CHAPTER 1

INTRODUCTION

1.1 Thermal pollution and its practical importance.

The environmental problems created by thermal pollution are of increasing concern to government, industry and the public. In the generation of electricity, the rejection of heat from the steam condenser of the power plant, has reached truly large proportions. Usually this waste heat is discharged directly into natural water bodies such as seas, lakes and rivers. The resulting increase in water temperature may be considered as ' thermal pollution ' effect because the warmer the water, the less it is able to hold dissolved oxygen. Thus thermal pollution may have the detrimental effects on fishes, plants and other organisms. Moreover, the high water temperature reduces the ability of the water to absorb waste products such as industrial and domestic sewage.

The most common system for heat disposal is the ' once through ' method where the cooling water after being withdrawn from the reservoir and heated up by $6 - 15\,^{\circ}C$ inside the condenser, is discharged back into the receiving body as a jet. Although other methods for cooling such as cooling towers have been proposed and are, indeed, in use, the simple system still enjoys much greater application since it is the cheapest to build and operate.

To control thermal pollution caused by the ' once through ' disposal method, the important parameter which must be taken into consideration is the mixing zone. The latter is defined as the surface area in the vicinity of the discharge point in which the water temperature rise above ambient is less than a considered ' safe ' value. It is the purpose of the present project to carry out an investigation in order that the dependence of the outfall configuration on various discharge factors and flow conditions can be established.

1.2 The problem considered.

1.2.1 Statement of the problem.

The particular form of thermal pollution problem studied in this thesis is the thermal discharge from the proposed Ao Phai Nuclear Power Plant owned by the Electricity Generating Authority of Thailand (EGAT). The plant will have a working capacity of 600 Megawatts and a cooling water flow of 35 cubicmetres per second with a discharge temperature rise above ambient of 10 °C. (for details, see Appendix B.)

1.2.2 Location of the Nuclear Power Plant.

The site of the proposed Ao Phai Nuclear Power Plant is located on rocky terrian along the east shore of the Gulf of Thailand approximately 5 kilometres south of the village of Sriracha and approximately 85 kilometres southeast of Bangkok, Thailand. (Fig. 1.1). The plant will be constructed on the shore facing the Gulf of Ao Phai and surrounded by three mountains of heights ranging from 100 to 150 metres. The shape of the coast is almost straight heading to the north and the south. The terrain may be considered as flat; for example, at a distance of 100 metres from the coast-line, the corresponding change in the height of the terrain is only 3 metres.

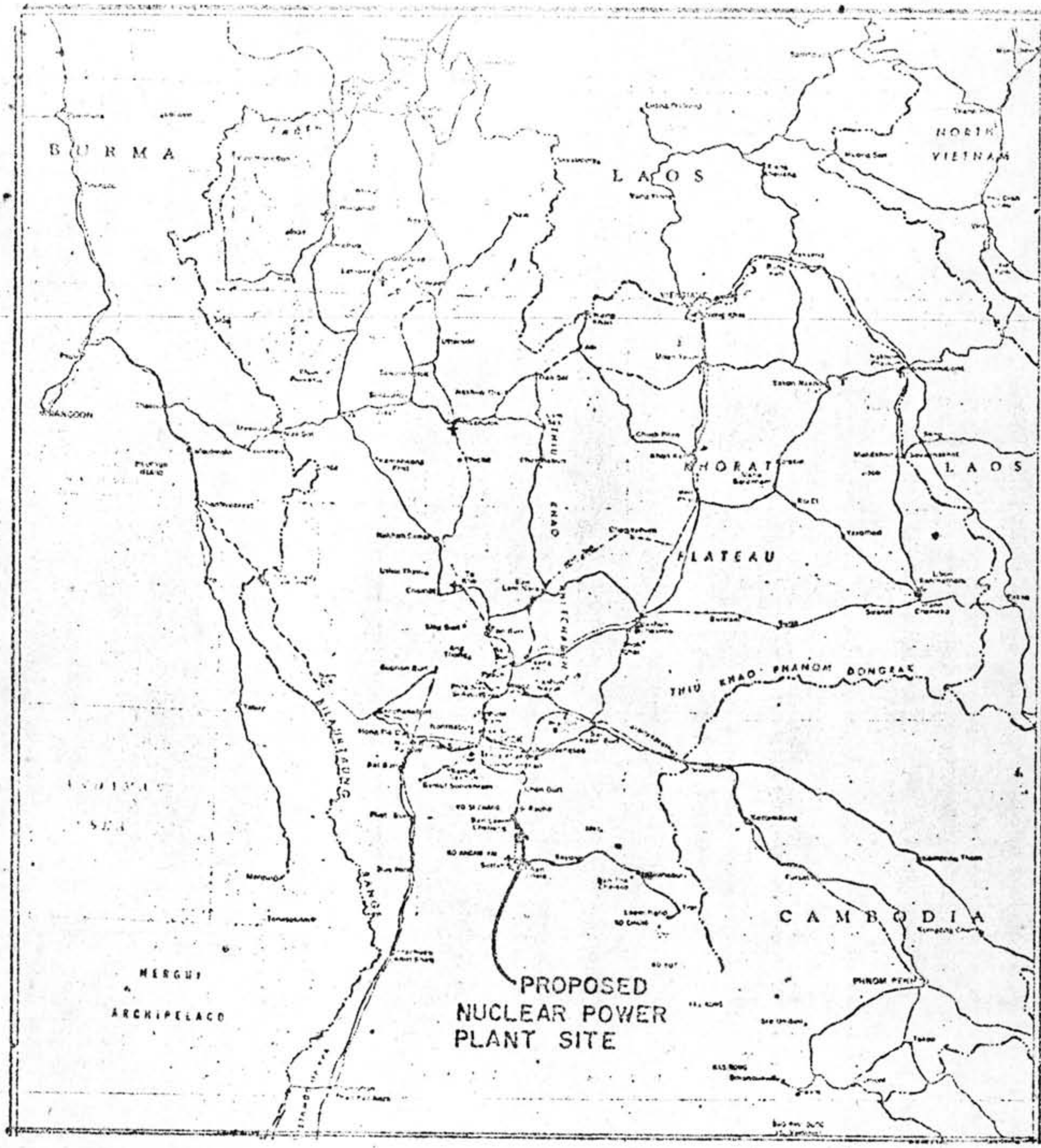

FIG 1.1 LOCATION OF THE PROPOSED NUCLEAR POWER PLANT

Major water movement in the Gulf of Thailand appears to be weakly clockwise from May to September and strongly counterclockwise from November to March (4). April and October are transition months. This movement is in response to tidal action, winds, Coriolis force, and local physiography. Winds during November to January are from the northeast, but during the period from May to September, they are from the southwest. October and February to April are also transition periods. The Coriolis force causes counterclockwise circulation, and the tides are responsible for north-south water movement. Thus the strong net counterclockwise circulation in the Gulf in November to March results from the northeast winds and the Coriolis force reinforcing the tidal action. The weak net clockwise circulation in May to September indicates the balancing of tidal action and the Coriolis force by wind effects.

Currents at the margins of the Gulf refect these overall circulation patterns as shown in Fig. 1.2. Generally the water movement at the Ao Phai site may be assumed to be northeast-southwest.

1.2.3 Layout of the discharged outlet.

A selection of the point of discharge of cooling water is of most important, as, if not well selected, the discharged water would flow back into the inlet of the system resulting in the decrease in the efficiency of the condenser. Therefore, in order to prevent such undesirable outcome, a number of discharge systems have been tried. In the present work the on-shore intake and off-shore deep discharge have been chosen because:

1. Recirculation of cooling water does not occur if the intake and the discharge are placed far from each other.

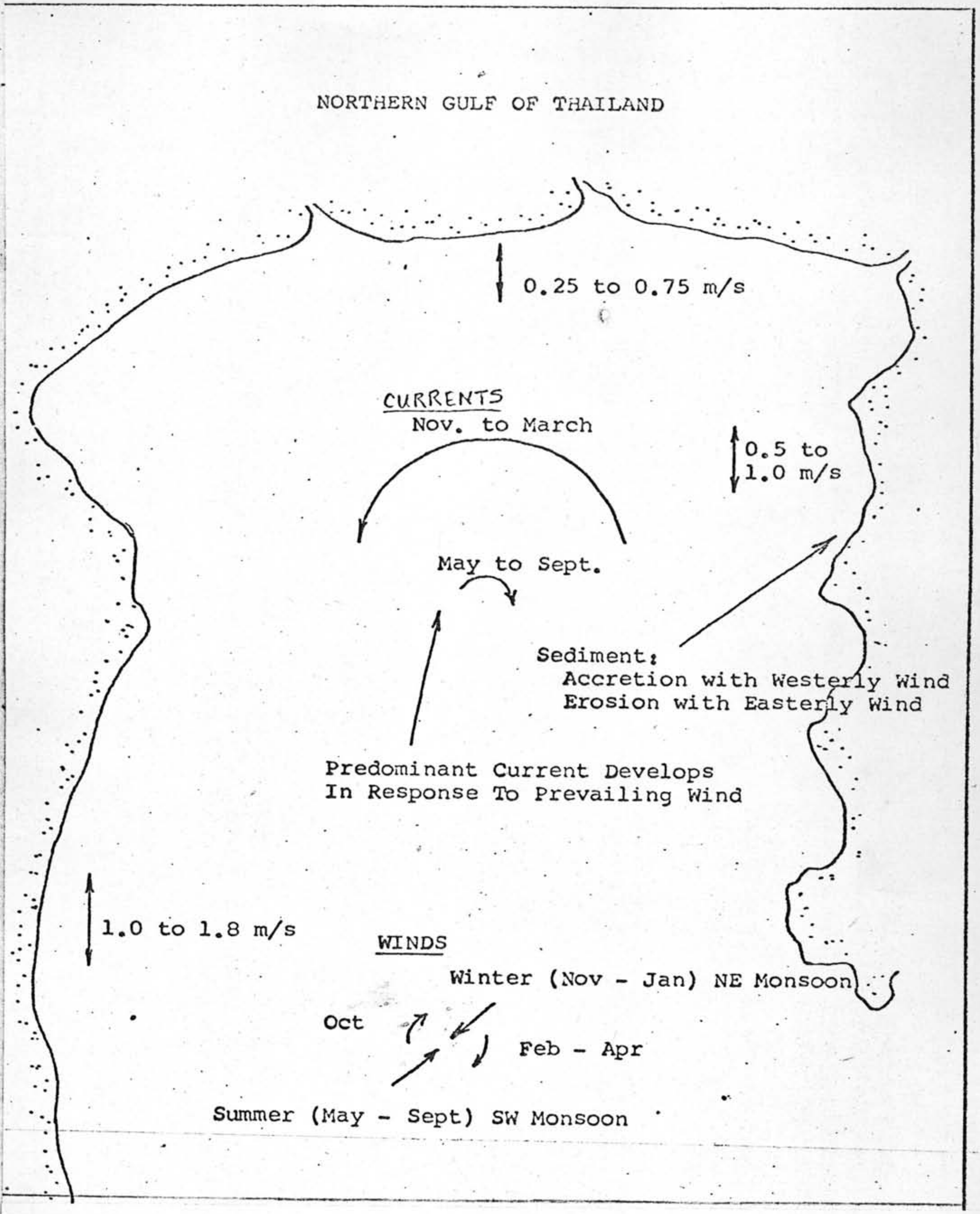

FIG 1.2 CURRENT IN THE GULF OF THAILAND

2. The closer the intake is to the coast, the less energy is required in pumping the cooling water.

The point of discharge can be single or multiple-port. A multi-port discharge dilutes the heated water more quickly and results in a smaller area of high temperature water. But the thermal patterns at a distance from the discharge are not greatly influenced by the mode of discharge. Certainly, the cost of multi-port would be higher than that of the single port. In this thesis, only the single port case will be considered.

1.2.4 Other details.

Other factors affecting the heat disposal may be assumed to be of the following nature:

1. An ambient current at the point of discharge is in the form of steady uniform parallel flow (or one dimensional flow).

2. Hot water is discharged from the outlet without encountering any obstacle.

3. The pipe carrying the cooling water is placed along the bed of the sea in order to achieve good mixing between the pollutant and the ambient water. The efficiency of the mixing process depends on the bouyancy effect; the deeper the point of discharge is, the greater the efficiency will be.

In the present work, the selected location of the outlet (represented by point A. in Fig. 1.3.) lies in directions N 1452630, E 704800 at 1350 metres from the coast. The depth of the sea at the selected point is approximately 8 metres. The corresponding average current velocity there was estimated to be 1 m/sec (4), but that recorded by EGAT in the

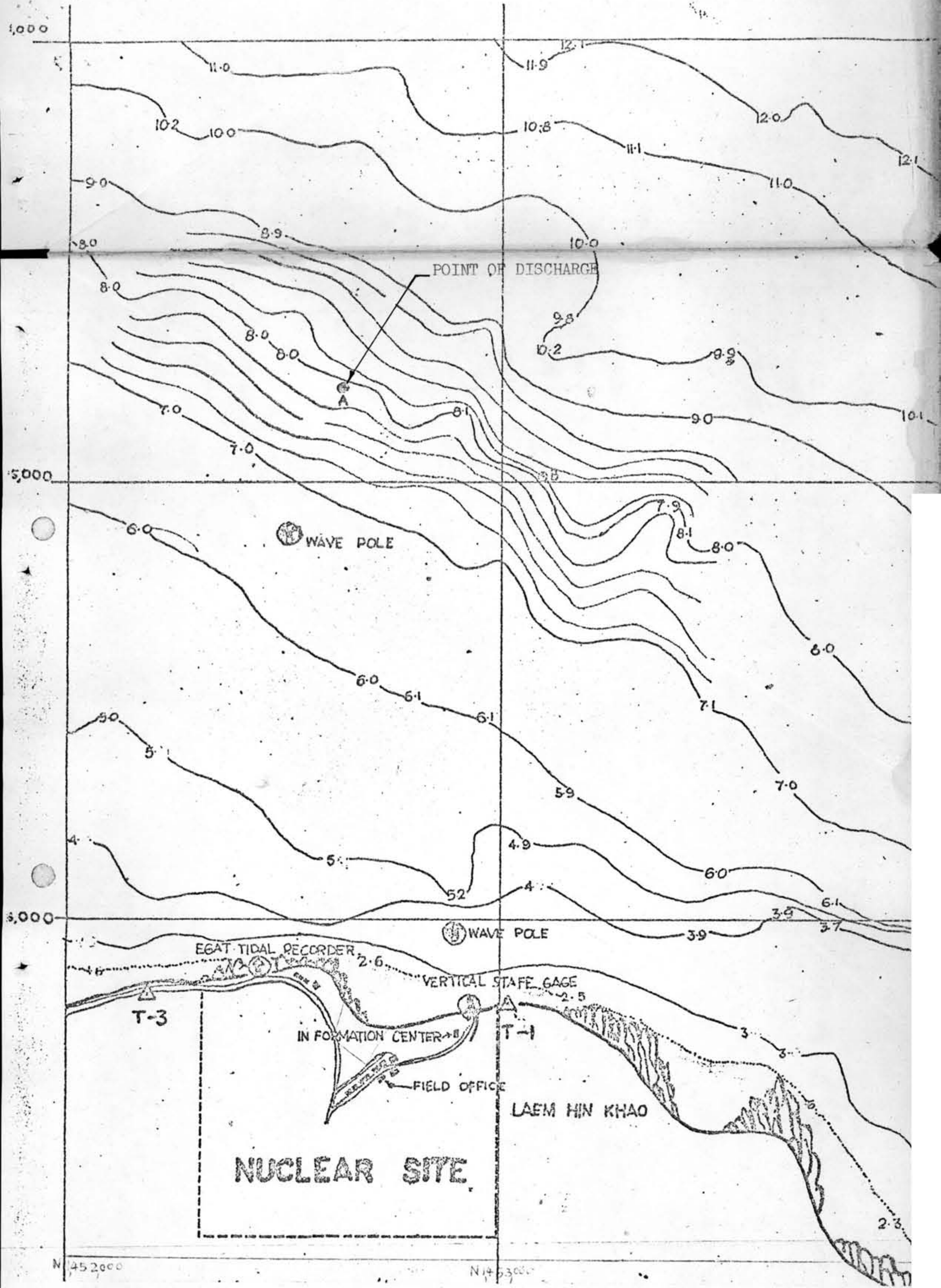

FIG 1.3 LOCATION OF THE OUTLET (POINT A)

year 1976 was 0.312 m/sec. Table 1.1 is the sample of data indicating current speed, sea level at various time in March 1976. The recorded level in the Table 1.1 is the level above Zero guage datum. Mean Sea Level is at 2.30 m. above Zero guage datum.

1.3 Previous work.

When heated water is discharged from the end of a pipe or from one of many ports of a diffuser, it is immediately subjected to a bouyant force proportional to the difference in density between the hot water and the heavier surrounding sea water. While the bouyant force drives the hot water towards the water surface, the turbulent mixing between the jet and the surrounding sea water results in the establishment of a field of diluted hot water near the point of discharge.

Discharge characteristics are categorized as surface bouyant, surface non-bouyant and submerged-bouyant discharges. Receiving water body characteristics are classified as stratified and non-stratified, and also according to the presence or the absence of the current. A classification of mixing conditions based on recent representative studies is given in Table 1.2. The case investigated in the present project is the ' submerged-bouyant discharge into the flowing ambient fluid '.

1.4 Objectives of the present work.

The main objectives of the present thesis may be listed as follows:

1. To design and construct a test basin in such a way that it simulates the point of discharge at the Ao Phai Nuclear Power Plant. This

TABLE 1.1

TIDE DATA AT THE PLUME OUTLET (POINT.A)

Date	time	Stage (m)	Depth (m)	Velocity (m/sec)	Direction
21/3/19	10.00	2.48	8.18	0.307	S 40 W
21/3/19	12.00	1.40	7.10	0.238	S 37 W
21/3/19	14.00	0.95	6.65	0.095	S
21/3/19	16.00	1.20	6.90	0.312	N 80 E
21/3/19	18.00	2.12	7.82	0.338	N 87 E
21/3/19	20.00	3.00	8.70	0.165	N 73 E
21/3/19	22.00	3.26	8.96	0.049	S 63 E
22/3/19	7.00	3.20	8.90	0.022	S 20 W

Note. 1. Sea bed is at 8.00 m. below Mean Sea Level.

2. Mean Sea Level is at 2.30 m. above Zero guage datum.

TABLE 1.2

Classification of mixing conditions

and representative studies.

RECEIVING WATER BODY CHARACTERISTICS		DISCHARGE CHARACTERISTICS. surface. Bouyant	surface. Nonbouyant	submerged. (Bouyant)
Nonstratified	No current	Jen et al. (1966) Tamai et al. (1969)	Yevdjevich (1966)	Albertson et al. (1948) Abraham (1965) Fan and Brooks (1966)
Nonstratified	Current		Carter (1969)	Fan (1967)
Stratified	No current	Harleman and StolZenbach (1967) Rigter (1970)		Hart (1961) Fan (1967)
Stratified	Current	Wada (1967)		

part of the work represents a joint effort between the author and his partner, Mr. Manatpong Chom-Ut.

2. To carry out an experimental investigation to obtain the temperature distribution in the area surrounding the round jet which issues the heated cooling water vertically upwards into the ambient water: and to use the obtained experimental data to determine the mixing zone. Included in the investigation is the study of the effects on the mixing process of the following two parameters, namely, the size of the port and the current velocity.

3. To deduce relations between the mixing zone, the port size and the current velocity.

1.5 Outline of the thesis.

The thesis consists of six chapters of which this is the first. Chapter 2 outlines the method of hydrothermal modelling and the scaling criteria employed to simulate the effluent plume shape of the heat dispersion process. Chapter 3 gives the method of dimensional analysis to find what parameters affect the thermal distribution. This chapter also gives the simple calculation to predict the thermal field at the water-air interphase near the point of discharge. Chapter 4 gives details of the model and the experimental equipments. The results and discussions are described in Chapter 5 . Finally, conclusions of the investigation are given in Chapter 6 . Other details relevant to the investigation are presented in the appendices.