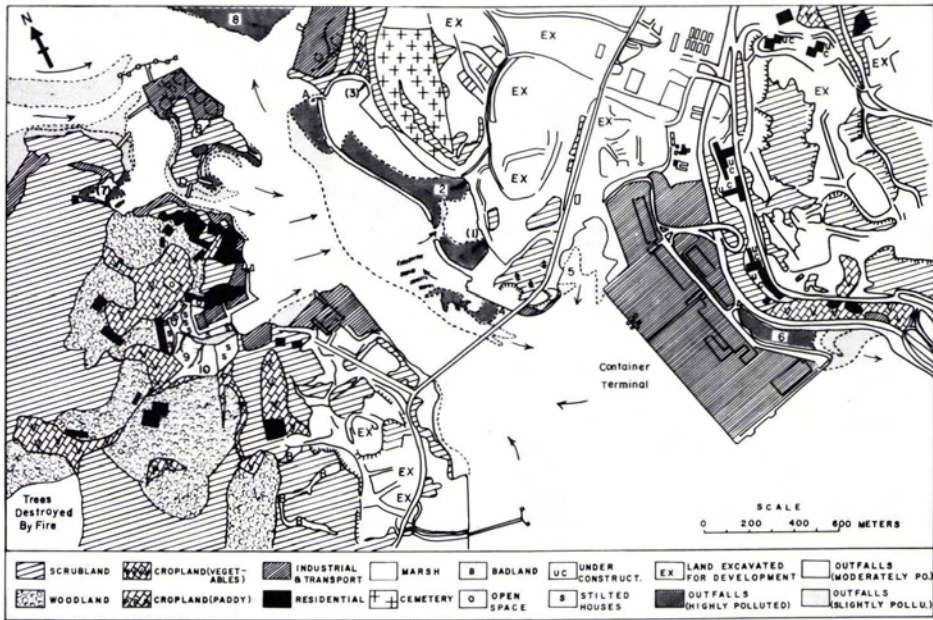


FIG. 3. Land use and water quality in Rambler Channel 1975 as interpreted from the aerial photographs.

RECLAMATION

The most dramatic change which has taken place in this area has been the modifications of the shorelines by reclamation. In 1956, Tsing Yi Island was still relatively free of reclamation. Only some minor strips around the Tsing Yi Bay area have been reclaimed. However, a large-scale reclamation had just started in the Lap Sap Wan (literally, "Garbage Bay") area on Kwai Chung mainland. This is indicated by the extensive plumes of sediment (labelled "A" in Figure 4) moved by currents towards the eastern coast. The name of the bay signifies that waste materials have been dumped as a means of garbage disposal and for reclamation. However, the bays and inlets in this area can still be delineated from the aerial photographs. By 1975, the reclamation has already covered up all these bays and inlets ("B" in Figure 5), while excavation of the hillsides has been carried out in order to provide the materials for filling up the bays ("C" in Figure 5). Similarly, on the shoreline of Tsing Yi Island, the Tsing Yi Bay has been so filled up that a footbridge can be constructed to link up the mouth of the bay, while excavation for the required filling materials has been carried out on the hillslopes adjacent to the new bridge (See also "D" in Figures 6 and 7). The effect of reclamation is to eliminate all indentations along the shorelines. However, in

order to provide adequate shelters for fishing boats and junks in this area, artificial sea walls have been constructed to enclose zones of quiet water along the newly formed coastline: one between Nga Ying Chau and North-east Tsing Yi Island, and one along the Kwai Chung coast on the mainland ("E" and "F" respectively in Figure 7).



FIG. 4. An aerial photograph of Lap Sap Wan area in 1956.



FIG. 5. An aerial photograph of Lap Sap Wan area in 1975.

LAND USE

In 1956 the surrounding coastal areas of Rambler Channel revealed a basically rural economy with the occurrence of crop land along the river valleys and on alluvial patches along river estuaries. Paddy rice, a crop showing a distinctively elongated field pattern and a fallow texture at the time of photography (the season being winter), was important in Tsing Yi Island which was then quite isolated from the mainland market ("G" in Figure 6). Intensive vegetable cultivation, being distinguished by the smaller plot size and dark texture of the leaves, also was practiced to a lesser extent on Tsing Yi Island but more importantly on the Kwai Chung mainland ("H" in Figure 4). Industrial activities were only of a small scale associated with the agricultural economy; the most important was the oil storage depot on an artificially reclaimed strip in Northern Kwai Chung coast. A noteworthy use of land is the cemetery ("J" in Figure 4) which covered only a small hilly area just above the oil storage depot. Another significant aspect was the extensive occurrence of gully erosion forming badland, especially on the hill areas of the Kwai Chung mainland (e.g., "K" in Figure 4).

By 1975 a very different land use picture emerges. Agriculture has declined, espe-

cially on the Kwai Chung mainland area, while on Tsing Yi Island, vegetable cultivation has become more predominant over paddy rice (e.g., "L" in Figure 7). More extensive areas of trees are found on Tsing Yi Island, reflecting an effort to check soil erosion, but on the other hand devastation of



FIG. 6. An aerial photograph of Tsing Yi coast in 1956.

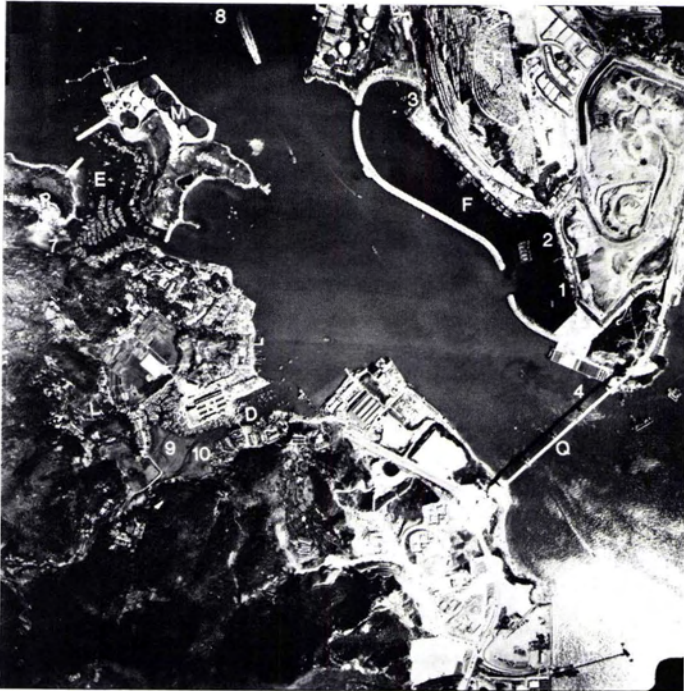


FIG. 7. An aerial photograph of Tsing Yi coast in 1975.

these trees by fires is quite common as shown in Figure 3. Large-scale industrial activities have been established, for example, the addition of a new oil storage depot on the island of Nga Ying Chua ("M" in Figure 7); the emergence of an iron scrap-machine fabrication factory ("N"), a cement factory ("O"); and a dyeing factory ("P"), all along the eastern shoreline of Tsing Yi Island (Figure 7). These have resulted in the growth of the Tsing Yi Town situated on Tsing Yi Bay. The most important development in the area has been the establishment of a modern container terminal complex on the reclaimed land of Kwai Chung coast ("B" in Figure 5). This terminal eventually will assume an important role as the outport of Hong Kong, and will necessitate the development of a new transport system, including the construction of a bridge ("Q" in Figure 7) linking up Tsing Yi Island with the Kwai Chung mainland and multi-level highway connections with the urban areas in the south-east; both are very vividly displayed in the aerial photographs. Finally, as an indication of growth, the cemetery has been greatly expanded since 1956 to include the other half of the hill in the north ("R" in Figure 7).

IMPACTS ON WATER QUALITY

The drastic modification of the shoreline

and the establishment of new types of land use have affected significantly the water quality of the area in several ways.

TURBULENCE AND TURBIDITY

A more narrow channel resulting from reclamation has increased the turbulence of the sea water as revealed by comparing the tone of the sea water registered on the aerial photographs at the two different dates. The strikingly uniform dark tone as exhibited by the water in the 1956 photography (Figures 4 and 6) contrasts with the much lighter and diffused tone of the water in the 1975 photography (black-and-white contact prints from true-color transparencies) (Figures 5 and 7). This indicates a greater degree of turbidity of the sea water in the Channel in 1975. One other factor of increased turbidity may be the greater number of vessels plying this channel in 1975 (as indicated by the presence of shelters and a large number of junks moving and anchoring in the area) than in 1956 (See Figures 6 and 7).

SOURCES AND TYPES OF POLLUTION

From the aerial photographs, the sources of pollution can be detected readily through tonal contrast. In 1956 one can detect eight major sources of pollution as marked on Figure 2. These are invariably located at the

river estuaries. The most seriously affected area is Lap Sap Wan (Garbage Bay) in the Kwai Chung mainland where three plumes of sediments (marked numbers 1, 2 and 3 on Figure 2; also see Figure 4) converge into the bay. The dark-colored and rough-textured plume in Figure 2 is indicative of the washing down of waste materials and garbage from the villages and farm land in the upper course of the stream. Deltas are under construction at 2 and 3 in Figure 4.

The high rate of sedimentation here is associated with soil erosion as indicated by the prevalence of gullies in the vicinity. Along the Tsing Yi Island shoreline, two major sedimentation areas are noted (marked as numbers 4 and 5 on Figure 2), leading to the formation of marshes. The most extensive piece of marshland so formed is at the head of Tsing Yi Bay (marked number 4 on Figure 2). The different stages of sedimentation are clearly revealed with the very fine and darker muddy sediments being deposited nearest the sea. An initial stage of reclamation can be seen with an earth-dam being built across the bay ("D" in Figure 6). The sedimentation on Tsing Yi coast is less severe than that on the Kwai Chung coast as a result of the more luxuriant vegetative cover and hence better soil conservation. The presence of the oil storage depot has not given rise to any signs of water pollution. It is noteworthy that reclamation work at the Lap Sap Wan area has caused plumes of dumped materials (marked as number 8 on Figure 2 and "A" on Figure 4) to be moved by currents across the mouth of the bay. In this way the work of reclamation is speeded up.

The employment of Ektachrome true-color reversal transparencies for 1975 has facilitated the detection of the polluting sources and particularly the identification of the types of polluting substances in the area. In all there are ten major sources of pollution which have been marked with a number on Figure 3 and the appropriate photographs. It is noteworthy that eight of these have been caused by men in the most direct way, while only two may be considered to be the result of sedimentation. The first three sources all occur within the artificially built boat shelter area ("F" in Figure 7) and are caused by discharges of underground sewerage drains. The most serious sewer source is marked 2 on Figure 3 and Figure 7 and gives out a long black plume of water. This sewer drain pollutes the sea water within the shelter area and renders the color of water much darker green than that outside. While the shelter may act temporarily to block out the polluting water

from the open sea, the seepage of the polluted water through an outlet marked A on Figure 3 is evident from the photograph (Figure 7).

The fourth source is iron stain coming out from the new iron pipes being installed as underground drains for the reclaimed land. The fifth source is pollution by the muddy materials used for reclamation on the coast. At number 6 on Figure 3, pollution of the water occurs between the newly established container terminal and the mainland coast. This is likely caused by oil residues left by boats and junks in this more sheltered area (Figure 5). Along the Tsing Yi shoreline, the most seriously polluted spot is the bay at number 7 marked on Figure 3. This bay is dangerously polluted by chemical wastes associated with the nearby dyeing factory. The color transparency reveals light bluish plumes and dark grey sediments (Figure 7) in the bay. Just opposite is the new boat shelter formed between this bay and Nga Ying Chau where a new oil storage depot is found. A great number of boats and junks has been attracted to berth inside the shelter. The situation is worsened by the presence of boat-building shacks along this strip of the coast of Tsing Yi Island (Figure 7). The area between the two oil storage depots has revealed a large patch and dark-toned water (marked as number 8 on Figure 3 and Figure 7) which is moved towards the Channel by the speedboat. This is most likely oil polluted.

Another source of pollution is the extensive marshland of Tsing Yi Bay, noted in the 1956 photographs, which has by now been partly reclaimed (marked as numbers 9 and 10 in Figures 3 and 7) with the establishment of a large machine fabrication factory and some warehouses at the footbridge crossing. These have led to the growth of a stilted-house settlement and boat-anchoring places around the factories. All these have contributed towards the pollution of the sea water, although sedimentation is still an important cause.

WATER MOVEMENTS

By examining the direction of movement of the plumes of discharged sediments, it has been possible to map the movements of water in the Rambler Channel as shown in Figures 2 and 3. It is clear that a south-to-north movement was dominant in 1956, but by 1975 with the construction of boat shelters and reclamation a less regular movement of the sea water is noted. Although the predominant south-to-north movement still can be discerned, there is also a great amount of west-to-east movement between Tsing Yi Island and Kwai Chung mainland. Because the

inner harbor area of Hong Kong is located to the south-east of Rambler Channel, the south-to-north movement is beneficial; the polluted water is diverted away from the more densely built-up inner harbor area. With the evidence interpreted from the aerial photographs, the reclamation appears to have affected the direction of movements of the sea water.

CONCLUSIONS

The aerial photographic analysis undertaken has succeeded in revealing in a most dramatic manner the effects of a changing shoreline on the pollution of the sea water in Rambler Channel. It is clear that the reclamation, with its accompanied urbanization of the rural areas, has brought about land-use changes from extensive cultivation to intensive, market-oriented cultivation and from agricultural to industrial. These changes have brought about pollution especially in the bays and inlets where reclamation takes place and where factories are set up. Land reclamation is obviously important to the economy of Hong Kong, particularly as witnessed by the establishment of the new container terminal. It is perhaps fortunate in this area that the seriously polluted sites are usually in confined locations and are less accessible to the open sea. Immediate measures, however, should be taken by the Government to clear up these seriously polluted sites as pin-pointed by the aerial photographs.

This study has supported the usefulness of aerial photographs in detecting the sources of pollution in the sea water. Color photography in the form of transparencies as employed in this study allows easy detection of discharge points along the shorelines and identification of the nature of the polluting substance. One great advantage of the aerial photography is

emphasized in this study: its ability to freeze a scene of the environment at a specific time and, by comparing scenes at different times, all the changes can be revealed. The availability of simple mapping instruments such as the Zoom Transfer Scope has facilitated the mapping of the sediment plumes in the sea, thus speeding up the exploratory study of water pollution.

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