(7) The land, etc. provided for temporary use by the Republic of Maldives shall be returned after restoration work and in the same initial conditions as when it was provided.

(8) Parts of the temporary access channel excavated for construction in the first priority construction zone within the reclamation limit line shall be refilled to the initial ground level after completion of the installation work of concrete armour units. Sufficient care shall be paid so as not to cause any trouble with regard to the construction of shore protection facilities in the future.

(9) The temporary jetty for the handling imported materials and equipment for the Project and the loading of concrete armour units shall be dismantled upon completion of the work.

5-4-2 Execution Method of Construction

(1) Conditions in the Maldives associated with execution of construction work

The major conditions in the Maldives associated with the execution of the construction works for the Project are the following:

1) Almost all the construction materials and equipment are imported from overseas.

2) Although foremen and skilled workers are available in the Maldives, they are mainly experienced in medium and small-scale building construction. As far as can be judged from an inspection of construction sites on Male' Island, skilled workers in the Maldives are considered to have a certain level of skills. In many cases, however, it seems to be difficult for such skilled workers to meet

all the requirements of overseas contractors when work has to be performed under their instructions because of their different customs, etc. On the other hand, it will be quantitatively easy to obtain labour from Sri Lanka, as a result of the decline in the demand for labour in the Middle East after the "Oil Glut". In the light of the fact that most of the workers returning from the Middle East are ordinary workers and that there are few foremen and skilled workers experienced in marine works, however, the securing of the required number of skilled workers is not expected. Moreover, it will be difficult to employ skilled Sri Lankan operators of construction machinery because of the limited quantity of construction machiery owned by private companies in Sri Lanka.

The work of the Project is roughly classified into on-land and marine work, and a large quantity of heavy units will be handled both on land and on sea. Such work is dangerous and requires special skills and experience. The special workers shall therefore be Singaporeans, while Sri Lankan workers shall be assigned to work under the Singaporean special workers. Maldivians will be employed mainly for miscellaneous operations.

3) The loading and unloading facilities in Male' Harbour comprise 25t cranes and 4t fork lifts.

(2) Construction method

1) Place of fabrication of concrete armour units

Although Sri Lanka and Singapore can be considered as the places for concrete armour unit fabrication in addition to the Project site, such concrete armour units shall be fabricated at the Project site for the following reasons:

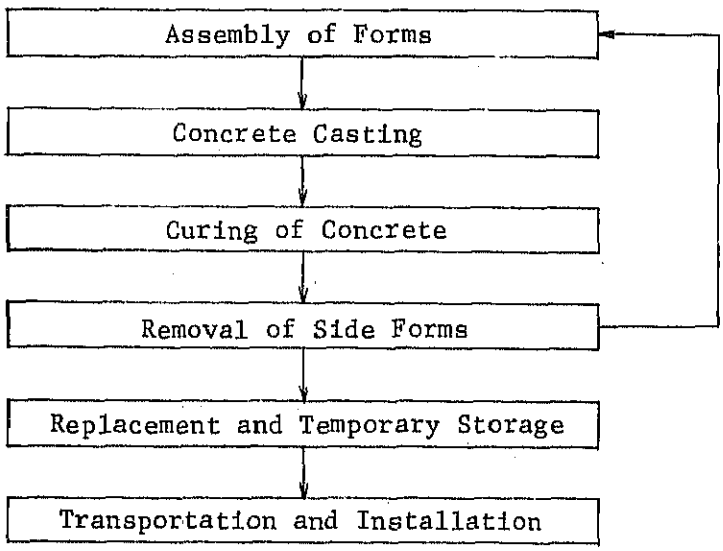
a) Should concrete armour units be fabricated in Sri Lanka or Singapore, transfer of technical knowledge and knowhow to Maldivian engineers and workers will not be attained. Moreover, the economic benefit to the Maldives cannot be attained sufficiently.

b) When fabricated armour units are shipped, the shipping volume of the products will become larger than that of raw materials, and the shipping cost shall be higher than in the case of fabrication at the Project site.

c) Although large-scale cargo handling facilities will be required for the unloading of these products, such facilities are not available at Male' Harbour.

d) Considering the fact that regular cargo liner services are limited between these countries, a wide product stockyard will become necessary in Sri Lanka or Singapore in addition to the stockyard at the Project site.

2) Execution flow diagram



3) Installation method

Subsequent to sufficient curing on yard, concrete armour units shall be transported by trailer truck to the temporary jetty and loaded onto a barge by using a crane.

The barge on which concrete armour units are loaded will be towed by a tugboat to the installation site, and each concrete armour unit shall be installed one after another with a floating crane.

By dividing the construction sites into first priority construction zone and other zones, the concrete armour unit installation work shall be carried out according to the following procedures:

a) First priority construction zone (Zone I)

i) A temporary access channel of a water depth of approximately 2m and a width of approximately 25m shall be excavated on the landward side of the concrete armour unit installation site.

ii) The installation work shall be performed by arranging the floating crane and the barge along this channel.

iii) The installation work shall be performed successively while reducing the effect of waves by means of the installed concrete armour units.

b) Other zones (Zones II and III)

i) Since a channel of a water depth of approximately 4m to 5m and a width of approximately 30m is

already available on the landward side of the proposed detached breakwaters installation sites in these zones, there is no need to newly excavate any channel.

ii) Installation of the concrete armour units shall be performed according to the same procedures as those in the first priority construction zone.

5-4-3 Construction Supervision Plan

For the purpose of properly and safely executing the detached breakwater construction work within the specified period, appropriate supervision of the overall construction work is required.

Supervision will be carried out with emphasis chiefly on the following items:

(1) Schedule Control

The construction schedule will be supervised using the PERT.

With regard to the fabrication and installation of concrete armour units, the output will be regularly monitored and supervised by constantly comparing the plan and results of the fabrication and installation.

In regard to the equipment and materials to be procured from third countries, the contractor will be instructed to place orders only after confirming the production ability of the supplier.

(2) Quality Control

Quality control will be executed chiefly with respect to the fabrication of concrete armour units. Quality control of concrete and its materials as well as the finished dimensions of concrete armour units will be carried out based on the provisions of the technical specifications.

(3) Safety Control

The contractor will be instructed to ensure that all workers take all safety precautions and that foremen should have the ability to predict possible dangers so as to avert accidents.

5-4-4 Procurement of equipment and Materials

Procurement conditions of the equipment and materials in the Maldives, Sri Lanka and Singapore are as described below:

(1) Maldives

1) Materials

The construction materials available in the Maldives consist of only coral sand and stone. All other materials rely on the imports, mainly from Singapore, Sri Lanka, India and other countries.

a) Coral Stone

Since there are no companies specializing in quarrying, coral stones are taken by individual coral stone takers, mainly Maldivian divers, from the submerged

reefs authorized by the Government and sold over to buyers. Therefore, the weight of the stones is limited to about 10kg to 20kg. Such coral stone is mainly used as a material for simple seawalls and building walls in the Maldives.

Although coral rocks weighing about 300 to 500kg which can be used for detached breakwater core are scattered over the submerged reefs near Male' Island, such coral rocks cannot be used for a large scale work such as the Project, because of the following reasons:

i) Since the natural environment constitutes an important resource in the Maldives, quarrying of coral rock shall not be performed prior to confirming that such quarrying will not cause any adverse effect on the environment after executing assessment of the environment. However, such assessment will require a substantially long period of time and large cost for investigations and study.

ii) The use of mechanical force is necessary to quarry a large number of coral stones in a short period of time. In view of the necessity of procuring the mechanical equipment for large scale quarrying from overseas, however, this is not practicable in view of the construction schedule and cost.

b) Coral Sand

There are no companies specializing in supplying coral sand. Coral sand quarrying is conducted on a small-scale by individuals. Since quarrying large amounts

of coral sand will cause similar problems as those mentioned in Item a) and the salt contents and other foreign matter contained in the sand will cause adverse effects upon the durability of concrete, it is not recommended to apply such coral sand for large scale concrete work.

2) Construction machines and equipment

The construction machines and equipment owned by leading construction companies in the country are small in type and quantity. In addition, most of them have deteriorated and are susceptible to give rise to trouble when operated.

(2) Sri Lanka

1) Materials

The materials required under the Project are generally available from Sri Lanka. However, the Port of Colombo is narrow and its cargo handling facilities are inadequate compared to the total amount of handled cargoes. Since cargo handling service is undertaken by a public corporation, it often takes such time for loading and transportation and this would cause fluctuations in the procurement period.

a) Cement

Although there are two companies owning cement production plants in Kaneksanthurai, Trincomalee, etc. in the northern part of the country, these plants are hardly being operated at present due to the domestic situation. Authority says that it will be possible to restart operation in January 1988, but it does not follow that the supply of cement is therefore

guaranteed. When the cement plants are put into full-scale production, production capacity will surpass domestic demand. The ordinary portland cement conforming to British Standards BS12/1987 is scheduled to be produced. In the case cement is procured right after the restart of production, there will be a problem in the securing of the quality and quantity of the product.

b) Aggregate

Although there are comparatively many aggregate suppliers, most of them are small in scale. Fine aggregate comprised of river sand is quarried in small quantities and there is a problem in the supply capacity. Sufficient preparation is therefore essential to arrange for the means of transportation, etc., in order to procure a large amount of fine aggregate over a short period. In the case of coarse aggregate, raw materials available from high quality quarry sites are crushed at crushing plants to produce coarse aggregate. Although there is a problem in the supply capacity as in the case of fine aggregate, it is considered possible to procure a sufficient quantity of coarse aggregate, provided the order is placed separately to several suppliers.

c) Timber

Timber produced in Sri Lanka is monopolized by the State Timber Corporation with priority being given to domestic supply. Under the present situations, when domestic supply does not meet the demand, private timber enterprises import most of the necessary timber from other countries (Malaysia, etc.) and sell the

timber products after processing. An export license is necessary for exporting domestic timber products.

2) Construction machines and equipment

The majority of large-scale construction machines and equipment are owned by the government agencies and public corporation, while a small number of them are owned by private construction companies. Many construction companies are not in a position to lease construction machines, and since the number of marine construction machines is particularly limited, it will be substantially difficult to procure such machines and equipment from Sri Lanka.

(3) Singapore

All construction materials and equipment required under the Project can be procured from Singapore. Because of sufficiently replenished distribution networks, it will be possible to obtain construction materials and equipment in compliance with the procurement schedule.

The construction materials and equipment that can be procured from Singapore are as follows:

1) Cement
2) Aggregate (fine and coarse aggregates)
3) Timber
4) Construction machines and equipment (on-land and marine machines and equipment)
5) Steel for temporary facilities

(4) In consideration of the above situation, and as a result of comparing the quality, production and supply capacity, reliability in the delivery period and prices, the construction materials and equipment used under the Project shall be procured from the following countries:

1) Procurement at Male'

Main fuels
Oils and greases

2) Procurement from Sri Lanka

Coarse aggregate
Fine aggregate

3) Procurement from Singapore

Cement
Timber for temporary facilities
Barges, ships and machinery
Steel for temporary structures

4) Procurement from Japan

Steel forms for concrete armour units
Simple type seawater desalination equipment (water for construction work)

The above-mentioned materials and equipment will be procured from Japan for the following reasons:

As a result of investigations at Male', it was found that there is no enterprises capable of leasing a large quantity of steel forms for concrete armour units in a short period in any Southeast Asian country. Therefore, such materials will be procured from Japan.

As for the simple type seawater desalination equipment, although such equipment seems to be available in Singapore, it is deemed difficult to obtain a sufficient quantity of this equipment since the available number is limited. This equipment will therefore also be procured from Japan.

(5) Transportation

Transportation of cargoes to the Maldives is carried out either by sea or airline route, though most of it is effected by sea. The harbour facilities at Male' are too small to allow the mooring of large-scale cargo carriers. All cargoes are therefore unloaded off the northern coast at present.

Should the shipping of materials and equipment be done from Japan, it will be necessary to transfer cargoes to small-scale cargo carriers in Singapore or Colombo.

In addition, the regular service of cargo liners between Colombo - Male' and Singapore - Male' is infrequent as once or twice a month.

As for the air cargo, daily air freight services by several airline companies are available from Singapore, Bangkok and Colombo. However, the shipment of materials and equipment by air is not considered under the Project.

5-4-5 Implementation Schedule

(1) Detailed design and construction supervision

1) Detailed design and tendering

a) Preparation of detailed design and tender documents

The detailed design and preparation for tender documents will be executed on the basis of the basic design study, detailed design study, confirmation thereof and upon discussion with the Maldivian authorities.

Upon conclusion of the Exchanges of Notes for each phase, the Japanese consulting firm will forthwith conclude a Consultant Contract with the Government of Maldives and thereupon commence the detailed design work.

b) Tendering and conclusion of contract

After the announcement for the tender and acceptance of the request for participation in tender, the holding of the explanatory meeting for the tender and issuance of tender documents, a fixed interval shall be provided for preparation of the tender. The tenders submitted shall be promptly evaluated and conclusion of the Construction Contract between the Government of Maldives and the successful Japanese construction firm shall be expedited.

2) Construction supervision

With the conclusion of the contract between the Government of Maldives and the Japanese contractor, who shall be a Japanese juridical person, this Project shall enter the stage of construction supervision.

The Consultant shall guide and supervise the Contractor regarding preliminary meetings and arrangements prior to commencement of the works, transport of material and equipment to the site, execution of construction work, and also carry out the management of progress, quality control and cost management in order to complete the work within the period stipulated in the Exchange of Notes.

(2) Construction period

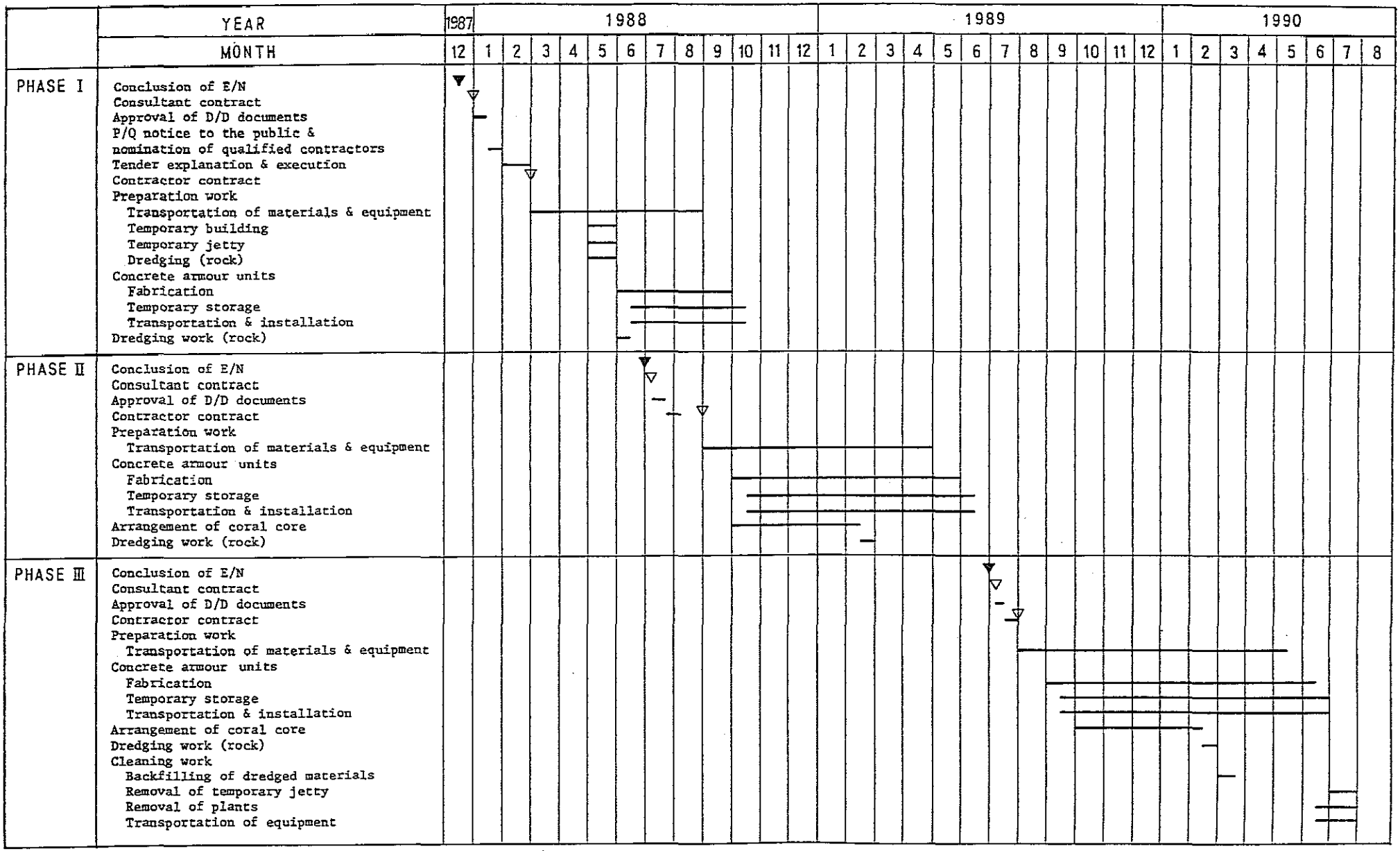
The construction works under the Project are divided into the following three phases, Phases I, II and III, and the construction period for each phase, subsequent to the conclusion of the Exchange of Notes, shall be as follows:

Phase I :	10.0	months
Phase II :	11.5	months
Phase III:	13.0	months
Total	34.5	months

The execution design period of the respective phases shall be of one (1) month.

The implementation schedule of the Project is as shown in Table 5-4.

Table 5-4 Implementation schedule.



5-4-6 Estimated Costs for the Project

(1) The cost of the works to be undertaken by the Maldives is calculated based on the following conditions. The works are executed under the direct control of the DPWL by DPWL staff and using DPWL construction machinery.

- o Date of estimation : Sepember, 1987
- o Execution method : Under the direct control of the DPWL
- o Depreciation of construction machinery : Nil
- o Personnel expense : Nil
- o Equipment and materials procured in the Maldives : Estimated unit price in the Maldives based on the unit price in singapore
- o Expense of land expropriation : Nil
- o Foreign exchange rate : US$1.00 = ¥147.44 = MRF 9.55 = S$2.11

(2) The major works to be undertaken by the Government of Maldives are as follows.

- o Provision of accessible roads to the Project site both from the main road and from the temporary office.
- o Provision of electricity, telephone and other incidental facilities to the temporary office.

TOTAL MRF 36,000

CHAPTER 6

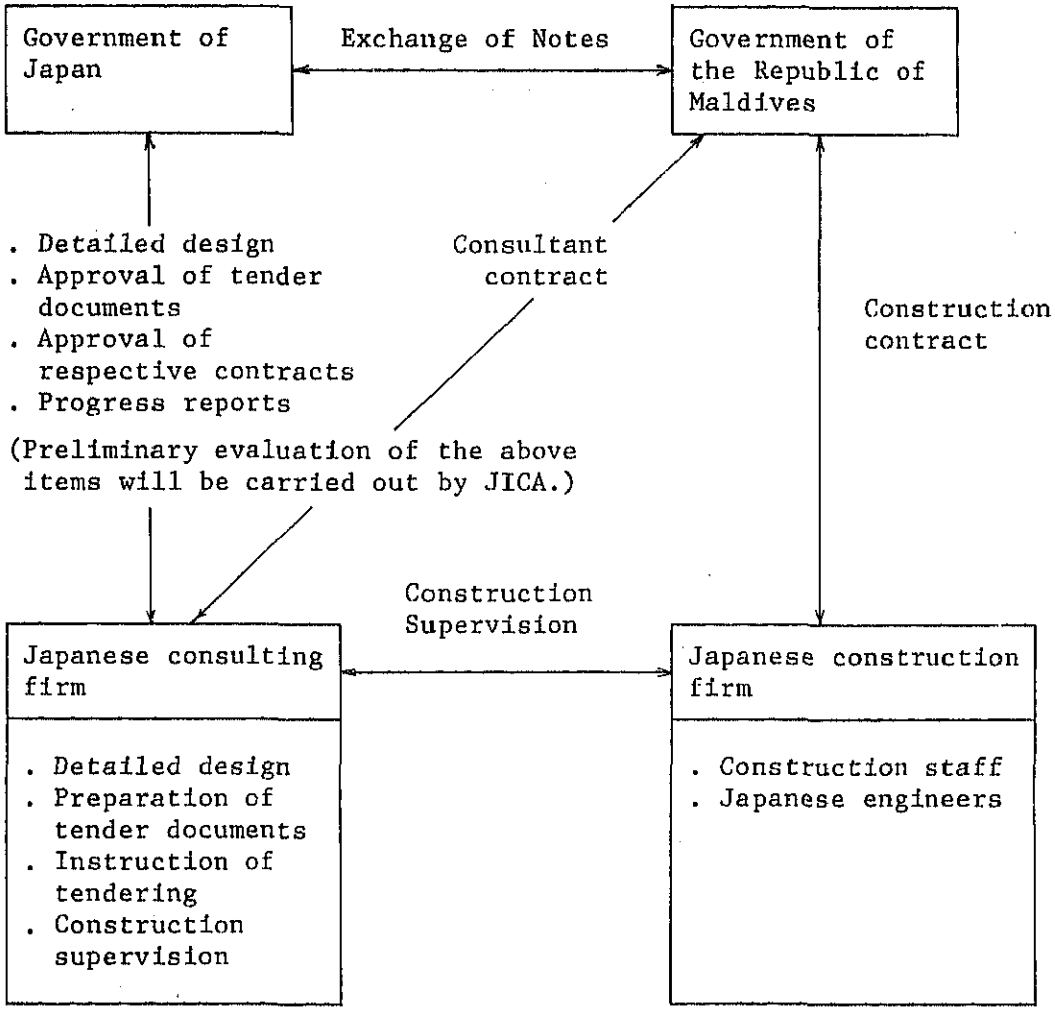
PROJECT IMPLEMENTATION

CHAPTER 6 PROJECT IMPLEMENTATION

6-1 Organization for Implementation

(1) Overall relationship

The overall relationship among the implementing organizations for the Project on the basis of Japanese grant aid is as illustrated below:



(2) Executing agency

The executing agency of the Project for the Government of Maldives shall be the DPWL. The DPWL shall appoint a representative responsible for the Project to ensure close communication and coordination through discussions with the Japanese Consultant and the Japanese construction firm and promote all works to be carried out smoothly under the Project.

The Japanese consulting firm shall be responsible for the detailed design and the supervision of construction. The Japanese construction firm shall be the contractor of the construction works and shall execute same.

6-2 Scope of Work

(A) Scope of Works to be Undertaken by the Maldives

(1) To secure land for the breakwaters and other related facilities.

(2) To provide temporary land for the construction of a construction liaison office (hereinafter referred to as "the office"), warehouse, stock yard, etc. during the construction period.

(3) To provide accessible roads to the Project site both from the main road and from the office.

(4) To provide facilities for the distribution of electricity, telephone lines and other incidental facilities to the office.

(5) To ensure the speedy unloading, tax exemption, customs clearance at ports of disembarkation in the Maldives of the products purchased under the Grant.

(6) To bear the following commissions to a Japanese foreign exchange bank for the banking services based upon the Banking Arrangement.

a) Advising commission of authorization to pay

b) Payment commission

(7) To accord Japanese Nationals whose services may be required in connection with the supply of the products and the services under the verified contract as may be necessary for their entry into Maldives and stay therein for the performance of their work.

(8) To maintain the breakwaters properly constructed under the Grant.

(B) Scope of Works to be Undertaken by the Government of Japan

(1) To construct the detached breakwaters between a section of 1.52km on the northern coast of Male'.

(2) To procure equipment, materials and the labour force required for the construction of the detached breakwaters.

6-3 Maintenance and Management Plan

(1) Present organization for maintenance and management

As described in Paragraph 2-1-2, the DPWL is responsible for shore protection services and undertaking the maintenance and management of the existing shore protection facilities.

(2) New organization

Since the foundation bed for the detached breakwaters to be constructed under the Project consists of comparatively rigid coral limestone and is less susceptible to scouring, undermining, settlement, etc. at the foot of the slope, there shall be almost little need to perform maintenance and management tasks.

Because the ground level of the Maldives is low inherently to coral reef area, attacks of high tides and high waves are inevitable. Therefore, the maintenance and management organization should, by all means, be systematized with emphasis on the countermeasures against high tide and waves.

The new maintenance and management organization should preferably have such functions as to make it possible to precisely and promptly execute overall management and thereby contribute to the enhancement of the safety and living standards of the population.

For this purpose, the organization is required to be systematized to meet the following requirements:

1) The role and responsibility of the personnel shall be clarified, and an organization responsible for the accomplishment of assignments shall be established.

2) The organization shall be capable of taking immediate measures not only with regard to management but also in times of emergency.

3) The organization shall adopt a working system and an education and training programme that will improve the technical level of the maintenance staff.

4) The organization shall have a planning and public relation function capable of promoting high tide and high wave countermeasures useful for improving the safety and living environment of the people.

5) The organization shall be capable of feeding back the information and data collected during the maintenance and management stage to the planning stage and of collecting and analysing such data so as to reflect them in the future shore protection project.

The assignments of maintenance and management section established taking into account the above-mentioned requirements are shown in Table 6-1 below:

Table 6-1 Assignments of maintenance and management.

Sectors	Assignments
Construction	Planning and design
	Execution of construction work
General administration	Materials and accounting
	Planning and public relations
	General administration (Education and training)

CHAPTER 7

PROJECT EVALUATION

CHAPTER 7 PROJECT EVALUATION

Male', as the capital of the Maldives, is the political and economic centre of the country. The provision of adequate urban facilities in Male' is required to secure the effective administrative functions of the Maldives. Among others, the provision of shore protection facilities is given top priority as these will substantially contribute to the preservation of urban functions, the protection of human lives and livelihoods, and the development of the capital city.

Only deteriorated seawalls and a detached breakwater made of coral rocks exist on the southern coast, and together with the increase in population and the social and economic development in Male', the expansion of the reclaimed area and the prevention of recurring high tide disasters are urgently required. In view of the insufficient rehabilitation of the existing shore protection facilities, the area is facing an extremely dangerous situation, particularly in regard to the onslaught of high tides and waves. Bearing in mind the strong request from the Government of Maldives for immediate economic and technical assistance for the construction of shore protection facilities, the Project is hereby evaluated in regard to its effects and suitability.

7-1 Effects

(1) Degree of Urgency

As already described, the current shore protection facilities on Male' are causing an extremely dangerous situation.

These existing facilities consist of only deteriorated seawalls with a length of 100m and a height of 1m to 1.5m from the foundation bed, made of coral stones with cement mortar, and single detached breakwaters with a length of about 600m and a height of 2m to 3m from the foundation bed which are

piled up with coral rocks. There are no other seawalls or detached breakwaters in any other location of the southern coast.

Therefore, the eastern edge of the southern coast in front of the proposed primary school and power station sites have been deeply eroded for a width of about 250m owing to the unusual high tides in April, 1987. There is only about 25m to 30m of land between the existing houses and the shoreline on the southern coast. Although a small embankment with a height of about 1m has been provided as an emergency measure along the shoreline, the overall shore protection facilities are insufficient for disaster prevention. This dangerous situation will be accelerated further by the promotion of urban development in the reclamation area in the future.

In order to preserve the urban functions as well as the inhabitants' safety, the construction of breakwaters in this area constitutes an urgent task. The prompt implementation of the Project will, therefore, have a significant effect.

(2) Socio-Economic Benefits

The construction of detached breakwaters and the protection of the reclaimed land under the Project will help to resolve the present situation, whereby the shortage of land constitutes a serious problem along with the population increase and the development of industry. As a result, the fundamentals important for the improvement of the living standards and the promotion of production and exports, which constitute the top priority strategy in the three-year national development plan, will be established.

(3) Benefits for Inhabitants

Implementation of the Project is expected to ensure the protection of inhabitants from high tidal wave disasters and to contribute to increased employment opportunities and the improvement of daily life together with the promotion of the national development plan.

(4) Contribution to Shore Protection Technology

The shore protection facilities in Male', excluding part of those in the harbour area of the northern coast, are considerably deteriorated due to severe wave attacks. Moreover, no rehabilitation, maintenance or management is being carried out at present. This can be attributed to the inadequate accumulation of knowhow for shore protection.

Implementation of the Project is expected to greatly contribute to the transfer of technical knowledge and knowhow to the Maldives and to the promotion of the construction and the progress of shore protection maintenance and management techniques of facilities, not only in the southern coast area but also throughout the country.

7-2 Suitability

(1) Technical Aspect

Judging from the results of the inspections and discussions with the authorities concerned and the constructors of the Maldives with regard to construction works during the field investigation, no problems exist with respect to the design and execution techniques for the undertakings by the Maldivian side under the Project, such as the provision of accessible roads to the temporary site office and a temporary material

storage yard, etc.. However, sufficient attention should be paid to the completion period of such undertakings, so as not to affect the smooth progress of the breakwater construction work.

(2) Financial Aspects

Annual expenditures will be required for the following work to maintain the shore protection facilities.

1) Patrols during and after stormy weather.

2) Rearrangement in the event that concrete armour units are scattered due to unusual high tides or waves.

Therefore, the implementation of the Project will not impose a major financial burden to the Government of Maldives.

(3) Maintenance and Management Aspects

As mentioned in Chapter 6, the technical level of the maintenance and management staff is inadequate. Therefore, the utmost efforts will be directed to attaining the transfer of technical knowledge and knowhow to the Maldivian engineers for the smooth execution of maintenance and management without any problems after the completion of the Project.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8-1 Conclusion

In general, the existing shore protection facilities on the southern coast of Male' have not been properly maintained, further aggravating the extent of erosion of the reclaimed land, the flooding of houses and other damages together with the population increase and the development of urban facilities.

It is believed that the construction of the proposed detached breakwaters in this area will help considerably to prevent the spread of such disasters.

The study for the Project has been conducted mainly for improving the effectiveness of the facilities, safety, ease and cost of construction work, taking into account coordination with the existing shore protection facilities, navigation routes, new harbour construction project and other requirements.

Implementation of the Project will greatly contribute to the preservation of urban functions, the protection of inhabitants' lives and livelihoods, and the development of the southern coast area of Male' in accordance with the objectives of the Maldivian Government's Three-Year National Development Plan, i.e. the improvement of the inhabitants' standard of living and the attainment of greater self-reliance for future growth.

Accordingly, the implementation of the Project with Japan's grant aid is quite meaningful and highly justifiable.

8-2 Recommendations

The Project basically intends the construction of new shore protection facilities with the utilization of those already existing.

When the present situation of Male' is taken into consideration, the improvement of such basic infrastructure facilities as the proposed detached breakwaters under the Project will have a more direct impact on the fundamental requirements of preserving urban functions and protecting the lives and livelihoods of the inhabitants, compared to the improvement of other basic infrastructure facilities. Therefore, the improvement of the shore protection facilities shall be executed systematically while coordinating and balancing with other basic social infrastructure facilities. From this view point, the Maldives' present improvement plan for the shore protection facilities is considered to be inadequate.

(A) Recommendations Pertaining to the Project

For the purpose of effective Project implementation and semi-permanent functional acquisition of the facilities, it is recommended the Government of Maldives to take adequate countermeasures with regard to the following items:

(1) Several technical management staff who will be in charge of planning, construction, maintenance and management of the future shore protection shall be appointed in order for them to fully recognize and acquire the technical knowledge and knowhow pertaining to the shore protection facilities by participating in the Project from the initial stage of implementation. In this way, the project implementation organization shall be expanded by appropriate staffing.

(2) In order to assure the functions of completed facilities for a long period, patrol inspections of the facilities shall be carried out after high tidal wave attacks. Should the scattering or settlement of concrete armour units be detected, such units shall be replaced and restored as required.

(3) Since the proposed detached breakwaters are of a permeable type and waves with a height equivalent to about 0.4 times of the incident wave height will be transmitted to the water area behind the breakwaters, there is a possibility of some extent of wave overtopping even if a seawall is constructed along the shoreline of the reclaimed land. In order to drain overtopped seawater in a short time and to improve the utilization value of the living environment and land, it is recommended that a drainage facility landward behind the future seawall shall be provided at the time of future seawall construction.

(4) At the eastern edge of the southern coast, a garbage disposal facility is scheduled to be constructed. However, the proposed construction site will interfere with the proposed detached breakwater construction site and the drainage pipeline route from the power station. Since the proposed site is located adjacent to the reef edge, moreover, this site will be easily affected by direct high tidal wave attacks. Consequently, if the garbage disposal facility is constructed at the proposed site, a large scale shore protection facility would be required around the site. It is, therefore, recommended that the garbage disposal site be changed to a place free from the effects of high tides and waves and distant from the proposed construction site of the detached breakwaters.

(5) The reclamation area on the southern coast shall not be expanded seaward out of the proposed reclamation limit. The crest height of seawalls to be constructed in the future in the reclamation area shall be set at not lower than DL+2.3m in order to prevent flooding and improve the living environment

and land utilization value by keeping the wave overtopping rate within an allowable level.

(6) Since the proposed site of the power station in the eastern edge of the southern coast is located adjacent to the reef edge, it is highly probable that it will suffer the onslaught of high tidal waves. Consequently, it is recommended that the location be moved landward from the present proposed site in order to prevent and minimize damage due to high tidal waves.

(B) Recommendations Pertaining to the Shore Protection facilities in the Eastern, Western and Northern Coast Areas

With respect to the shore protection facilities in the eastern, western and northern coast areas, it is recommended that the Government of Maldives takes sufficient countermeasures for the following items after recognizing the present situations.

(1) Judging from the results of the wave uprush height survey, etc. the seawalls on the east coast have been directly attacked by high wave and presumably a considerable amount of wave overtopping must have entered into the housing area and roads.

In order to reduce the overtopping rate, therefore, it is recommended that the crest height of the existing seawalls be raised or mounds of rocks or concrete armour units be placed on the seaward flank of the seawalls. In addition, it is recommended that the considerably damaged base sections of the seawalls be immediately repaired and reinforced to relieve the damage due to high tidal waves.

(2) The seawalls on the west coast are less susceptible to wave attacks than those on the east coast except in the case of a west wind, because the west coast does not directly face the Indian Ocean and is blocked by Villingili Island. However, it is recommended that several parts of the substantially damaged seawalls be immediately repaired and reinforced to prevent the occurrence of any disasters.

(3) Among the shore protection facilities on the northern coast, the Male' Harbour breakwaters have been particularly extensively damaged and a section of several ten meters has collapsed and does not retain its initial form. Further, the crest and seaward side of the other breakwaters have also been exposed to dangerous conditions such as the formation of large voids due to progress of damages. If these facilities are left as they are without any countermeasures being taken, it is anticipated that the Male' harbour facilities will ultimately suffer from serious damage caused by high waves overtopping the breakwaters. Thus, it is recommended that immediate countermeasures be taken for restoration. Furthermore, it is also recommended that the base sections of seawalls inside of Male' Harbour which have been considerably damaged be immediately repaired and reinforced to retain the safety and the functions of these facilities.

In addition, part of the seawalls in front of the court is observed to have been inclined and deformed toward the anchorage at the seawall crest, presumably because of the excessive load or dredging of the front sea bottom. Therefore, it is recommended that no further excessive load be applied, nor more dredgings executed in this area.

APPENDIX

APPENDIX

APPENDIX I

MINUTES OF DISCUSSION

APPENDIX I MINUTES OF DISCUSSION

MINUTES OF DISCUSSION

OF
THE BASIC DESIGN STUDY FOR THE PROJECT OF CONSTRUCTING
BREAKWATERS ON SOUTHERN COAST OF MALE
IN
THE REPUBLIC OF MALDIVES

In response to the request by the Government of the Republic of Maldives, the Government of Japan decided to conduct a basic design study for the project of constructing the breakwaters on southern coast of Male (hereinafter referred to as "the Project"),and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent the Basic Design Study Team headed by Dr.Takaaki UDA, Head, Coastal Engineering Division, Public Works Research Institute, Ministry of Construction, from July 30th to August 21st, 1987.

The Japanese Team held a series of discussions and exchanged views on the Project with the authorities concerned of the Government of Maldives.

As a result of the study and discussions, both parties mutually agreed to recommend to their respective Governments that the major points of understanding reached between them, attached herewith, should be examined toward the realization of the Project.

Male, August 12th, 1987

Takaaki Uda
DR.TAKAAKI UDA
LEADER
BASIC DESIGN STUDY TEAM
JICA

MR.MOHAMED SHAREEF
DIRECTOR OF EXTERNAL RESOURCES
MINISTRY OF FOREIGN AFFAIRS

ATTACHMENT

1. The objective of the Project

The objective of the Project is to construct necessary facility to protect the Southern Coast of Male against disastrous high tidal waves.

2. Responsible and coordinating Agency for the Project;

Ministry of Foreign Affairs

Implementing Agency for the Project;

Department of Public Works and Labour.

3. Project Site

The Project site is located at the Southern Coast of Male, the Republic of Maldives as shown in Annex 1.

4. The basic concept of the facility and the implementation priority among the total Project are described in Annex 2.

5. The Team will convey to the Government of Japan the desire of the Government of Maldives that the latter will provide necessary measures and facility to cooperate in implementing the Project within the scope of Japan's Grant Aid Programme.

6. The Maldives side has understood the system of Japanese Grant Aid and the necessity of consulting services of a Japanese consulting firm for the implementation of the Project.

7. The Government of Maldives will undertake to provide the necessary measures as listed in Annex 3 on condition that Grant Aid by the Government of Japan is extended to the Project.

8. The Government of Maldives will undertake to provide the necessary budget and personnel for the proper and effective maintenance of the facility provided under the Grant Aid.

T.U.

ANNEX-1

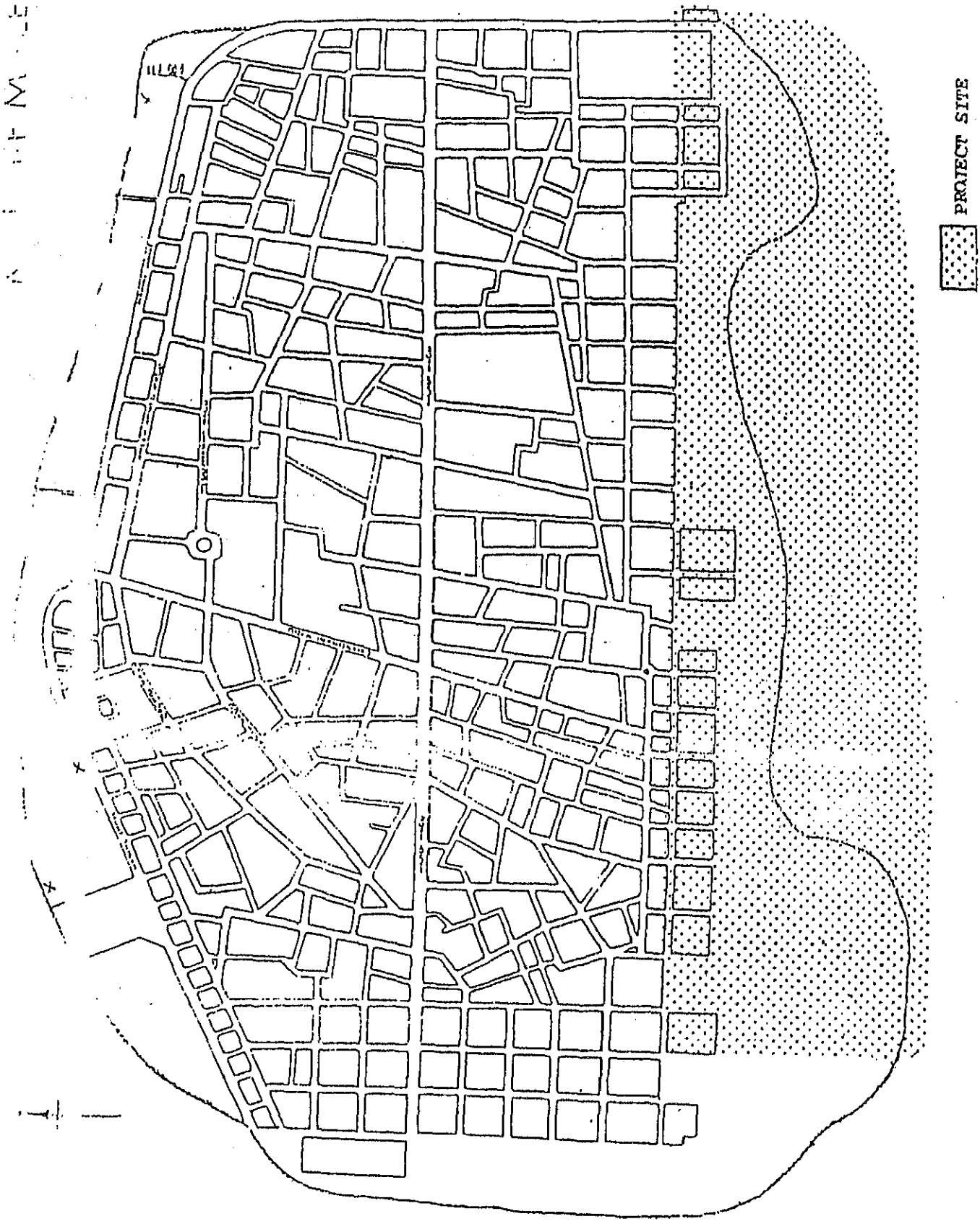


Figure 1. MALE ISLAND

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Annex 2

The Basic Concept of Layout and Typical Section of the Breakwaters

The basic concept of layout and a typical section of the breakwaters is planned as illustrated in Annex 2-1 and Annex 2-2, respectively, based upon the data and the information obtained in April, 1987 by the expert team for disaster relief and by this Basic Design Study Team.

However, both or either the Layout and/or the Typical Section may be modified by the result of a detailed study in Japan based upon data and information which could be obtained from now on.

1.Layout of Breakwaters described in Annex 2-1 was designed on the basis of the following conditions.

(1) To keep the existing shoreline of a land reclamation to the utmost.

(2) To make use of the existing breakwaters as much as possible.

(3) To make an alignment plan of the breakwaters in consideration of its safety and durability.

(4) To secure safety for the power plant and the primary school to be constructed in the near future.

2.Typical Section described in Annex 2-2 was designed on the basis of the following conditions

(1) To plan a typical section of the breakwaters, taking safety and durability into account.

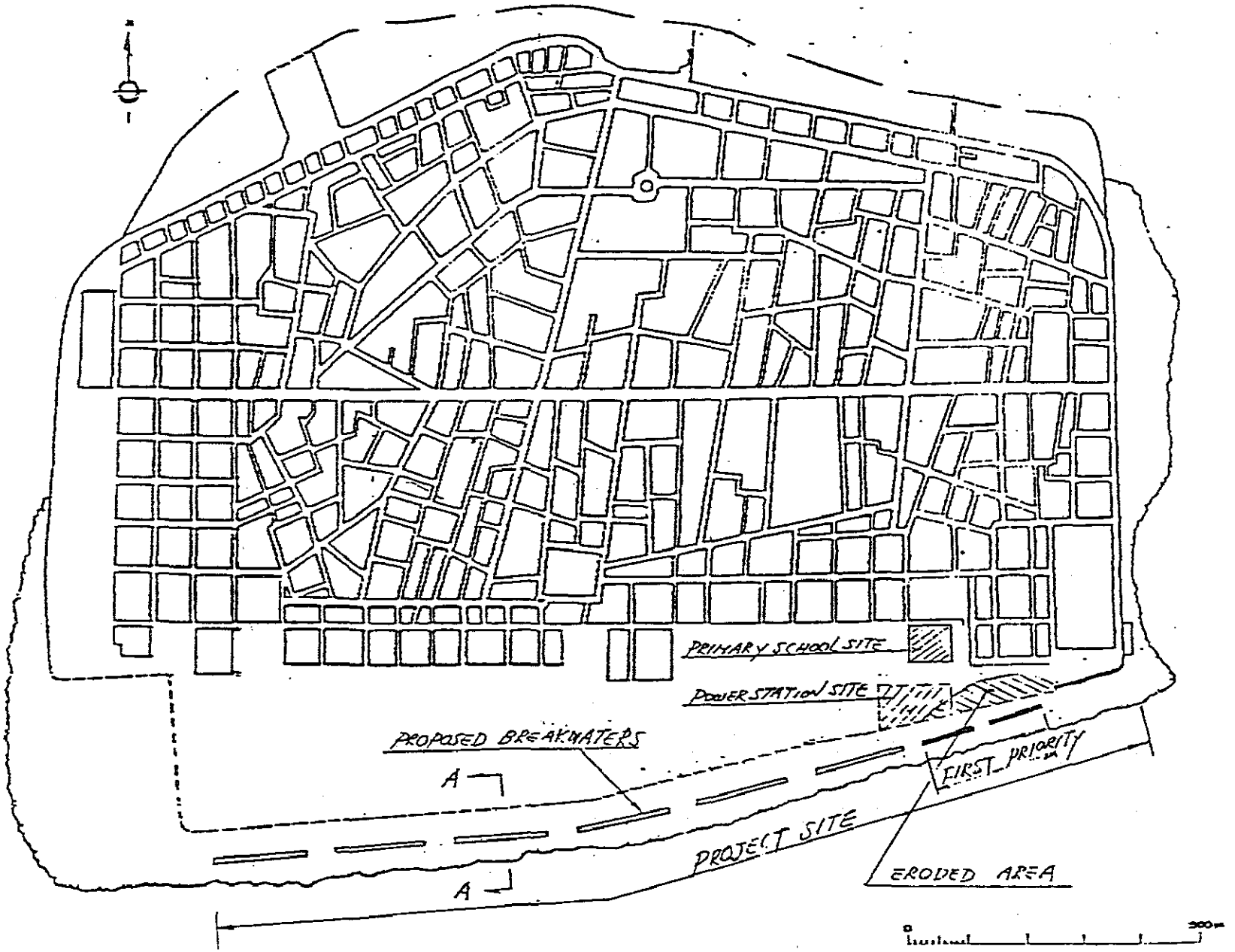
(2) To use materials obtainable in Maldives (coral rocks and sand) as much as possible.

(3) To simplify a construction method.

(4) To minimize the works in and under the water.

T.U.

ANNEX 2-1. LAYOUT OF BREAKWATERS (DRAFT)



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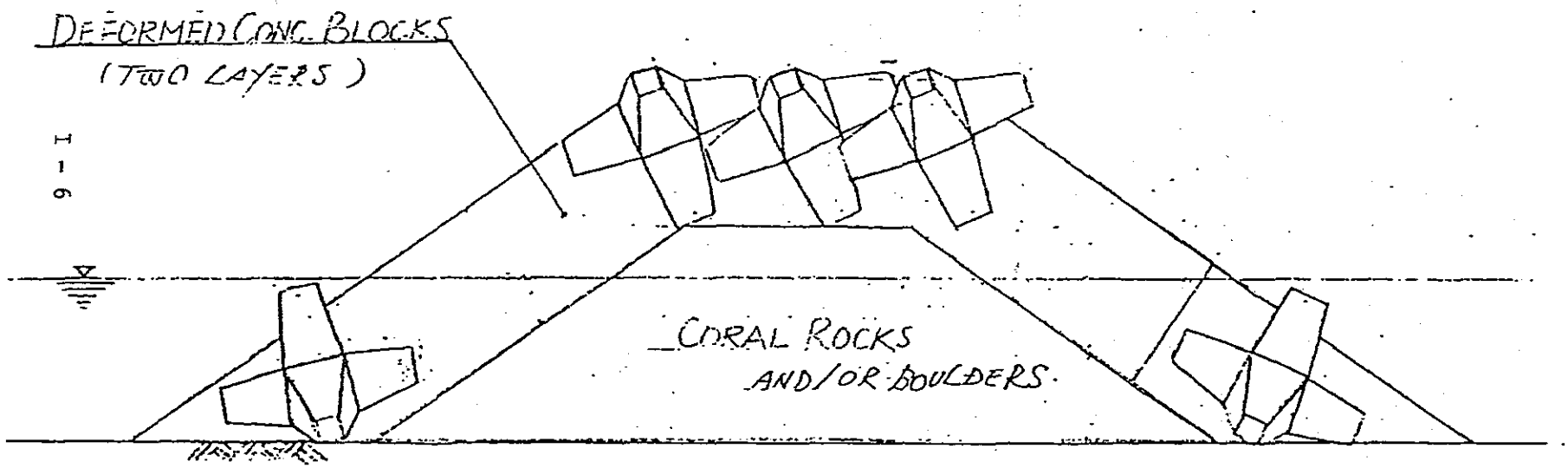
ANNEX 2-2. TYPICAL SECTION "A-A" (DRAFT)

DEFORMED CONCRETE BLOCK TYPE WITH CORAL ROCKS AND/OR BOULDERS SLOPING BREAKWATER



T.U.

Annex 3

Undertakings by the Government of Maldives

1. To secure land for the breakwaters and other related facilities.

2. To provide the following temporary land for a construction liaison office (hereinafter referred to as "the office"), warehouse, stock yard, etc. during the construction period.

   400ft x 200ft

3. To provide accessible roads to the Project site both from the main road and from the office.

4. To provide facilities for distribution of electricity, telephone and other incidental facilities to the office.

5. To ensure speedy unloading, tax exemption, customs clearance at ports of disembarkation in Maldives, of the products purchased under the Grant.

6. To bear the following commissions to a Japanese foreign exchange bank for the banking services based upon the Banking Arrangement.

   a) Advising commission of authorization to pay

   b) Payment commission

7. To accord Japanese Nationals whose services may be required in connection with supply of the products and the services under the verified contract as may be necessary for their entry into Maldives and stay therein for the porformance of their work.

8. To maintain the breakwaters properly constructed under the Grant.

9. To provide necessary data and information for a detail design,

T.U

APPENDIX II

MEMBER LIST OF THE BASIC DESIGN STUDY TEAM

APPENDIX II MEMBER LIST OF THE BASIC DESIGN STUDY TEAM

MEMBERS OF THE TEAM

Name	Assignment	Position
Dr. Takaaki Uda	Leader	Ministry of Construction
Mr. Saisuke Kashiwagi	Grant Aid programme	Ministry of Foreign Affairs
Mr. Juro Chikaraishi	Project coordinator	Japan International Cooperaion Agency
Mr. Ryosuke Teranisi	Coastal revetment planner	Yachiyo Engineering Co., Ltd.
Mr. Koji Kumakura	Seawater level analysist	Yachiyo Engineering Co., Ltd.
Mr. Mitsuo Yuge	Survey supervisor	Sanyo Hydrographic Survey Co., Ltd.
Mr. Toshio Yano	Cost estimator	Yachiyo Engineering Co., Ltd.

APPENDIX III

SURVEY SCHEDULE

APPENDIX III SURVEY SCHEDULE

This study team carried out field survey from 30th July 1987 to 21st August 1987 and from 11th to 17th September 1987 in accordance with the field survey schedule as listed below:

No.	Day	Date	Weather	Place of stay	Schedule	Detail of Study Items
1	July 30	Thu.	Fine	Bangkok	Left Narita TG-643 10:50	Yano and Kumakura left Tokyo
2	31	Fri.	Fine	Colombo	Left Bangkok TG-307 10:40	Visit to JICA Sri Lanka office
3	Aug. 1	Sat.	Fine	"		Market survey
4	2	Sun.	Fine	"		Preparation for installation of tidal gauges, Investigation of Constructors
5	3	Mon.	Fine	"		Investigation of suppliers/vendors, and visits to Ports Authority Colombo 1 and Embassy of Japan in Sri Lanka
6	4	Tue.	Fine	Bangkok	Left Narita TG-643 10:50	Team Leader Uda, Kashiwagi, Chikaraishi, Teranishi and Yuge left Tokyo
			Fine	Colombo		Investigation of suppliers/vendors, and installation of tidal gauges
7	5	Wed.	Fine/Rainy	Colombo		Visit to JICA Sri Lanka office and Embassy of Japan in Sri Lanka. Investigation of suppliers/vendors, inspection of tidal gauges, and collection of meteorological and oceanometeorological data
8	6	Thu.	Fine	Maldives	Left Colombo UL-101 10:00	Field reconnaissance and study team meeting

No.	Day	Date	Weather	Place of stay	Schedule	Detail of Study Items
9	Aug. 7	Fri.	Cloudy/Fine	Maldives		Visit to JOCV office, courtesy visit to the Government of Maldives, market survey and preparation for installation of tidal gauges
10	8	Sat.	Fine/Cloudy	"		Survey of existing seawalls, assembly of tidal gauges, and measurement of wave breaker height
11	9	Sun.	Fine	"		Explanation on Inception Report, free aid cooperation system and questionnaire, discussion on the schedule of study team, etc. Setting of leading point and tidal gauges, and trace survey
12	10	Mon.	Rainy/Fine Cloudy/Fine	"		Collection of data and information from authorities concerned. Survey of existing seawalls, shoreline survey and inspection of tidal gauges
13	11	Tue.		"		Preparation of the Minutes of Discussion and recommendation, shoreline survey and tide observation
14	12	Wed.	Fine/Rainy	"		Signing of the Minutes of Discussion, lunch with the Maldive Government officials, and shoreline survey
15	13	Thu.	Fine/Cloudy	Colombo	Left Male UL-102 11:15	Team Leader Uda, Kashiwagi, Chikaraishi, Teranishi and Kumakura left Maldives
			Fine	Maldives		Shoreline survey, market survey and investigation of suppliers/vendors
16	14	Fri.	Fine	Bangkok	Left Colombo TG-308 13:25	Team Leader Uda, Kashiwagi, Chikaraishi, Teranishi and Kumakura left Sri Lanka
			Fine	Maldives		Sounding, and arrangement of collected data and information

No.	Day	Date	Weather	Place of stay	Schedule	Detail of Study Items
17	Aug. 15	Sat.	Fine	Tokyo	Left Bangkok TG-640 10:30	Team Leader Uda, Kashiwagi, and Chikaraishi arrived in Tokyo
			Rainy	Hong Kong	Left Bangkok TG-630 9:40	Arrangement of collected data and information
			Fine	Maldives		Sounding , market survey and investigation of suppliers/vendors
18	16	Sun.	Fine	Tokyo	Left Hong Kong NH-910 14:45	Teranishi and Kumakura arrived in Tokyo
			Cloudy	Maldives		Levelling, market survey and investigation of suppliers/vendors
19	17	Mon.	Cloudy	Singapore	Left Male SQ-035 10:05	Yano left Maldives
			Rainy	Colombo	Left Male UL-103 11:15	Yuge left Maldives
20	18	Tue.	Fine	Singapore		Market survey and investigation of suppliers/vendors
			Cloudy	Colombo		Arrangement of the results of survey
21	19	Wed.	Fine	Singapore		Market survey and investigation of suppliers/vendors
			Fine	Bangkok	Left Colombo TG-308 13:25	Yuge arrived in Thailand
22	20	Thu.	Fine	Travelling	Left Singapore JL-710 22:35	Market survey and investigation of suppliers/vendors
			Fine	Tokyo	Left Bangkok TG-640 10:30	Yuge arrived in Tokyo
23	21	Fri.	Fine	Tokyo		Yano arrived in Tokyo

No.	Day	Date	Weather	Place of stay	Schedule	Detail of Study Items
24	Sept.11	Fri.	Cloudy	Singapore	Left Narita JL-719 13:00	Kumakura left Tokyo
25	12	Sat.	Fine	Maldives	Left Singapore SQ-036 22:00	Kumakura left Singapore
26	13	Sun.	Fine	"		Recovery of tidal gauges
27	14	Mon.	Fine	Colombo	Left Male UL-102 10:45	Kumakura left Maldives
28	15	Tue.	Fine	"		Recovery of tidal gauges
29	16	Wed.	Rainy	Bangkok	Left Colombo TG-308 13:25	Kumakura left Sri Lanka
30	17	Thu.	Fine	Tokyo	Left Bangkok TG-640 10:30	Kumakura arrived in Tokyo

APPENDIX IV

LIST OF INTERVIEWEES

APPENDIX IV LIST OF INTERVIEWEES

The interviewees concerned with this study team are listed as follows;

Occupation and Name	Position
Sri Lanka	
THE JAPANESE EMBASSY	
Yasuya Hamamoto	Ambassador Extraordinary and Plenipotentiary
Toshinao Urabe	Counseller
Atsushi Matsumoto	Third Secretary
JICA SRI LANKA OFFICE	
Jiro Hashiguchi	Resident Representative
PORTS AUTHORITY	
Mr. E. M. T. Ekanayaka	Chief Hydrographic Surveyor & Licensed Land Surveyor
Mr. A. J. Wijesekera	Hydrographic Surveyor
DEPARTMENT OF METEOROLOGY	
Mr. G. H. P Dharmaratna	Deputy Director
LANKA HYDRAULIC INSTITUTE LTD.	
Mr. S. Balangoda	Licensed Surveyor & Leveller
St.ANTHONY'S CONSOLIDATED LTD.	
Mr. Sarath Perera	Marketing Manager
LANKA CEMENT LIMITED	
Mr. K. M. Jaufer	Marketing Manager
SRI LANKA CEMENT CORPORTION	
Mr. Samarasinghe	Additional General Manager
MAHAWELI MARINE CEMENT CO., LTD.	
Mr. F. R. Neuert	Managing Director
CHANDRANAYAKE & CO., (PTE) LTD.	
Mr. M. G. Kularatne	Managing Director
W.A.PERERA & CO., LTD.	
Mr. R. Ratnasena	Director

W.A.FERNANDO & SONS
Mr. Smaraweera — Director

IBRAHIM JAFFERJEE
Mr. Y. I. Jafferijee — Managing Partner

STATE TIMBER CORPORATION
Mr. B. Samadanayake — Acting Marketing Manager

NAWALOKA TRADING CO., LTD.
Mr. T. Hewakapuge — Manager

PLYWOOD CORPORATION
Mr. Ranasinghe — Marketing Manager

SRI LANKA BUREAU OF FOREIGN EMPLOYMENT
Mr. G. D. G. P. Soysa — Chairman

LAGODAN (PTE) LTD.
Mr. L. A. B. Perera — Chairman

MACKINNON MACKENZIE & CO. OF CEYLON LTD.
Mr. R. Wanigasundara — Manager

CONSTRUCTION & DEVELOPMENT CO., LTD.
Mr. A. E. Prepera — Managing Director

CARSONS CONSTRUCTION LTD.
Mr. R. F. Poulier — Director

THE CEYLON SERVICE & SUPPLIES CO., LTD.
Mr. H. R. J. de Soysa — Director

AMARAN
Mr. A. Arangallage' — Chairman

MALSHIP (CEYLON) LIMITED
Mr. M. Macky Hashim — Director

CEYLON OPERATORS (PTE) LTD.
Mr. M. I. M. Nilar — Managing Director

A.R.M.MUSHIN & CO., LTD.

Mr. F. M. Mushin	Manager

EAST-WEST MOTORS (PVT) LIMITED

Mr. Dan S. Mukunthan	Director

Maldives

JOCV MALDIVES OFFICE

Hideyuki Adachi	Coordinator
Hiroyuki Yoshida	surveying Engineer

MINISTRY OF FOREIGN AFFAIRS

Mr. Mohamed Shareef	Director of Expternal Resources
Mr. Abdul Gafoor Mohamed	Assistant Undersecretary

DEPARTMENT OF PUBLIC WORKS AND LABOUR

Mr. Abdulla kamaludeen	Director
Mr. Ahmed solih	Planning Manager
Mr. Mohamed shameem	Statistical Officer
Mr. Stephen Cork	Consulting Engineer

MINISTRY OF PLANNING AND DEVELOPMENT

Mr. Ismail Shafeeu	Director of Planning
Mr. Mohamed Saeed	Undersecretary
Mr. Hamaun A.Hameed	Senior Project Officer

MINISTRY OF HEALTH

Ms. Shaheeda Adam Ibrahim	Assistant Director

MINISTRY OF HOME AFFAIRS, ENVIROMENTAL SECTION

Mr. Hussein Shihab	Director

MALDIVES MONETARY AUTHORITY

Mr. Ismail Fathy	Vice Governer
Mr.Adam Maniku	General Manager

MALDIVES ELECTRICITY BOARD

Mr. Abdul Shakoor	Director

DEPARTMENT OF METEOROLOGY

Mr. Abdullahi Majeed	Director
Mr. Hassan Riza	Assistant Director

OFFICE FOR PHYSICAL PLANNING AND DESIGN

Mr. Mohamed shafeegu	Deputy Director
Mr. Phillip M. Richards	Architect

MALE' WATER SUPPLY AND SEWERAGE PROJECT UNIT

Mr. Mohamed Ibrahim	Project Manager
Mr. Richard J. Coackley	Consulting Engineer

HALE' MUNICIPALITY

Mr. Bandu Ahmed Saleem	Deputy Chairman
Mr. Abdullah Saleem	Project Officer

MALDIVES TRANSPORT & CONTRACTING CO.

Mr. Adam Sallem	Director

R. K. L. WOOD & METAL WORKS

Mr. R. K. LATUTTU	Proprietor

ALIA STORE

Mr. Ilyas Abdullah	General Manager

MONAZA CONSTRUCTION

Mr. Ahmed Naeem	Director

CHINA INTERNATIONAL WATER & ELECTRIC CORP.

Ms. Li Yisui	Vice Director Engineer

HEILIT & WOERNER

Mr. Shilling	Engineer

TOUCHWOOD (MALDIVES) PTE. LTD.

Mr. Adnan Ali	Director

DIVER

Mr. Hassan Maniku

SINGAPORE

HONG LEONG CORPORATION LTD.

Mr. Tan Kiak Liew	Sales Manager

TRIPLE STAR SHIPPING & TRADING CO. (PTE) LTD.
Mr. Michael G. S. Yeo — Managing Director

TWINCEM SHIPPING & TRADING CO. PTE. LTD.
Mr. Yeo Peng How — Assistant Sales Manager

JOHORE SAND AND GRANITE SUPPLIES
Mr. Jeffrey K. K. Lim — General Manager

QUALITY SAND SUPPLIES PTE. LTD
Mr. Willam Lee — Manager

COMFORT MARINE PTE. LTD.
Mr. Tan Koon — Director

QUALITY MATERIALS TRADING PTE. LTD.
Mr. Rickson Chng — Manager

SHEBAB INTERNATIONAL (PTE) LTD.
Mr. M. Hussein — Managing Director

EASTLAND TIMBER CO.
Mr. Lye Kim Chia — General Manager

MARITIME (PTE) LIMITED
Mr. Lai Ka Tim — Marketing Director

SUM CHEONG PILING PTE. LTD.
Mr. Teo Beng Teck — General Manager

GRAY MACKENZIE MARINE SERVICES PTE. LTD.
Mr. Francis Yeong — Regional Manager

TECHNOCEAN PTE. LTD.
Mr. M. Okada — Managing Director

MARINE DIVING SERVICES PTE. LTD.
Mr. M. Aoyagi — Director

EAST MARINE PTE. LTD.
Mr. Jun. A. Ogawa — Director

KENKI CENTER PTE. LTD.

Mr. T. Sasaki	Engineer

TIAN SAN CO. (PTE) LTD.

Mr. Chia Ah Sai	General Manager

WALTER WRIGHT MAMMOET (S) PTE. LTD.

Mr. Vincent Koh	General Manager

APPENDIX V

COUNTRY DATA

APPENDIX V COUNTRY DATA

I. Basic Indices

(1) Republic of Maldives

Capital - Male' (population: 50,462, as of 1986)

(2) Land Area and Population

Land Area - 298km^2
Population - 191,993, as of 1986
Population Density - 644 persons/km^2
Overall Average Population Growth Rate - 3.3% (1977 - 1985)
Urban Population Ratio - 25%, as of 1986
Average Span of Life - 52.23 years (as of 1982)

(3) Political System

Republic with a one-chamber cabinet system headed by the President who is also the Head of State.
President Maumoon Abdul Gayoon was inaugurated in May, 1978

(4) Religion - Islam

(5) Language - Maldivian (Dhivehi)

(6) Ethnic Composition - Maldivian

(7) Education

Functional Literacy Rate - 86.6% (age 10 - 45, as of 1983)

(8) Currency and Exchange Rate

Maldivian rufiyaa, 9.6431 = US$1 (average in July, 1987)

(9) Climate

The Republic of Maldives has a tropical monsoon climate. The period between November and April is the northeastern monsoon season which is dry with a moderate wind and little rainfall while the period between May and October in the southwestern

monsoon season, or rainy season, which has strong winds and a lot of rainfall accompanied by thunderstorms. The yearly temperature and humidity do not greatly vary, ranging from 25°C to 32°C and 79% to 86%, respectively, and the annual average precipitation is 2,000mm.

(10) Geography

The country consists of atolls resulting from the ring-shaped linkage of various small-sized coral islands formed in shallow seas as a consequence of volcanic activity, etc., as well as separate islands. In general, these islands compose a flat topography with an elevation of approx. 1m to 2m above sea level.

(11) Longitude and Latitude

Long. 72°31'30" E - Long. 73°45'54" E
Lat. 7°6'30 N - Lat. 0°41'48" S

II. Socio-Economic Indices

(1) Gross Domestic Product (1985)

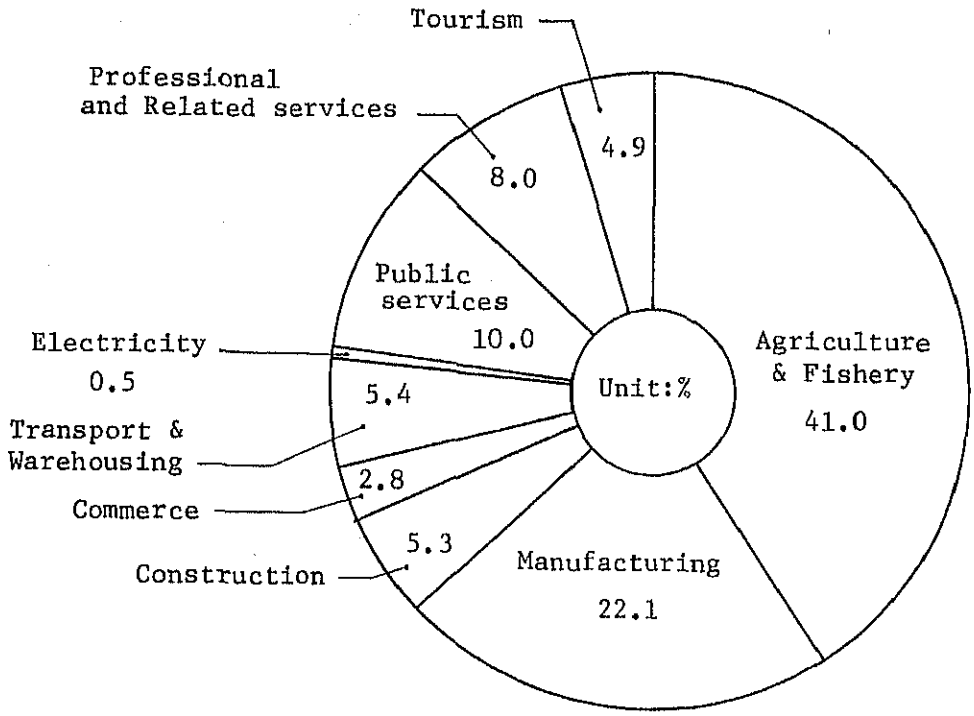
GDP	: US$96.2 million
GDP per capita	: US$530

(2) Gross National Product (estimated for 1986)

GNP	: US$57 million
GNP per employed person	: US$740

(3) Industrial Structure

Structure of total employment by industrial sectors (1985)



(4) Employed population as of 1985

87,900

(5) Inflation rate

(Unit: rufiyaa)

Price of principal goods

Year	Price (per kg)	Sugar (per kg)	Coconut (per place)	Skipjack (per fish)	Electricity (per kWh)	Gasoline (per litre)
1977	0.97	2.03	0.60	4.00	1.48	2.40
1978	1.67	1.41	0.33	5.90	1.50	3.52
1979	1.54	1.70	0.37	2.25	1.50	5.53
1980	1.61	3.07	0.61	14.28	1.50	6.45
1981	2.23	4.95	0.69	12.28	1.50	5.95

(Source: Maldives - Recent Economic Development, March 16, 1982, IMF)

(6) International balance of payments

Export and import of the Republic of Maldives (1981-1985)

(Unit: US$1,000)

	1981	1982	1983	1984	1985
Import					
Consumer goods					
Food and edible animals	8,659	7,819	9,424	11,602	10,615
Beverages and tabacco	904	2,159	5,260	2,382	3,071
Oil and lubricant	4,682	2,177	4,784	6,649	7,403
Chemical products	1,196	3,355	3,821	3,244	2,957
Industrial products	5,502	9,549	8,435	12,481	12,094
Subtotal	20,943	25,059	36,724	36,358	36,140
Capital goods					
Raw materials	1,793	3,964	4,947	1,672	3,213
Machinery and transportation equipment	5,117	10,259	10,053	13,535	8,538
Subtotal	6,910	14,223	15,000	15,207	11,751
Total imports	27,853	39,282	51,724	51,565	47,891
Export					
Raw and Processed fish and shell fish	6,997	6,247	6,899	-	15,410
Clothing	1,363	3,318	6,276	-	7,477
Handicraft products	235	172	214	-	67
Tropical fish	54	61	52	-	78
Total exports	8,649	9,798	13,441	-	23,032

(Source: Statistical Yearbook of Maldives, 1984, 1986)

(7) Trade with Japan

(Unit: US$1,000)

	1981	1982	1983	1984	1985
Imports from Japan	5,338	3,347	2,552	1,069	2,322
Exports to Japan	N.A.	N.A.	N.A.	N.A.	N.A.

(8) Treasury balance of the Government of the Republic of Maldives (1982-1985)

(Unit: 1 million rufiyaa)

	1982	1983	1984	1985
Total annual revenue	122.8	129.2	170.3	169.5
	(100%)	(100%)	(100%)	(100%)
Grant from overseas countries	23.4	12.4	35.2	30.0
	(19%)	(10%)	(21%)	(18%)
Domestic revenue	99.4	116.8	135.1	139.5
	(81%)	(90%)	(79%)	(82%)
(Breakdown) Tax revenue	42.1	51.6	71.1	77.5
Profit from national companies	52.9	64.2	63.8	61.7
Capital return	4.4	1.0	0.2	0.3
Total annual expenditure	129.5	163.5	182.9	198.2
Public services	41.9	64.4	71.5	69.3
Social welfare				
Education	12.1	15.0	19.7	22.4
Health	8.2	7.6	9.1	12.4
Social welfare services	27.5	14.8	7.5	8.9
Others	13.0	32.9	35.1	24.9
Economy				
Agriculture and fishery	1.6	1.9	2.6	2.5
Transport and communication	18.0	13.3	16.6	21.2
Tourism	0.8	1.2	2.2	1.5
Trade, etc.	1.1	1.0	4.8	3.5
Repayment of debt	5.3	11.4	13.8	31.6
Balance of annual revenue deficits	6.7	34.3	12.6	28.7

(Source: Statistical Yearbook of Maldives, 1986)

III. Development Indices

(1) National Development Plan

In 1978, the Gayoom Administration established the National Planning Agency for the purpose of preparing an economic development plan in order to attain uniform economic and social development throughout the Republic of Maldives.

In 1982, the Agency was renamed as the Ministry of Planning and Development, and a three-year development plan for 1985 to 1987 was prepared for the first time in the country.

This Plan is compiled in two volumes. The macroscopic perspectives for economic and social development are described in Part I of Volume 1 and the developmental perspectives for each sector are presented in detail in Part II of Volume I.

In Volume 2, detailed development projects for the three years between 1985 and 1987 are presented.

Long Term Objectives

- To improve of the living standard of the people
- To balance population density and economic and social progress between Male' and the atolls
- To attain greater self-reliance for future growth

Priorities

1. To increase the national product and particularly foreign exchange earnings
2. To improve health and sanitary conditions
3. To achieve uniformity and upgrade education and training levels
4. To accelerate the integrated development of atolls
5. To relieve Male' of its congestion in terms of population and economic activity
6. To prevent damage to the national environmnet

(2) National Budget

The national budget by sectors in the three-year (1985 - 1987) National Development Plan of the Maldives is as listed below:

(Unit: US$ million)

Sectors	Domestic Fund	Overseas Fund	Total
Agriculture	0.2	2.6	2.8
Fishery	1.3	14.7	16.1
Manufacturing	0.5	3.4	3.9
Motive and Electric Power	0.6	5.9	6.5
Tourism	1.1	0.3	1.4
Transportation and Communications	2.1	26.3	28.4
Public Services	0.8	4.0	4.8
Education	1.8	8.0	9.8
Health and Sanitation	2.3	17.1	19.4
Other Urban Development	5.1	11.2	16.3
Other Atoll Development	1.9	6.5	8.4
Total	17.8	100.0	117.8

(Source : Ministry of Planning and Development, 1984)

IV. Main Index of Each Sector

1. Features of Each Industrial Sector

The features of each industrial sector in the ROM are as outlined below:

(1) Fishery

Fishery is the mainstay of the Maldives' economy. As the land area is small and natural resources are scarce, Fishery constitutes the country's most important natural resource. In order to attain economic development, top priority should be given to fishery development and the modernization of fishing boats, equipment and methods is an absolute necessity. Furthermore, the fishermen have a fairly low standard of living and lack of adequate investment funds for modernization.

Based on overseas economic assistance, the Government of Maldives is providing a financing system for fishermen in view of the mechanization of fishing boats. Japanese grant aid has also been provided for the mechnization of fishing boats in 1975, 1977 and 1978.

The total catch in 1985 was 61,900 tons, an increase of 12.3% on the previous year. The breakdown of the catch was 68.8% for skipjack, 9.9% for yellowfin tuna, 8.1% for other tuna-related species and 13.2% for reef fish, etc. (according to 1986 data).

(2) Tourism

Tourism constitutes an important industry next to fishery, and is playing a major role in the invisible trade in the international balance of payments.

The development and effective utilization of the resources for turism is an important economic task. Therefore, the Gayoom Administration is promoting the development of the environment in an effort to increase the number of tourists. Moreover, the development of tourism is expected to play a strategic role in the development of the island other than Male' and other atolls.

(3) Shipping Industry

In view of the geographical features of the Maldives, located nearly at the center of the Indian Ocean, the shipping industry is one of the country's most important industries. For this reason, Maldives Shipping Ltd., a government owned company, established and the profits from this company are a valuable source of foreign currency for the ROM. The shipping industry is, therefore, a major industry for the Maldive economy, together with the above-mentioned fishery and tourism industries as those covering the trade deficit in the international trade balance of the Maldives.

(4) Agriculture

In contrast to the above-mentioned three industries, agriculture is a minor industry supplementing the earnings of fishermen or islanders. The arable land area is narrow and does not amount to even 10% of the total land area. Because of the sandy soil which has low water retainability and extremely high alkalinity, the natural conditions are unsuitable for agriculture, posing a major obstacle for development in the future. In consideration of the prevailing situation where the country heavily relies on imported rice and other foods, however, the promotion of agriculture and the expansion of the domestic food production are important tasks for the economic development of the country and to further reduce the international trade deficit.

The major agricultural products include coconuts, bananas, millet, yams, maize etc. Of these coconuts are the most popular and about 76% of the total number of households are reported to own coconut trees according to the 1977 census.

(5) Manufacturing

The manufacturing industry was formerly comprised of a small number of enterprises manufacturing soft drinks, bread, furniture, fishing boats, handicrafts and other consumer goods for the domestic market. However, a textile factory (a joint venture between the State Trade Organization (STO) and a Hong Kong capital) and a sewing factory (a joint venture between the STO and a Singaporian capital) were established and started production in 1981 in view of manufacturing export products. The export value of these apparel products amounted to US$7.5 million in 1985, the second largest export item next to fishery products, and accounting for 49% of the total export amount in 1985.

2. Employed Population by Industrial Sectors

Sectors	Employed Population (1,000 employees)	Retio of Employed Population (%)
Agriculture	7.3	8.3
Fishery	28.7	32.7
Manufacturing	19.4	22.1
Construction	4.7	5.3
Commerce	2.5	2.8
Electricity	0.4	0.5
Transportation	4.8	5.4
Tourism	4.3	4.9
Public Services	8.8	10.0
Professional and Related Services	7.0	8.0
Total	87.9	100

Note : The employed population is based on 1985 data.

APPENDIX VI

GEOLOGICAL AND METEOROLOGICAL DATA

APPENDIX VI GEOLOGICAL AND METEOROLOGICAL DATA

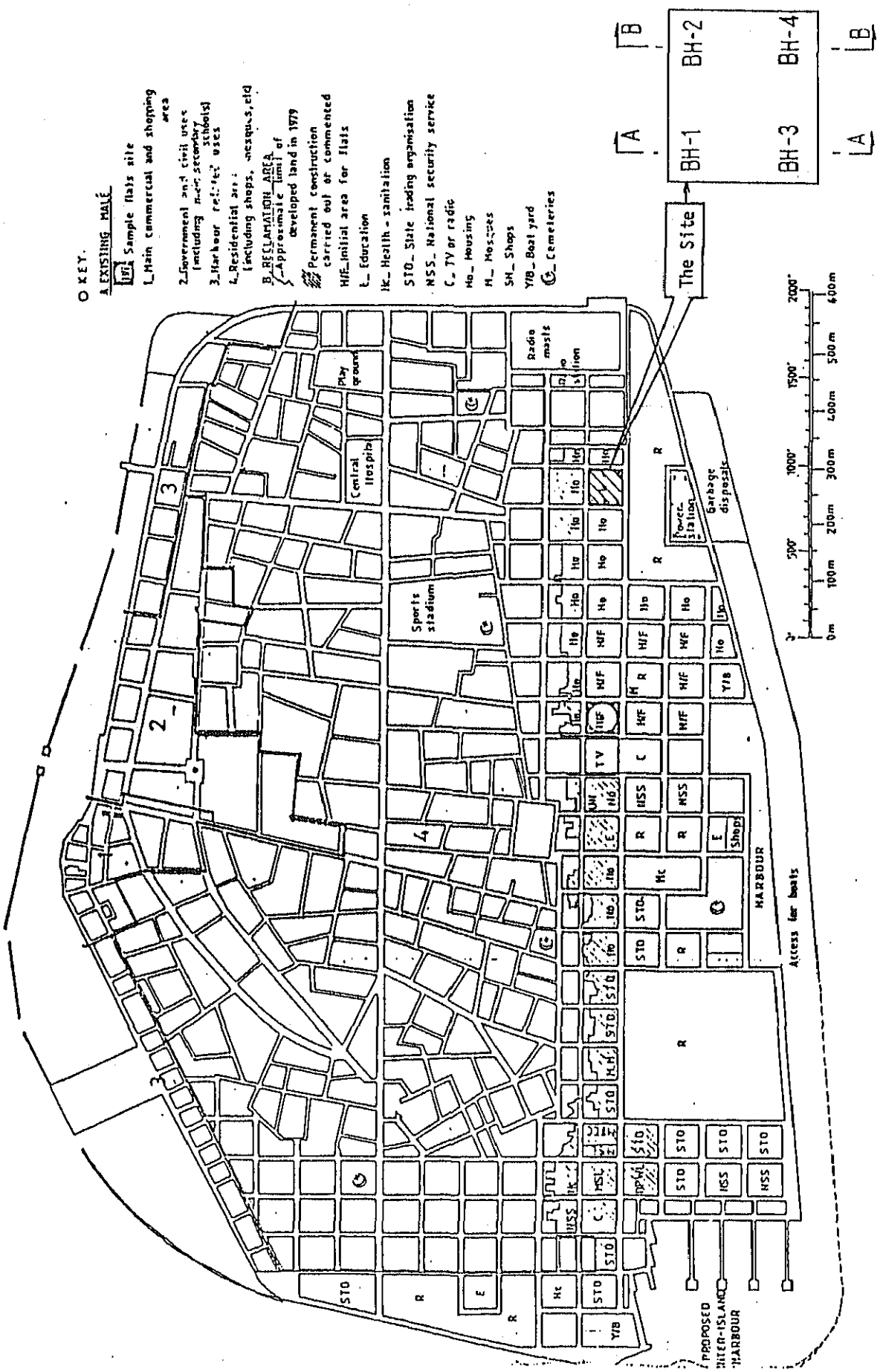


Fig. A6-1 Borehole Location.

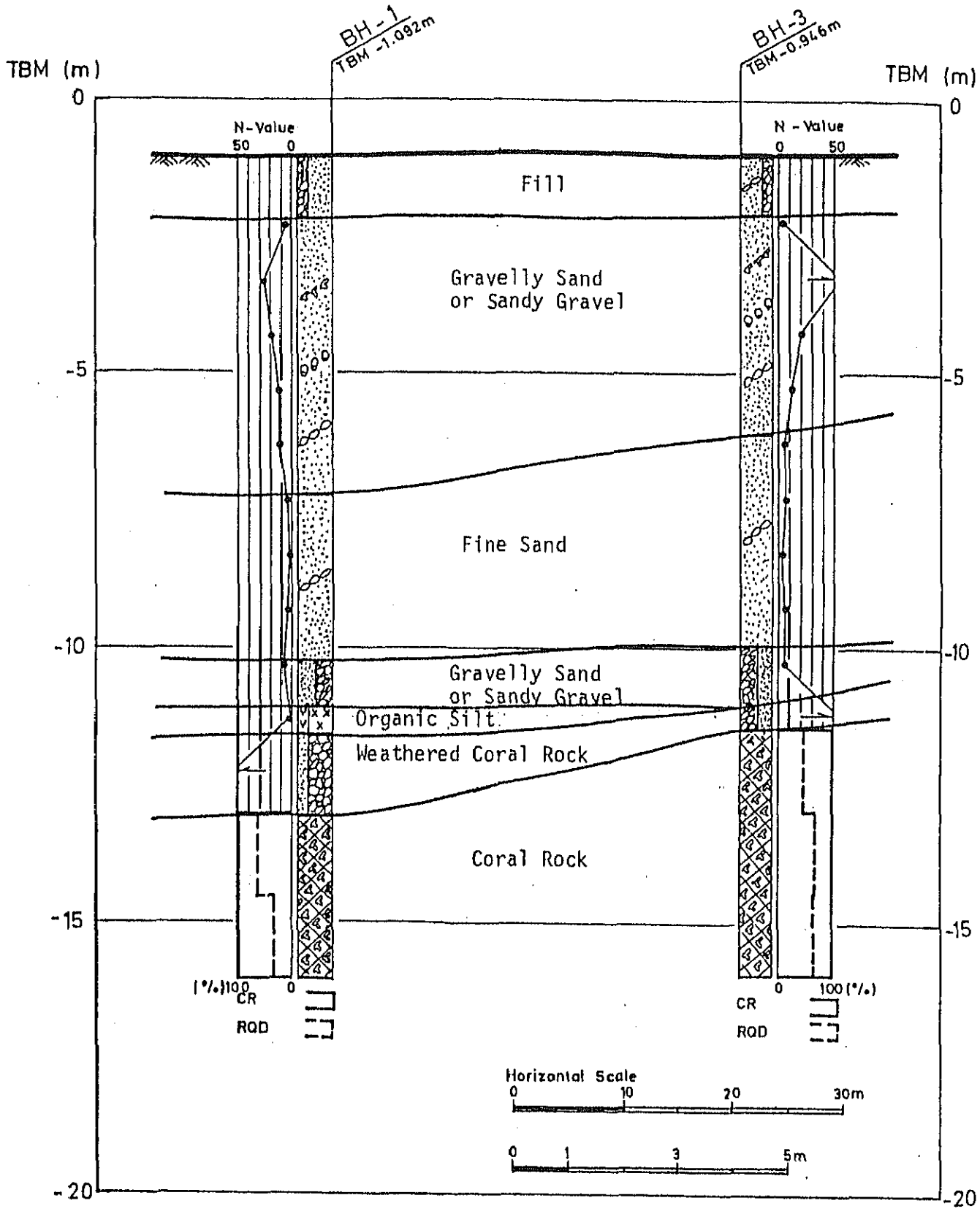


Fig. A6-2 Soil profile A-A.

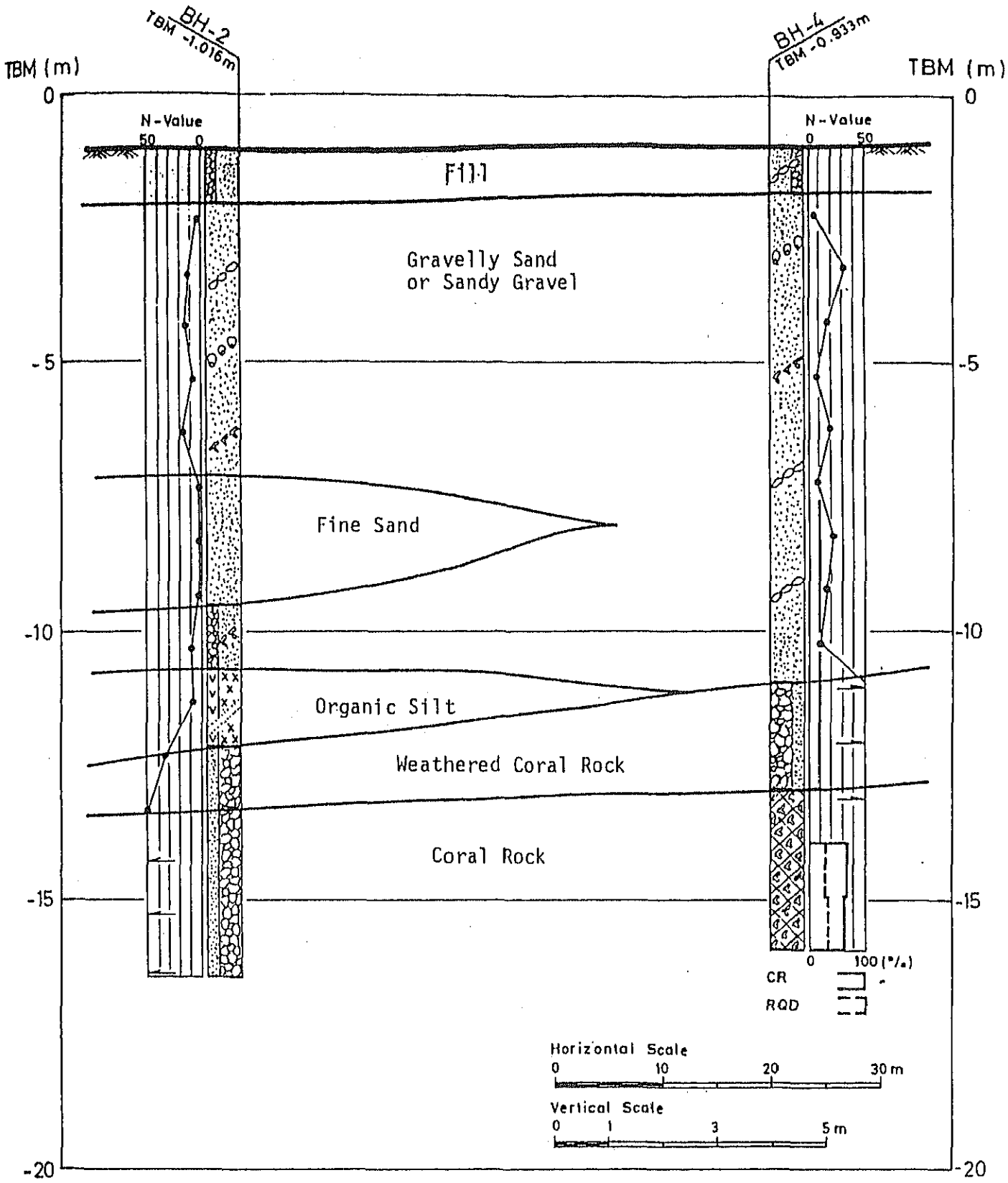


Fig. A6-3 Soil profile B-B.

Meteorological Data

PLACE — MALE (MALDIVES). LAT. 04° 12' N. LONG. 73° 29' E. Height above Mean Sea Level, 6m

WMO No. 43395

Climatic Table compiled from 6 to 19 Years' Observations, 1945 to 1965

Month	Pressure at M.S.L. Mean	Air temperature: Mean daily max.	Air temperature: Mean daily min.	Air temperature: Highest in each month	Air temperature: Lowest in each month	Relative humidity: 0800	Relative humidity: 1	Cloud %: Clear	Cloud %: Cloudy	Rain: Average fall	Rain: No. of days with 2.5 mm or more	Wind direction ø: Percentage of observations from N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm	Wind direction: Percentage of observations from N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm	Mean wind speed ø	Mean wind speed 1	No. of days with gales‡	No. of days with fog	No. of days with thunder
	mb	°C	°C	°C	°C	%	%			mm																				Knots			
January	1011	31	24	32	23	81	—	45	23	221	7	16	51	13	1	1	2	4	9	3									7	1	0	2
February	1010	31	24	32	24	79		38	28	8	1	25	45	11	1	1	3	5	7	2									6	1	⊕	2
March	1010	32	25	33	24	76		55	12	89	4	23	24	4	4	7	1	8	20	9									8	1	⊕	4
April	1010	33	26	36	23	76		29	34	109	6	6	3	2	2	6	18	36	20	7									8	1	0	2
May	1009	33	26	34	24	80		9	64	185	11	2	2	2	1	6	25	46	12	4									9	1	0	2
June	1009	32	25	32	25	80		12	61	178	10	2	2	1	6	13	29	29	12	6									8	1	⊕	3
July	1010	32	25	32	25	81		15	54	155	7	2	1	2	9	17	33	23	7	6									8	1	0	2
August	1010	32	25	32	25	80		22	45	135	8	2	1	1	7	9	17	42	13	8									7	1	0	1
September	1010	32	25	33	24	81		22	39	124	8	3	1	1	4	7	21	36	19	8									8	1	⊕	1
October	1010	32	24	33	24	80		20	45	360	15	5	1	1	5	8	13	37	23	7									9	1	0	2
November	1011	31	24	31	23	78		17	44	130	8	12	3	2	1	5	14	28	29	5									8	1	⊕	1
December	1011	31	23	31	22	77		36	32	362	11	15	30	6	8	1	6	9	20	5									7	1	⊕	2
Means	1010	32	24	—*	—**	79	—	—	—	—	—	9	14	4	4	7	15	25	16	6									8	—	—	—
Totals	—	—	—	—	—	—	—	—	—	2056	96	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	⊕	23
Extreme values	—	—	—	36†	22††	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
No. of years' observations	19											6																	15	—	15	15	19

*Mean of highest each year.
**Mean of lowest each year.

†Highest recorded temperature.
††Lowest recorded temperature.

⊕Rare.
øAll observations.
‡Force 7 in gusts.

Source: Meteorological Office, Bracknell.

DEPARTMENT OF METEOROLOGY
MALE'
REPUBLIC OF MALDIVES

DAILY WEATHER REPORT

FOR APRIL 1987

Station N.M.C.

Day	MEAN PRESSURE P1P1P1P1	TEMPERATURE Mean	Min	Max	Mean R/H %	Mean Cld Amt.	MEAN WIND (kts)	Sun Shine Hrs+Ths	Solar Radiation Cal/c^2m	RAIN FALL (mm)
01	1009.7	28.4	24.0	32.0	81	6	NNE 05	08.8		23.7
02	1010.3	28.7	27.6	31.9	80	7	ENE 05	04.4		3.9
03	1010.3	29.3	27.5	31.8	76	2	NNW 02	11.7		NIL
04	1010.8	29.3	26.6	32.4	78	6	SW 05	06.3		—
05	1011.1	28.9	27.2	32.2	77	7	CALM	04.8		—
06	1011.0	30.0	28.2	32.0	75	5	SE 04	09.8		TR
07	1011.3	30.3	27.2	32.3	75	2	SE 03	10.4		—
08	1010.8	30.0	27.8	32.8	75	3	SW 02	09.8		0.1
09	1011.1	30.4	28.5	33.0	73	1	W 08	11.0		—
10	1011.6	30.2	24.8	32.6	75	2	W 10	11.0		20.7
11	1011.9	29.3	27.6	32.0	80	5	WNW 08	08.4		—
12	1012.2	29.8	28.3	31.8	74	5	NW 12	10.6		—
13	1012.2	29.6	27.9	31.6	72	2	NW 11	10.9		—
14	1010.9	29.5	27.6	32.0	71	2	NW 08	11.2		—
15	1010.5	29.6	27.2	31.8	71	1	NW 06	11.3		—
16	1011.0	29.6	26.0	32.0	72	3	WNW 03	11.1		2.0
17	1011.1	27.7	24.2	31.6	84	5	SSW 04	06.9		42.8
18	1010.6	28.5	24.8	31.6	82	6	NE 07	05.6		13.1
19	1011.5	27.0	24.0	28.2	82	7	VRB 06	00.1		37.5
20	1010.2	29.5	27.9	32.0	74	3	NNW 07	11.4		TR
21	1010.5	28.5	24.6	32.1	81	6	NW 07	07.0		7.3
22	1011.1	28.0	25.5	31.0	84	6	NW 08	04.0		0.7
23	1010.9	27.9	24.0	28.8	75	7	WNW 07	00.8		15.2
24	1011.0	26.7	24.4	28.8	85	8	WNW 09	01.1		2.6
25	1010.1	28.1	25.2	31.4	81	6	WNW 06	07.0		17.6
26	1010.2	28.7	25.0	32.0	82	6	SSW 04	08.1		11.2
27	1010.3	28.7	25.3	31.3	82	5	WNW 07	07.2		51.8
28	1011.0	27.5	22.8	31.6	85	7	SSW 07	06.1		33.9
29	1010.2	28.5	27.0	31.7	75	6	W 06	05.2		—
30	1010.0	29.4	26.2	32.4	79	4	W 09	08.5		—
31								—		
Total								230.5		254.1
Mean										

MAX WIND: DIRECT ESE SPEED 43 KTS 49.5 DATE/TIME 28/1825 Z

THUNDER DAYS: 01, 17, 21, 22, 28

HEAVIEST RAINFALL: 51.8 MM DAY 27th

LOWEST MIN. TEMPERATURE 22.8°C LOWEST MAX. TEMPERATURE 28.2°C

HIGHEST MIN. TEMPERATURE 28.5°C HIGHEST MAX. TEMPERATURE 33.0°C

Asst FORECASTER's
~~Supervisor's~~ Name ABDUL MUHUSIN Signature

APPENDIX VII

TIDE OBSERVATION DATA BY THE UNIVERSITY OF HAWAII

APPENDIX VII TIDE OBSERVATION DATA BY THE UNIVERSITY OF HAWAII

University of Hawaii at Manoa

Department of Oceanography
Division of Natural Sciences
1000 Pope Road • Honolulu, Hawaii 96822
Telephone: (808) 948-7633 • Cable Address: UNIHAW

Mr. Abdudullahi Majeed
Director
Department of Meteorology
Male
Republic of Maldives

Dear Mr. Majeed

We have completed processing of the sea level data from Male for the months May and June 1987. I enclose plots of the data and listings of hourly readings for the entire period of record from February to June 1987. All data are referred to the zero point of the tide staff. Relevant bench mark information is also enclosed. A copy of this letter and of all enclosures is being send to Yachiyo Engineering in Tokyo.

The analysed data indicate that no excessive tides or sea levels were observed in April and June 1987 as stated in your letters. Monthly mean sea levels ranged from 201 cm in March to 211 cm in June, monthly maximum high water ranged from 253 cm in March and May to 261 cm in June. There is no indication of abnormal conditions at any time during the observation period. The original records indicate that waves were higher during the periods April 10 to 13 and June 15 to 20, but such wave action is largely filtered out by the tide well. The gauge is not designed to measure waves. I assume that the damage mentioned in your letter was due to high waves, but it is certainly not related to high sea level.

I hope that the enclosed information and comments will help in the construction of the new port facilities. I am glad to learn that the repairs on the breakwater have been completed and that the gauge will be installed soon. Mr. Ted Murphy is planning to visit your station at the end of October.

Best regards

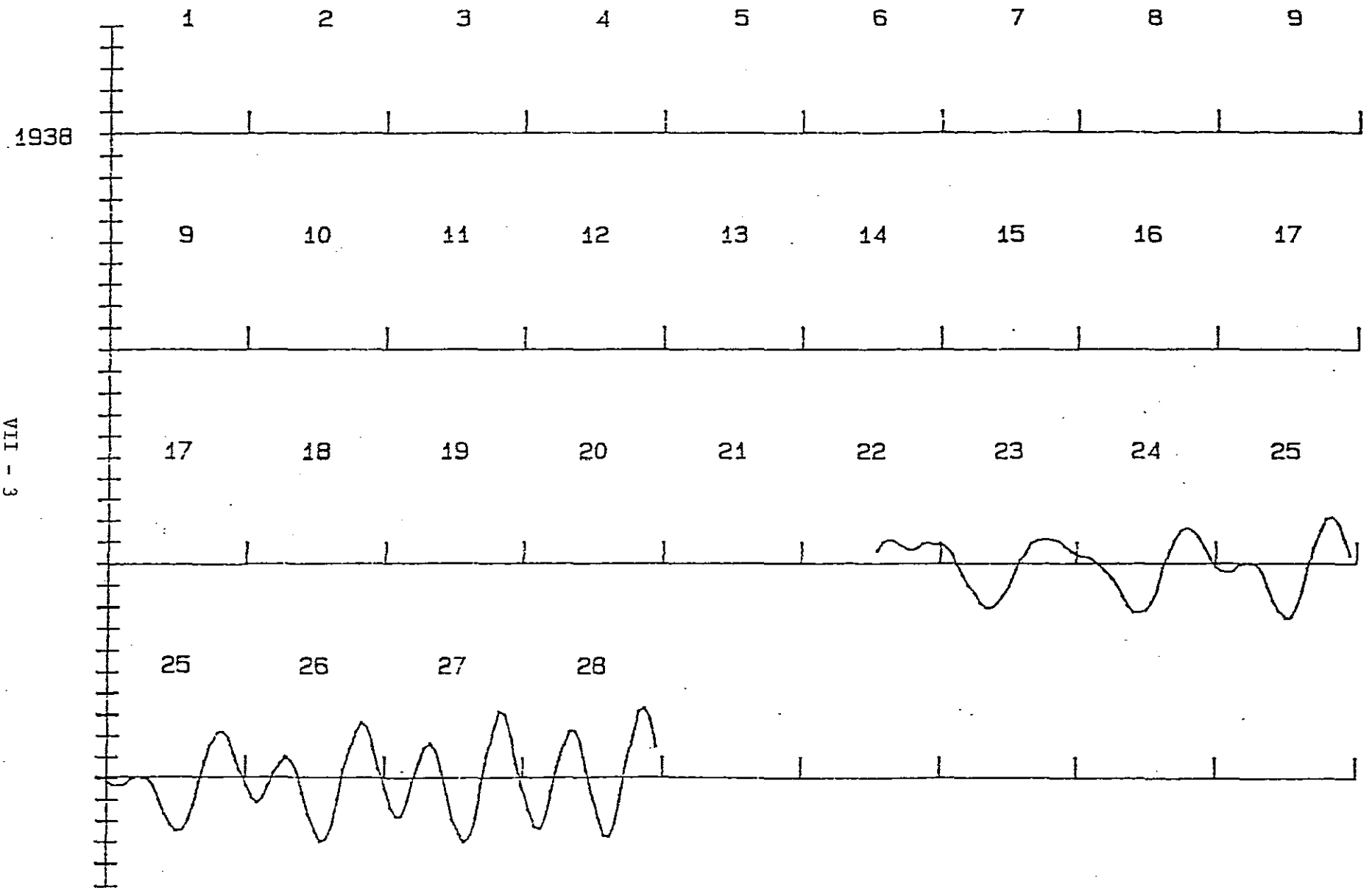
Very Truly Yours,

Klaus Wyrtki
Professor of Oceanography

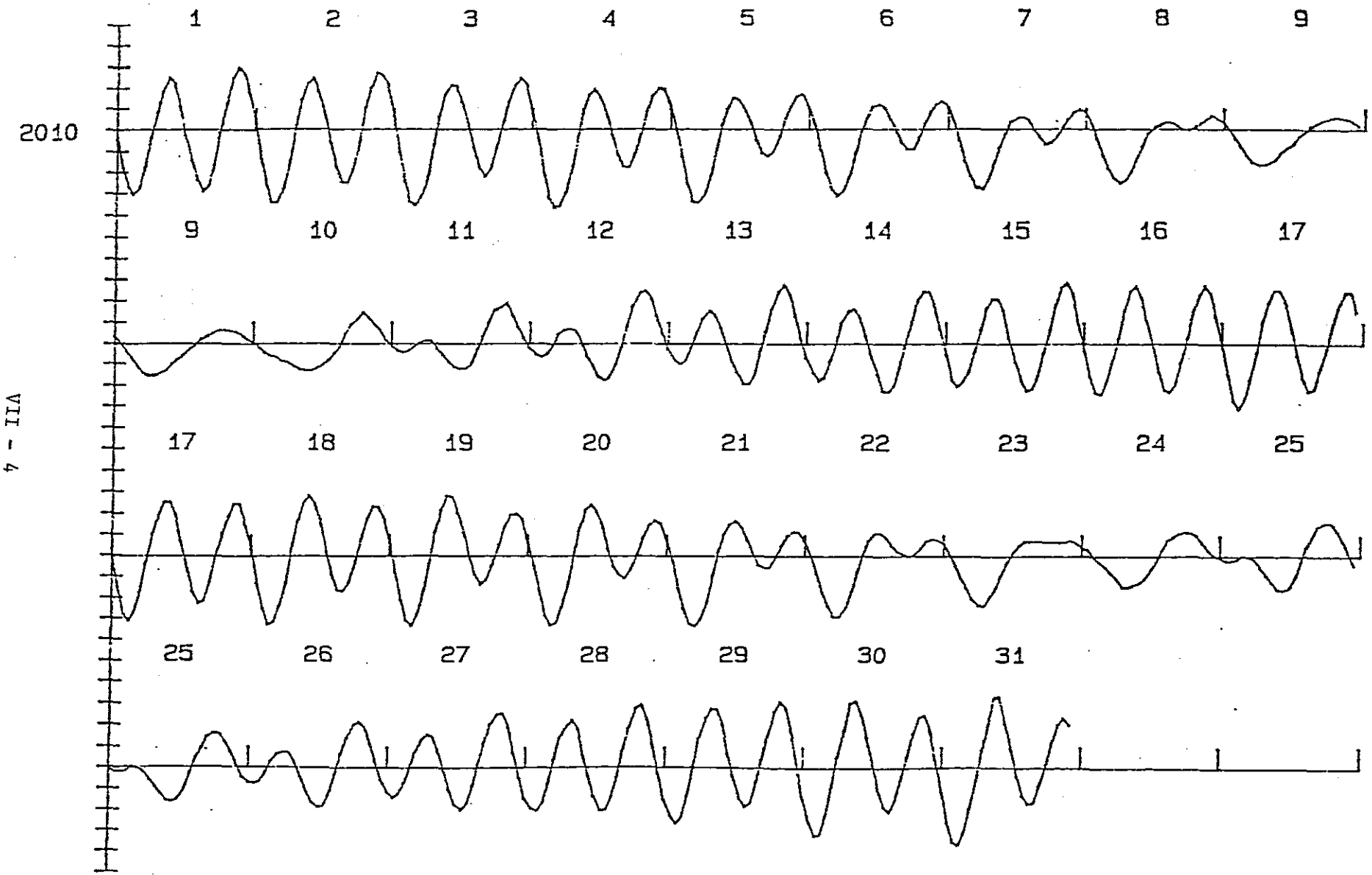
KW:rg

cc:Yachiyo Engineering Co., Ltd. - Mr. R. Teranishi

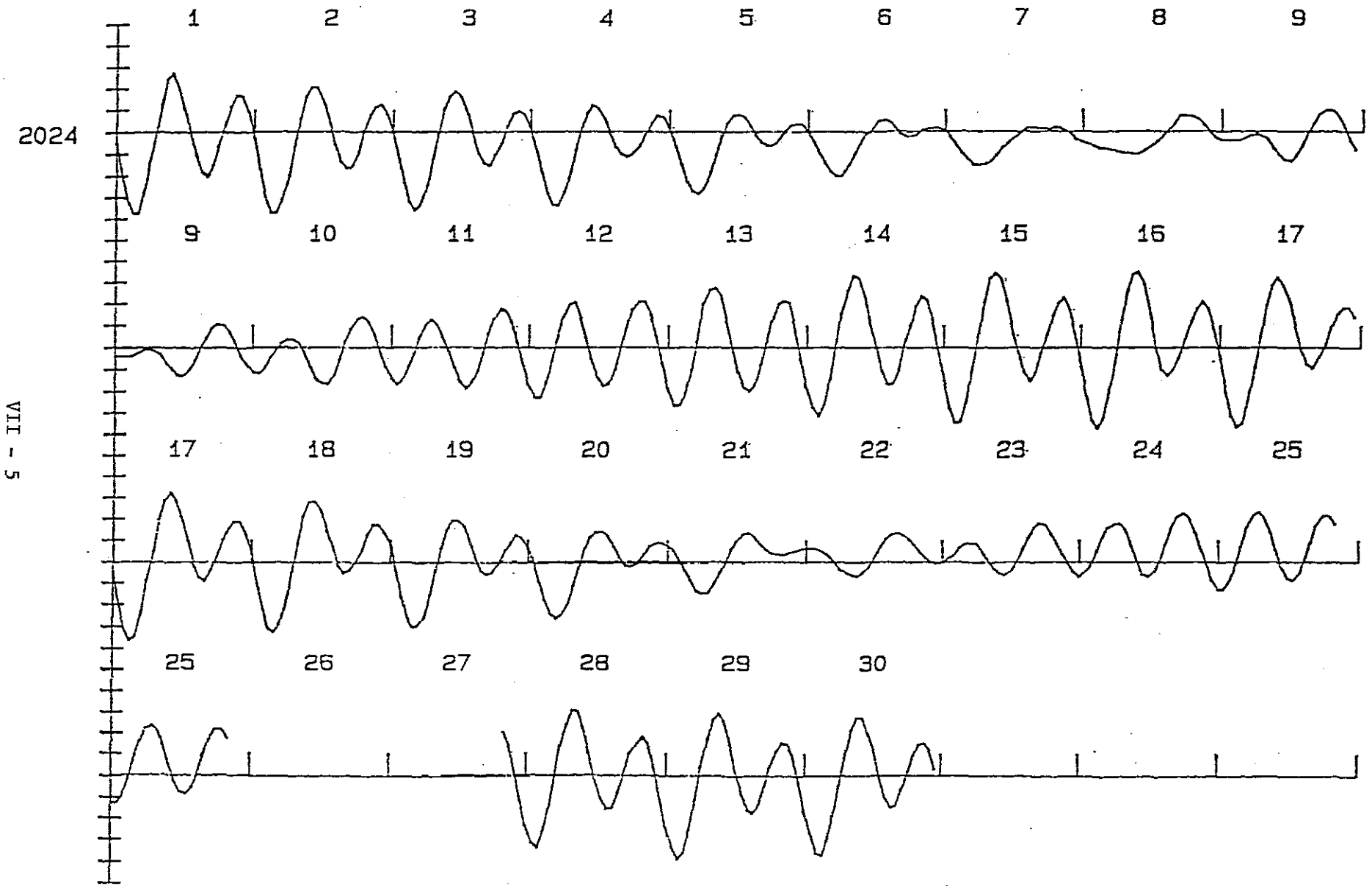
Encl.



STATION: MALE INTERVAL: 60 MINUTES SOURCE: ANA
VERTICAL SCALE: 150 MM/TIC Cmean=1928 Std=228 TMZONE=GMT REF=00000 FEB 87



STATION: MALE INTERVAL: 60 MINUTES SOURCE: ANA
VERTICAL SCALE: 150 MM/TIC Cmean=2010 Std=235 TMZONE=GMT REF=00000 MAR 87



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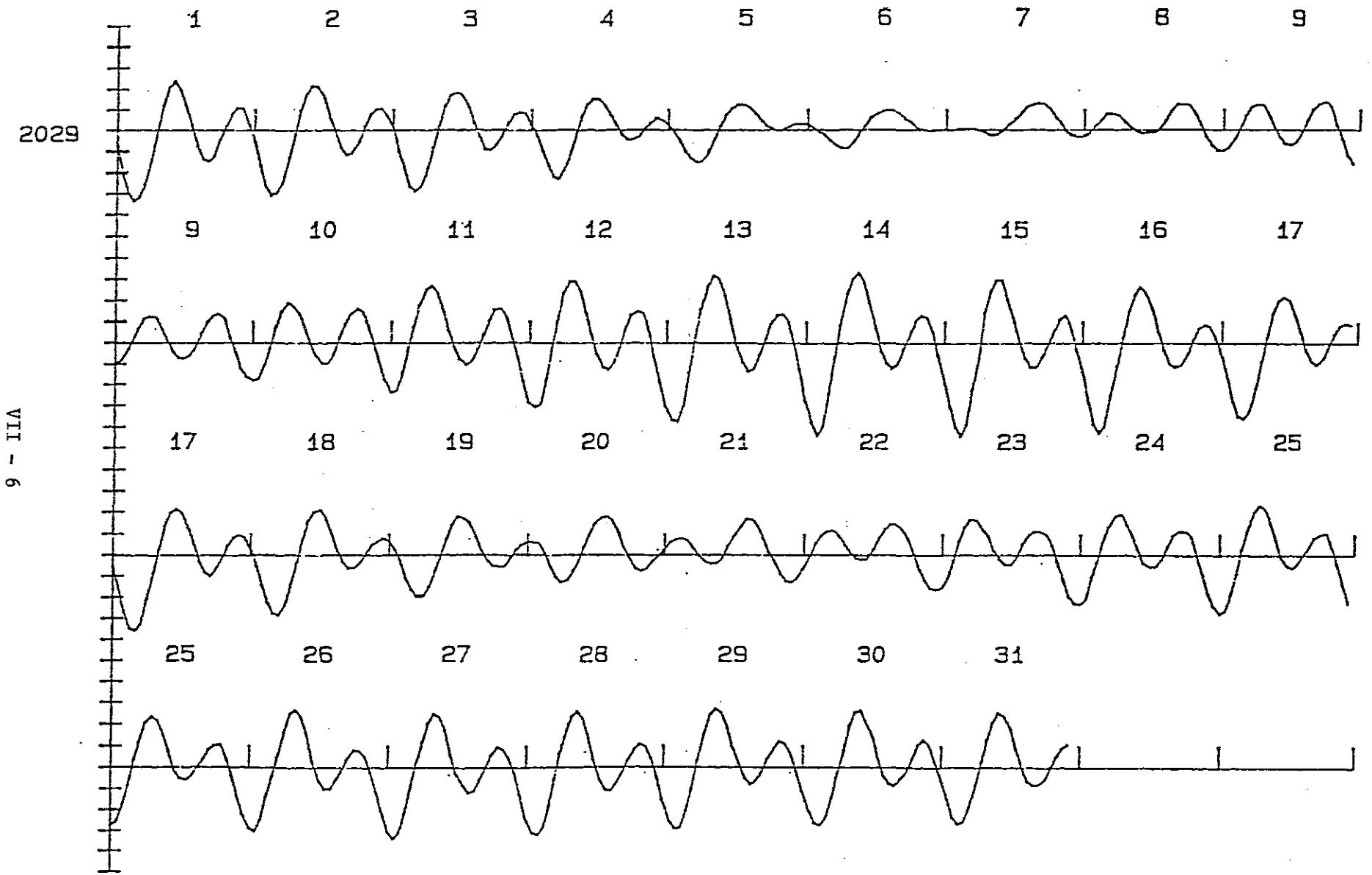
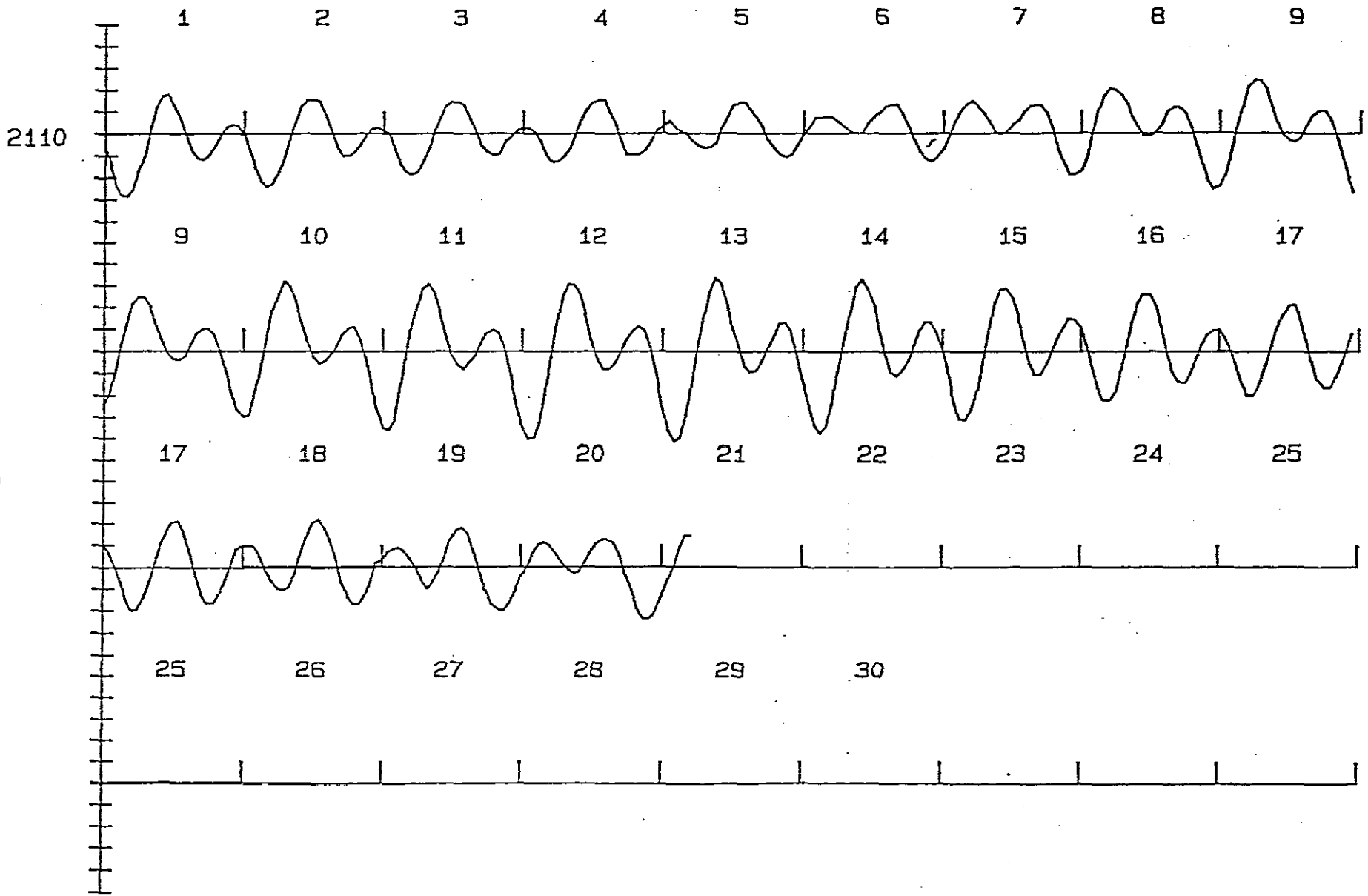


STATION: MALE INTERVAL: 60 MINUTES SOURCE: ANA
VERTICAL SCALE: 150 MM/TIC Cmean=2029 Std=216 TMZONE=GMT REF=00000 MAY 87



STATION: MALE INTERVAL: 60 MINUTES SOURCE: ANA
VERTICAL SCALE: 150 MM/TIC Cmean=2109 Std=214 TMZONE=GMT REF=00000 JUN 87

STATION 104 MALE FEB 1987 LAT = 04 10.8N LONG = 073 30.6E TZONE = GMT UNITS = CM SOURCE : ANALOG

DAMO	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AVE
1 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
2 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
3 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
4 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
5 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
6 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
7 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
8 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
9 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
10 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
11 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
12 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
13 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
14 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
15 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
16 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
17 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
18 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
19 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
20 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
21 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
22 2	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	203	209	211	210	207	204	203	205	208	209	207	9999
23 2	208	205	201	194	186	179	174	167	164	164	167	172	179	188	197	202	209	211	212	212	211	210	206	203	193
24 2	200	199	199	197	194	190	185	180	173	166	161	161	163	168	177	192	202	211	218	220	217	213	206	199	191
25 2	192	189	189	189	193	195	195	194	189	179	169	162	157	158	165	176	192	206	218	227	228	223	212	200	192
26 2	190	181	177	181	189	198	205	210	207	199	184	169	157	150	152	162	180	201	216	228	235	231	218	202	193
27 2	187	174	167	167	178	192	206	216	220	215	200	183	165	155	149	153	166	190	210	230	242	240	225	205	193
28 2	188	172	160	158	167	185	202	218	228	229	219	200	183	166	153	152	163	182	205	225	242	245	237	217	196

MAX = 245

MIN = 149

100	0
80	0
60	0
40	0
20	8
0	146

MEAN SEA LEVEL (MSL)	193
PAST REFERENCE LEVEL (Zo)	0
MEAN SEA LEVEL ABOVE STAFF ZERO (MSL - Z)	193

STATION 108 MALE MAR 1987 LAT = 04 10.8N LONG = 073 30.6E TZONE = GMT UNITS = CM SOURCE : ANALOG

DAMO	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AVE
1 3	195	176	162	156	161	176	195	214	230	240	235	219	198	181	167	159	163	178	200	221	240	247	243	229	199
2 3	206	182	163	151	151	161	181	205	224	236	240	230	212	194	177	166	165	175	194	218	233	244	242	235	199
3 3	212	187	166	152	149	155	170	192	212	228	235	234	223	205	189	176	170	176	190	208	223	235	240	235	198
4 3	218	197	173	155	148	149	159	177	198	217	228	232	226	213	199	185	177	176	185	200	216	227	233	231	197
5 3	222	203	184	165	152	151	156	171	189	206	218	226	224	216	207	195	186	184	188	198	211	220	227	229	197
6 3	220	207	189	173	161	156	160	171	187	201	211	219	221	218	210	202	194	189	189	197	207	215	221	223	198
7 3	218	208	195	180	170	162	161	168	179	190	199	208	211	212	209	202	197	192	194	198	204	210	215	217	196
8 3	214	207	196	185	176	169	165	168	174	183	191	200	204	206	208	207	205	202	202	204	207	210	213	210	196
9 3	207	202	196	191	185	180	178	178	180	182	187	190	193	198	201	205	207	209	211	212	211	210	208	205	197
10 3	202	199	195	193	192	189	188	185	183	182	182	184	187	190	195	200	209	216	220	225	221	216	212	205	199
11 3	200	197	195	197	200	203	205	204	198	194	189	185	183	184	188	198	207	217	226	228	231	223	214	206	203
12 3	199	194	192	195	201	209	212	213	211	203	193	186	178	175	179	187	199	214	228	238	240	234	222	210	205
13 3	198	190	187	190	200	210	220	226	223	214	202	190	181	173	173	180	197	211	226	239	244	237	223	206	206
14 3	192	181	175	178	189	201	217	225	227	221	208	194	180	168	167	172	185	201	218	233	239	239	229	213	202
15 3	194	176	171	175	181	195	212	227	234	234	226	206	189	176	168	170	179	195	212	230	242	245	238	218	204
16 3	197	178	167	165	175	188	206	225	239	243	235	219	200	182	169	167	173	188	206	225	236	243	238	222	204
17 3	200	180	161	155	162	176	196	217	231	240	240	232	213	194	177	168	170	183	200	217	230	239	239	225	202
18 3	207	183	165	153	155	166	183	208	227	240	245	239	225	205	189	178	177	183	198	214	229	237	237	230	203
19 3	212	190	171	156	152	160	177	197	219	235	245	244	233	219	202	189	182	185	195	210	223	232	233	229	204
20 3	215	196	178	160	153	155	166	183	203	222	235	239	234	223	207	195	189	186	192	203	215	224	228	226	201
21 3	216	200	180	165	154	152	157	170	188	205	218	225	228	223	214	205	196	194	194	202	210	217	220	220	198
22 3	214	203	190	177	167	159	159	166	177	191	203	213	219	219	216	210	206	204	202	204	208	213	215	214	198
23 3	211	204	196	187	180	172	167	167	173	179	188	197	205	210	213	213	213	213	212	213	212	212	214	212	198
24 3	208	207	202	198	195	191	186	180	180	182	183	186	193	199	207	214	216	219	220	219	217	212	207	203	201
25 3	201	199	199	200	203	202	200	194	189	184	179	178	180	187	198	209	216	224	227	226	221	214	205	196	201
26 3	192	191	193	199	207	212	214	213	206	196	187	178	174	176	185	198	212	223	233	235	230	220	207	194	203
27 3	185	181	184	191	201	213	222	226	224	214	201	187	176	172	177	189	205	220	233	240	241	231	213	196	205
28 3	180	173	171	177	191	208	224	232	236	230	212	197	182	171	172	181	195	214	230	244	247	236	219	199	205
29 3	180	168	162	167	182	201	223	237	244	244	233	213	197	181	175	178	192	208	225	242	249	245	228	208	208
30 3	183	165	154	155	169	188	210	229	248	250	240	225	205	187	175	171	179	193	211	227	238	240	229	209	203
31 3	185	163	149	146	156	173	194	215	233	252	253	234	216	197	183	177	178	190	205	221.	233	238	233	217	202

MAX = 253

MIN = 146

100	0
80	0
60	0
40	0
20	43
0	700

MEAN SEA LEVEL (MSL)	201
PAST REFERENCE LEVEL (Zo)	0
MEAN SEA LEVEL ABOVE STAFF ZERO (MSL - Z)	201

STATION 108 MALE APR 1987 LAT = 04 10.8N LONG = 073 30.6E TZONE = GMT UNITS = CM SOURCE : ANALOG

DAMO	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	AVE
1 4	195	173	157	147	147	161	182	203	222	240	244	234	219	202	187	175	172	180	193	209	221	229	228	218	197
2 4	200	178	159	148	148	157	174	194	213	228	235	235	224	210	195	183	178	180	190	205	215	221	223	216	196
3 4	203	186	169	156	150	154	167	185	202	219	228	232	228	216	202	189	182	180	188	196	208	216	218	215	195
4 4	207	192	176	162	154	153	162	176	191	206	216	222	220	212	202	193	188	186	189	194	202	209	215	214	193
5 4	207	195	182	170	163	161	165	176	188	200	210	215	216	213	207	201	196	194	194	198	204	208	209	209	195
6 4	204	197	189	182	176	173	174	181	188	195	202	204	211	212	211	207	202	200	200	202	205	206	206	206	197
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11 4	182	178	182	190	199	210	219	223	219	210	201	190	181	175	179	187	199	213	223	230	228	221	207	192	202
12 4	178	169	169	179	194	209	224	233	235	224	210	195	183	177	179	188	202	216	229	235	235	226	211	193	204
13 4	176	163	164	173	188	207	233	243	245	239	222	204	187	176	173	178	191	205	221	233	236	234	216	195	204
14 4	177	162	156	164	181	203	226	243	253	251	239	221	203	187	178	178	187	204	218	232	239	236	223	203	207
15 4	181	162	151	152	165	187	212	235	251	255	251	236	213	199	186	180	186	199	212	225	234	238	230	214	206
16 4	190	170	153	147	154	172	196	222	241	254	256	248	226	203	188	184	188	196	209	221	230	235	230	217	205
17 4	196	173	156	148	151	167	189	210	232	246	252	246	235	218	202	192	189	196	205	218	226	231	231	224	206
18 4	209	188	170	157	154	160	175	195	216	235	245	246	239	225	214	201	195	197	204	211	222	229	229	224	206
19 4	215	198	179	166	158	159	165	180	197	213	226	232	232	227	216	205	197	194	196	203	211	216	222	220	201
20 4	214	203	190	177	167	164	166	174	186	199	212	220	224	225	221	214	206	201	200	203	208	214	216	217	201
21 4	215	211	204	198	191	183	181	182	188	195	203	212	218	223	224	221	216	212	209	208	208	210	211	212	206
22 4	213	213	212	210	207	203	198	196	194	193	196	200	208	214	220	223	224	222	219	215	210	206	203	202	204
23 4	203	206	208	213	216	217	216	210	204	199	196	194	198	204	212	220	227	231	229	223	217	209	203	197	211
24 4	193	197	201	210	220	227	230	231	226	216	205	195	193	197	205	216	227	235	238	234	224	213	202	191	214
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29 4	169	153	145	150	165	186	209	229	243	248	241	226	207	190	180	177	184	196	209	220	227	226	217	200	200
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MAX = 256

MIN = 145

100	0
80	0
60	0
40	0
20	39
0	633

MEAN SEA LEVEL (MSL)	202
PAST REFERENCE LEVEL (Zo)	0
MEAN SEA LEVEL ABOVE STAFF ZERO (MSL - Z)	202

STATION 108 MALE MAY 1987 LAT = 04 10.8N LONG = 073 30.6E TZONE = GMT UNITS = CM SOURCE : ANALOG

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2 5	194	178	163	156	158	165	183	199	217	229	235	234	226	212	201	190	185	187	194	205	214	218	219	213	199
3 5	204	188	176	163	159	162	175	190	205	220	228	230	228	220	208	198	189	188	192	200	208	214	216	215	199
4 5	207	198	188	178	170	168	175	187	200	213	222	226	226	221	214	207	200	196	196	199	204	208	212	210	201
5 5	207	201	195	188	183	180	181	188	197	206	214	219	222	222	219	215	210	206	204	202	204	206	208	208	204
6 5	208	204	201	199	195	192	190	190	195	201	206	212	215	217	218	217	215	211	208	204	203	202	202	203	205
7 5	203	202	204	204	204	204	202	200	199	200	203	207	211	215	220	222	223	222	218	212	208	201	199	198	208
8 5	199	201	206	210	215	215	213	209	205	202	200	201	201	204	210	217	222	222	221	215	207	198	192	188	207
9 5	188	191	197	204	213	220	222	221	214	205	198	193	192	195	201	210	218	222	224	220	207	197	185	179	205
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11 5	168	170	181	198	215	230	241	244	238	227	213	201	192	188	191	199	209	219	227	228	221	207	194	176	207
12 5	161	157	160	177	200	219	238	247	247	239	225	210	196	186	184	190	200	214	223	226	224	212	192	175	204
13 5	158	148	147	158	182	207	227	243	251	248	237	221	203	190	183	185	195	205	217	223	224	218	203	185	202
14 5	163	147	137	144	167	192	216	238	249	253	246	232	214	198	189	185	189	199	210	219	223	221	212	195	202
15 5	175	158	144	137	145	169	193	225	240	248	248	234	219	204	193	186	186	193	203	212	220	223	215	199	199
16 5	183	163	146	139	144	165	187	207	225	237	243	238	227	212	199	189	186	188	196	206	214	217	215	207	197
17 5	194	179	162	151	149	156	171	190	207	224	233	236	233	223	212	199	191	188	193	202	210	216	218	216	198
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19 5	213	207	199	187	179	174	175	181	192	203	215	225	231	229	226	217	207	200	196	195	195	201	207	211	203
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21 5	207	213	215	216	214	209	203	199	197	198	202	210	217	224	229	229	225	216	206	198	190	185	184	188	207
22 5	194	203	212	218	221	222	218	211	205	201	200	201	208	216	222	226	226	223	215	205	194	186	180	179	208
23 5	181	188	200	214	224	229	228	222	217	207	201	197	197	203	212	218	221	221	218	211	199	187	175	170	206
24 5	169	173	188	199	213	224	231	233	226	218	208	198	195	195	201	209	218	221	221	217	204	191	177	168	204
25 5	162	165	176	190	208	221	234	239	236	227	215	202	196	194	198	204	209	216	219	220	210	198	183	170	204
26 5	160	157	166	182	195	210	228	241	244	239	228	209	194	188	188	194	201	209	216	215	211	200	187	173	201
27 5	157	152	157	170	188	205	221	234	241	239	230	213	199	191	185	187	195	203	212	218	216	210	200	184	200
28 5	167	156	154	160	175	194	213	229	239	243	238	226	209	194	187	186	192	199	208	216	220	218	210	197	201
29 5	180	165	159	160	172	188	208	227	240	245	242	233	218	206	196	191	194	200	209	217	222	220	213	201	204
30 5	187	173	164	162	168	181	198	215	232	242	244	235	225	210	198	192	190	195	201	210	219	223	219	208	204
31 5	194	182	168	163	165	175	191	207	223	235	242	240	231	217	204	194	191	191	195	203	211	217	220	215	203

MAX = 253

MIN = 137

100	0
80	0
60	0
40	0
20	20
0	723

MEAN SEA LEVEL (MSL)	203
PAST REFERENCE LEVEL (Zo)	0
MEAN SEA LEVEL ABOVE STAFF ZERO (MSL - Z)	203

STATION 108 MALE JUN 1987 LAT = 04 10.8N LONG = 073 30.6E TZONE = GMT UNITS = CM SOURCE : ANALOG

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2 6	210	199	188	179	175	177	185	196	209	220	230	234	235	233	224	214	203	196	196	199	204	210	214	215	206
3 6	213	211	201	191	186	183	185	193	201	213	222	230	233	233	230	221	213	203	199	196	198	206	209	213	201
4 6	215	215	212	206	197	192	192	196	201	210	220	227	232	235	234	226	218	206	197	197	197	200	206	213	210
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9 6	175	183	198	215	229	243	248	247	241	229	219	210	206	205	208	216	223	226	227	221	210	197	183	171	214
10 6	166	168	184	200	218	238	250	259	255	245	232	219	207	203	205	209	214	222	227	228	219	207	190	173	214
11 6	159	157	163	183	205	225	242	254	257	251	238	223	209	202	199	204	208	216	223	226	223	214	197	178	211
12 6	161	151	152	162	182	206	228	249	257	256	250	236	219	205	199	199	203	210	218	225	228	225	214	197	210
13 6	175	157	149	152	166	187	211	235	252	261	257	244	228	214	201	197	198	204	212	221	230	231	225	209	209
14 6	192	175	161	155	160	175	197	220	238	255	260	254	242	225	209	197	194	198	205	215	225	231	231	224	210
15 6	211	195	176	165	164	171	185	206	225	244	253	254	247	235	218	203	195	195	203	212	220	227	233	232	211
16 6	227	215	200	186	178	177	183	198	214	230	244	250	249	242	228	211	197	190	189	196	206	215	222	225	211
17 6	226	220	211	201	189	181	181	190	201	213	226	235	242	243	233	220	205	192	186	186	193	202	212	223	209
18 6	226	226	225	218	209	202	196	195	198	207	220	231	242	245	239	230	218	201	191	186	186	192	201	214	212
19 6	217	222	224	225	222	217	210	202	196	202	209	218	230	237	239	234	222	209	196	186	183	181	186	194	211
20 6	205	212	221	227	229	226	221	214	210	207	208	214	221	228	231	230	228	220	207	195	183	176	176	180	211
21 6	190	203	211	223	233	233	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
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25 6	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
26 6	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
27 6	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
28 6	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999	9999
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MAX = 261

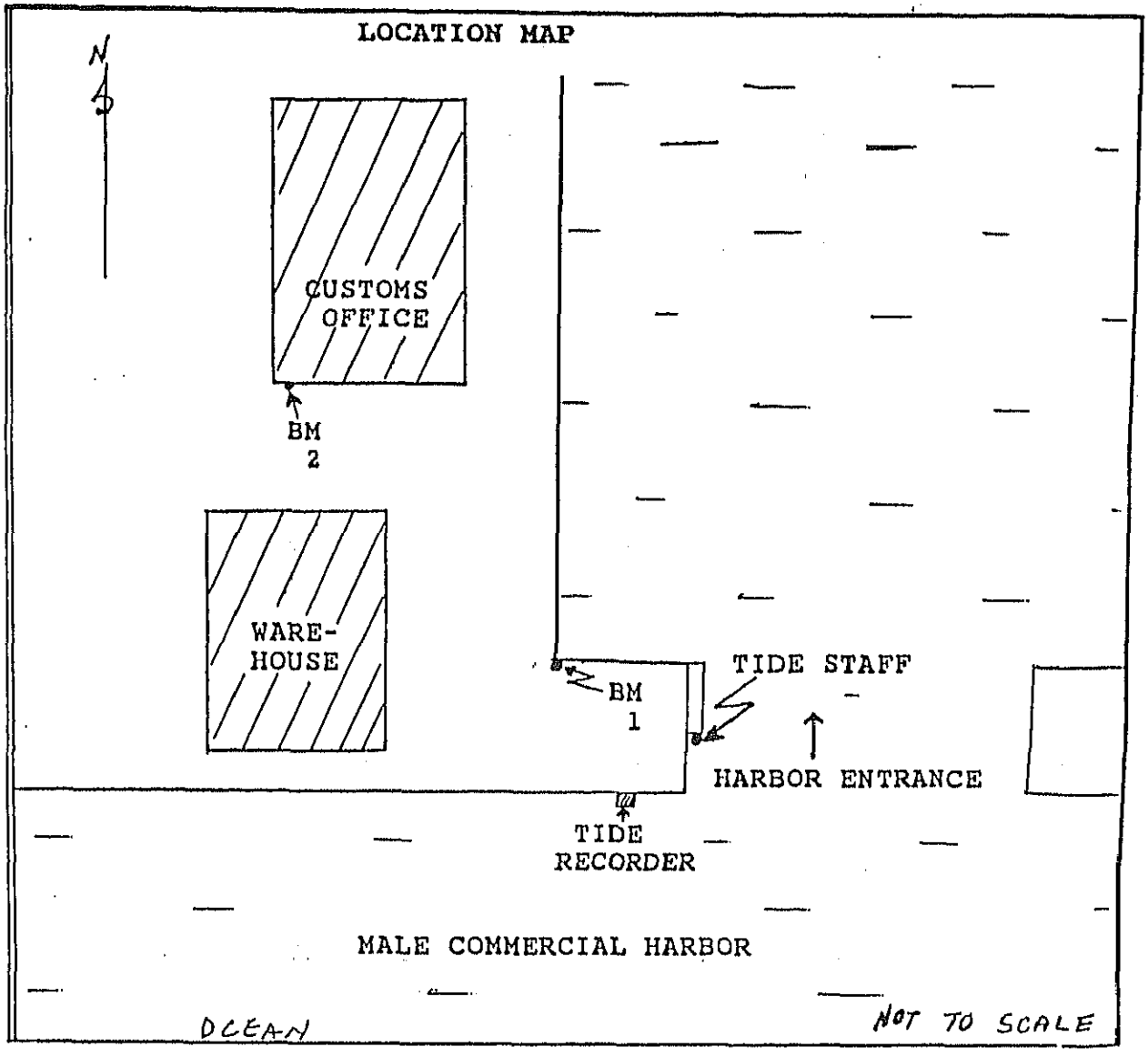
MIN = 149

100	0
80	0
60	0
40	0
20	15
0	470

MEAN SEA LEVEL (MSL)	211
PAST REFERENCE LEVEL (Zo)	0
MEAN SEA LEVEL ABOVE STAFF ZERO (MSL - Z)	211

Station # 108 **MALE, MALDIVES**

July 9, 1987



Datum for MSL data is based on the zero of Tide Staff

BM ELEVATIONS

BM @	9.843 ft	3.000 m
BM 1	10.096 ft	3.077 m
BM 2	10.700 ft	3.261 m

FORM 006

STATION #108 MALE, MALDIVES

July 9, 1987

TIDE STATION BENCHMARK LEVELLING UPDATE

levelling date: Feb 23, 1987

Elevation of @ above zero of tide staff = 9.843 ft (3.000 m)

Old/New staff correction =

Corrected @ =

DIFFERENCES IN ELEVATION

SECTION DESIGNATION	FORWARD RUN	BACKWARD RUN	MEAN
@ -> BM 1	0.254	- 0.252	0.253
BM 1 -> BM 2	0.610	- 0.598	0.604

BM ELEVATIONS ABOVE TIDE STAFF ZERO

BM @	9.843	ft	3.000	m
BM 1	10.096	ft	3.077	m
BM 2	10.700	ft	3.261	m

NOTES:

Datum for MSL data is the tide staff zero.

FORM 007

STATION #108 MALE, MALDIVES

July 9, 198

TIDAL BENCHMARK LEVELLING RECORD

DATE	BM @	BM 1	BM 2	BM	BM	BM	REMARKS
Feb 23,87	9.843	10.096	10.700				Elevation in ft.

APPENDIX VIII

TIDE LEVEL DATA AT MALE' ISLAND

IN THE MALDIVES AND AT

THE PORT OF COLOMBO IN SRI LANK

APPENDIX VIII TIDE LEVEL DATA AT MALE' ISLAND IN THE MALDIVES AND AT THE PORT OF COLOMBO IN SRI LANK

I. Outline of Tide Observation

Up to the present, no full-scale tide level observation extending over a long period has been carried out in the Maldives and no datum level has been established.

In order to establish datum level and mean sea level in the Maldives in this basic design study, two hydraulic type self-recording tide gauges were installed at Male' Island and at the Port of Colombo and tide level observation was conducted during the following period.

Observation period

Male' Island : 10th Aug. 1987 to 13th Sept. 1987

Port of Colombo : 8th Aug. 1987 to 15th Sept. 1987

In addition, tide gauges were installed at the Port of Colombo due to the following reasons:

In view of the fact that the Port of Colombo is the nearest port to Male' Island and tide level observation data for more than twenty years is available, the Port can be deemed a standard port for Male' Island.

By clarifying the relationship between the said existing tide level data and the tide level observation data obtained in this study, the datum level and mean sea level at Male' Island can be found based on the tide level observation results at Male' Island and at the Port of Colombo.

Through the full cooperation extended by the ports authority of Sri Lanka, it was possible to install two tide gauges at the existing tide observatory within the Port of Colombo. The location of the tide gauge is shown in Fig. A8-1.

For tide level observation and maintenance of the tide gauges at the Port of Colombo, the study team requested the staff of the port authority in charge of observation of the existing tide gauge to extend cooperation to the team.

At Male' Island on the other hand, two tide gauges were installed inside of Male' harbour adjacent to the office of the port authority with the cooperation of the DPWL and the port authoriy. The location of the tide gauge is shown in Fig. A8-2.

For tide level observation and maintenance of the tide gauges at Male' Island, a member of the JOCV, Mr. Yoshida, was requested to assist the Team.

The tide observation data at the above two places was recorded for more than one month and dismantling of the tide gauges was carried out between the 11th and 17th of September, 1987. As a result, satisfactory tide records with very small missing rates were obtained. The results of analysis based on these records and the collected data are shown in the next pages.

II. Results of Analysis

(1) Summary of Analysis Results

Although the contents of analysis carried out based on the tide level observation records and collected data are described in Paragraph (2) below, the results of analysis are summarized as follows:

1) As a result of conducting harmonic analysis of tides at Male' Island and the Port of Colombo and comparing the four dominant constituent tides of harmonic constants, there was almost no difference in the constants between the two places.

2) As a result of comparing the pattern of tides at Male' Island with that at the Port of Colombo, both tide patterns were quite similar.

3) As a result of calculating the time difference for tide, height ratio and the standard deviations of sea levels, the following facts were found:

   a) The tide time at Male' Island is by 1 hour and 28 minutes ahead of that at the Port of Colombo.

   b) The ratio of the highest high tide at Male' Island to that at the Port of Colombo is 1.24 and roughly similar to 1.0.

   c) No substantial difference in the fluctuation of tide level was observed at both Male' Island the Port of Colombo.

4) Mean sea level at the Port of Colombo

The difference between the mean sea level (ΔH) based on the existing tide level data (1953 - 1956) and monthly mean water level observed under this study at the Port of Colombo is as follows:

$$\Delta H = H_1 - H_2$$

where H_1 : Montly mean water level observed under this study (cm)

H_2 : Mean sea level based on the existing tide level data (1953 - 1956)

$$\Delta H = 43 - 51 = -8\text{cm}$$

5) Judging from Items 1), 2) and 3) above, it can be mentioned that the constituents and pattern of tides at Male' Island is very similar to that at the Port of Colombo and the height ratio is comparatively minor with the time difference for tide being small as well. This fact indicates it is justifiable to have selected the Port of Colombo as a standard port for Male' Island.

Therefore, the mean sea level at Male' Island has been corrected by using a mean sea level correction value of 8cm at the Port of Colombo as calculated in Item 4) above.

(2) Contents of analysis

On the basis of the tide observation records and the data collected under this study, analysis were carried out as presented below.

1) Analysis based on the tide observation data made by the study team

a) Harmonic analysis of tides

Based on the Darwin's method, harmonic analysis of the tide concerning data for 30 days was carried out. The results are shown in Tables A8-3 to A8-6.

b) Comparison of the patterns of tides

In order to compare the pattern of tides at Male' Island with that at the Port of Colombo, the pattern at Male' Island was superimposed on that at the Port of Colombo with the adjustment of the local time and the results are shown in Figs. A8-7 and A8-8.

c) Calculation of time difference for tide and height ratio

On the basis of the Port of Colombo as a standard port, the time difference for tide and height ratio at Male' Island were calculated in accordance with "Tides", the Textbook on Water Channel Surveying Techniques published by the Japan Hydrographic Association, and the results are shown in Table A8-1.

Table A8-1 Height ratio and time difference for tide.

Height ratio	Time difference for tide
1.24	-1 hours and 28 min.

Detailed calculation methods of the time difference for tide and height ratio are as presented below:

Time difference for tide

$$= (Km/29) - (Km/29)o + 31/30\ (Lo - L) + (S - So)$$

Height ratio

$$= (Hm + Hs)/(Hm + Hs)o$$

where Km : Phase lag of M2 constituent tides (degree),

L : East longitude expressed in terms of time (L = 5.0 hours, Lo = 5.5 hours),

S : Standard time (S = 5.0 hours, So = 5.5 hours),

Hm : Amplitude of M2 constituent tide (m) (Refer to Table A8-9),

and Hs : Amplitude of S2 constituent tide (m) (Refer to Table A8-9).

The symbol 'o' attached to each data above shows the data pertain to the standard port.

Time difference for tide

$$= (16.7/29) - (59.8/29) + 31/30\ (5.5 - 5.0) + (5.0 - 5.5)$$

$$= -1.47 = -1 \text{ hour and } 28 \text{ minutes}$$

Height ratio

$$= (0.23 + 0.13)/(0.17 + 0.12)$$

$$= 1.24$$

d) Standard deviation of sea level

The standard deviations of the sea level for 30 days at Male' Island and the Port of Colombo are as shown in Table A8-2 below:

Table A8-2 Mean sea level and standard deviation of sea level.

	Mean values (H) (cm)	Standard deviation (σ) (cm)
Male' Island	292.52	23.9
Colombo Port	300.96	18.8

The standard deviations were calculated as follows:

① Male' Island

Mean value ($\overline{H}$)

$$\Sigma Hi = 215,877$$

$$N = 733$$

$$\overline{H} = \frac{\Sigma Hi}{N} = 292,516$$

Standard deviation (σ)

$$\Sigma (Hi - \overline{H})^2 = 420,326.305$$

$$\sigma = \sqrt{\frac{\Sigma (Hi - \overline{H})^2}{N}} = 23,865$$

② the Port of Colombo

Mean value ($\overline{H}$)

$$\Sigma Hi = 223,915$$

$$N = 774$$

$$H = \frac{\Sigma Hi}{N} = 300,961$$

Standard deviation (σ)

$$\Sigma(Hi - \overline{H})^2 = 262,877.87$$

$$\sigma = \sqrt{\frac{\Sigma(Hi - H)^2}{N}} = 18,797$$

2) Harmonic analysis of tides based on the records of tide level observed by the University of Hawaii

On the basis of the observation records of the University of Hawaii attached to APPENDIX VII, harmonic analysis of tides was carried out. The semi-range of four dominant constituent tides obtained based on this harmonic analysis is as shown in Table A8-7.

3) Harmonic analysis of tides based on the existing tide level data at the Port of Colombo.

Harmonic analysis was conducted based on the tide level data in 1953 through 1956 out of all the data obtained at the Colombo Ports Authority as missing values were few over this period.

The semi-range of four dominant constituent tides obtained according to this harmonic analysis is as presented in Table A8-7.

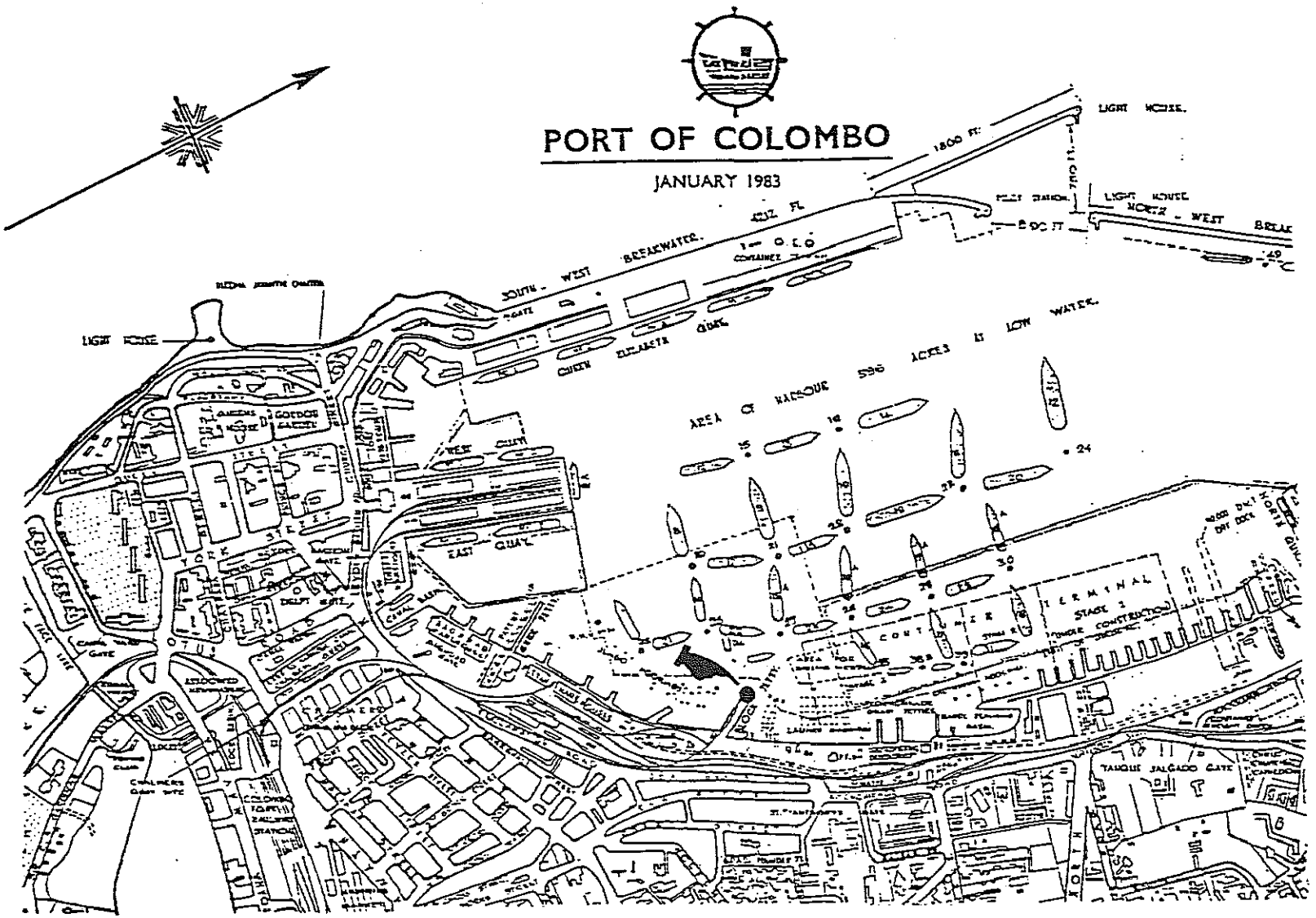


Fig. A8-1 Location of tide gauge (Port of Colombo).

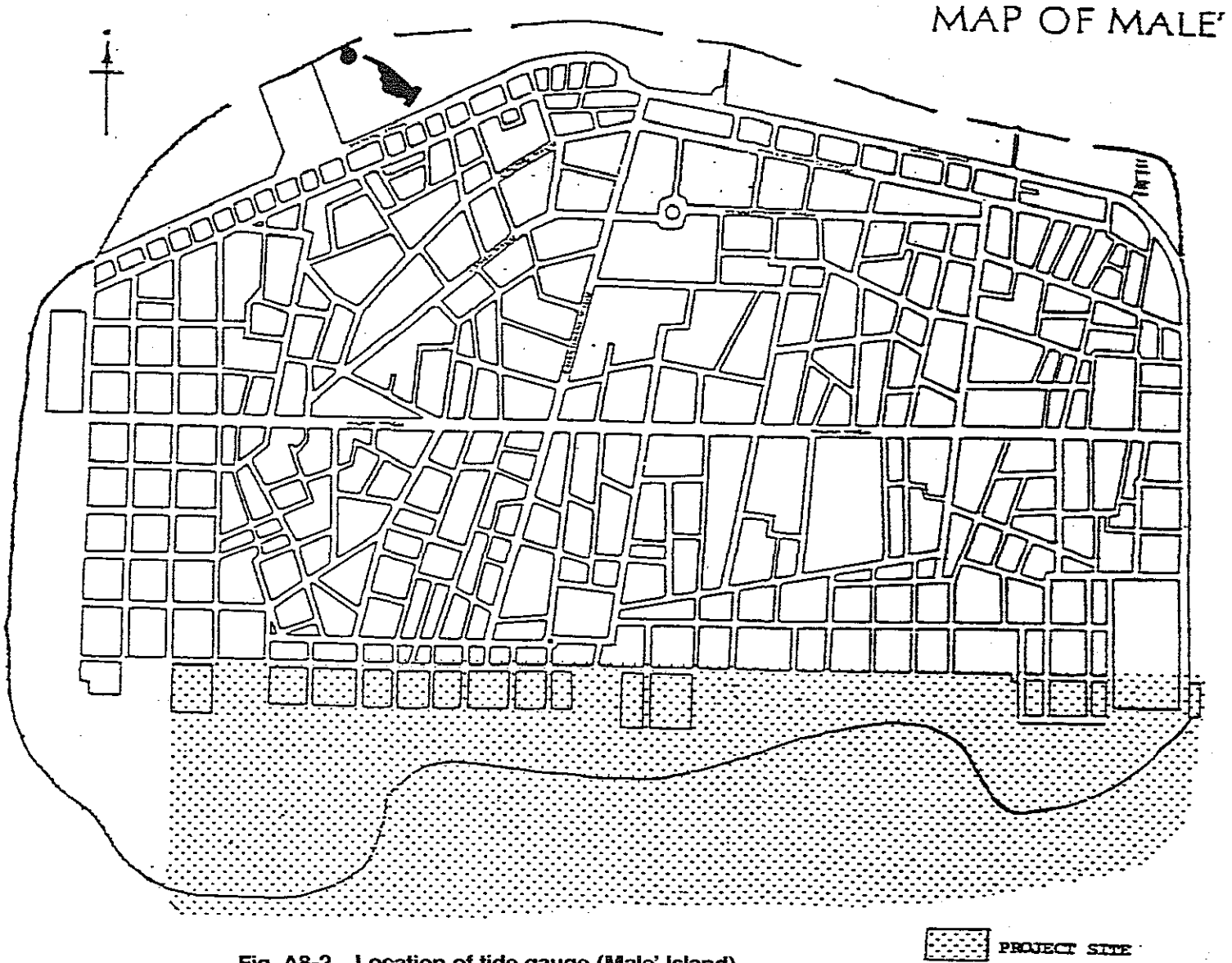


Fig. A8-2 Location of tide gauge (Male' Island).

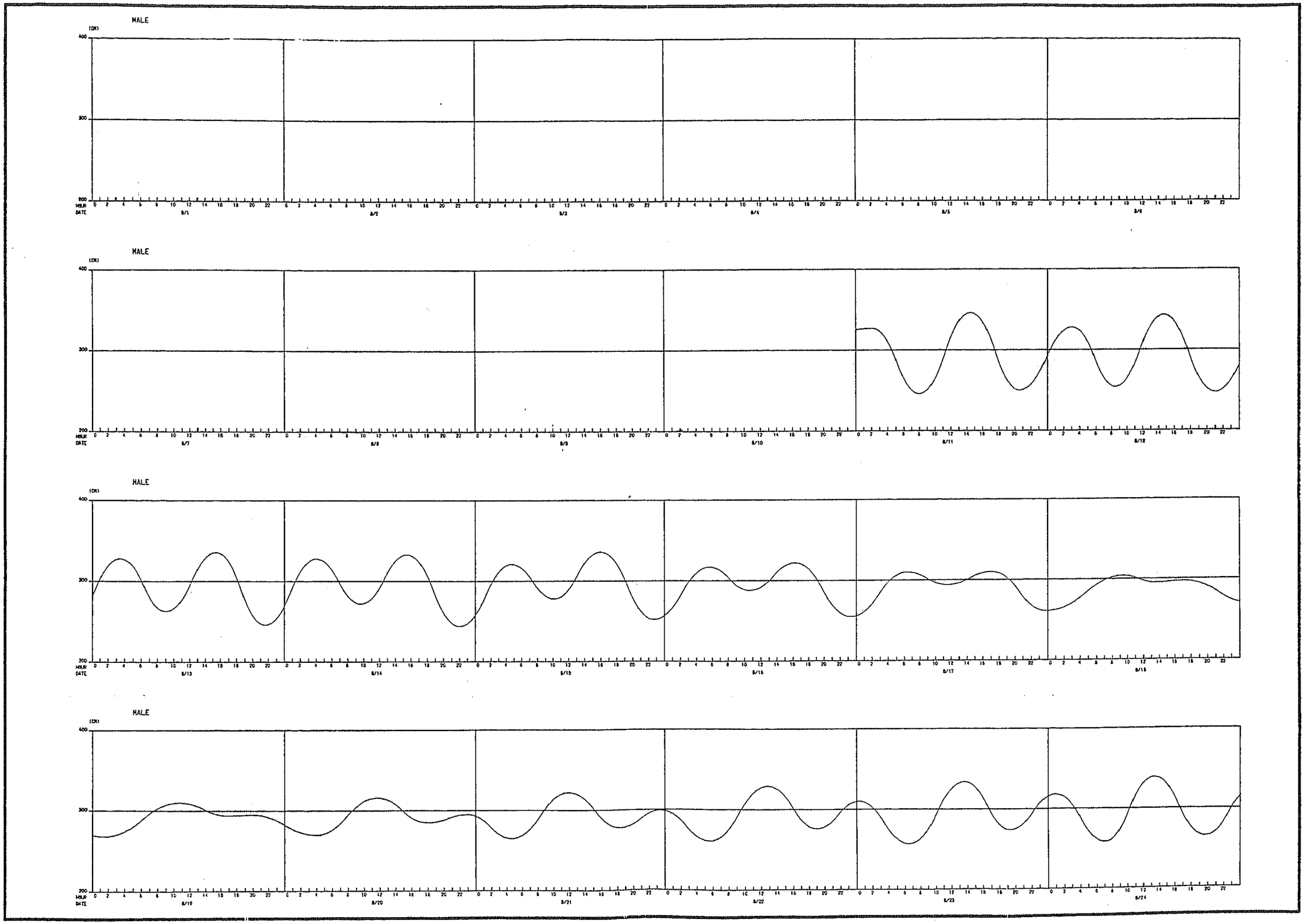
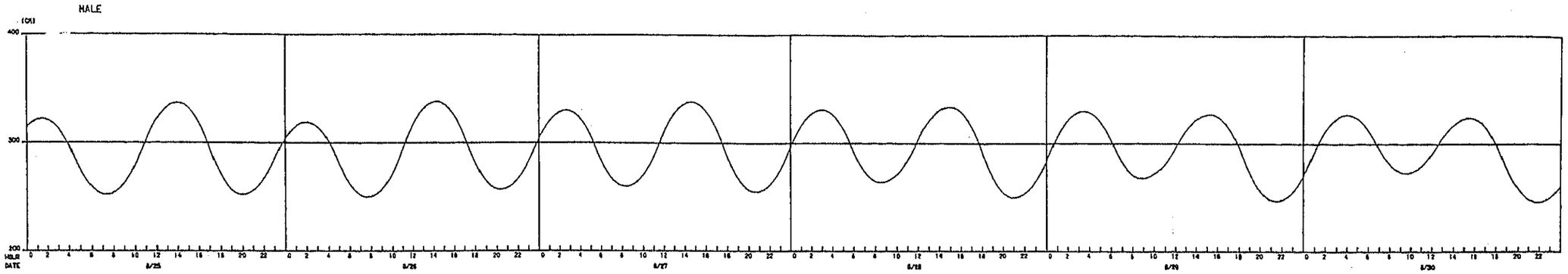
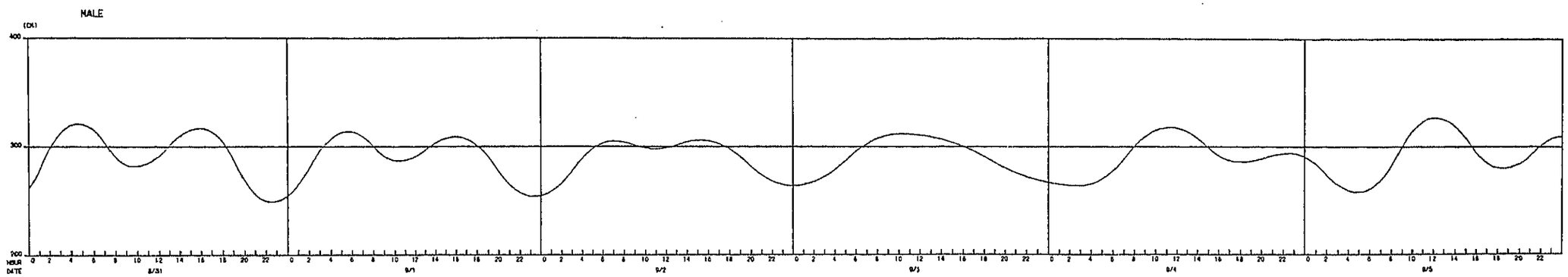


Fig. A8-3 Tide curve at Male' Island (1/2).





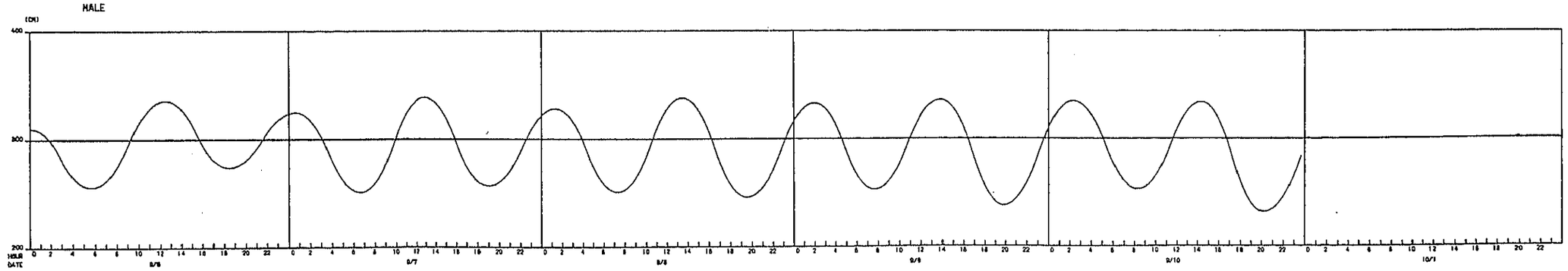


Fig. A8-4 Tide curve at Male' Island ('2 /2).

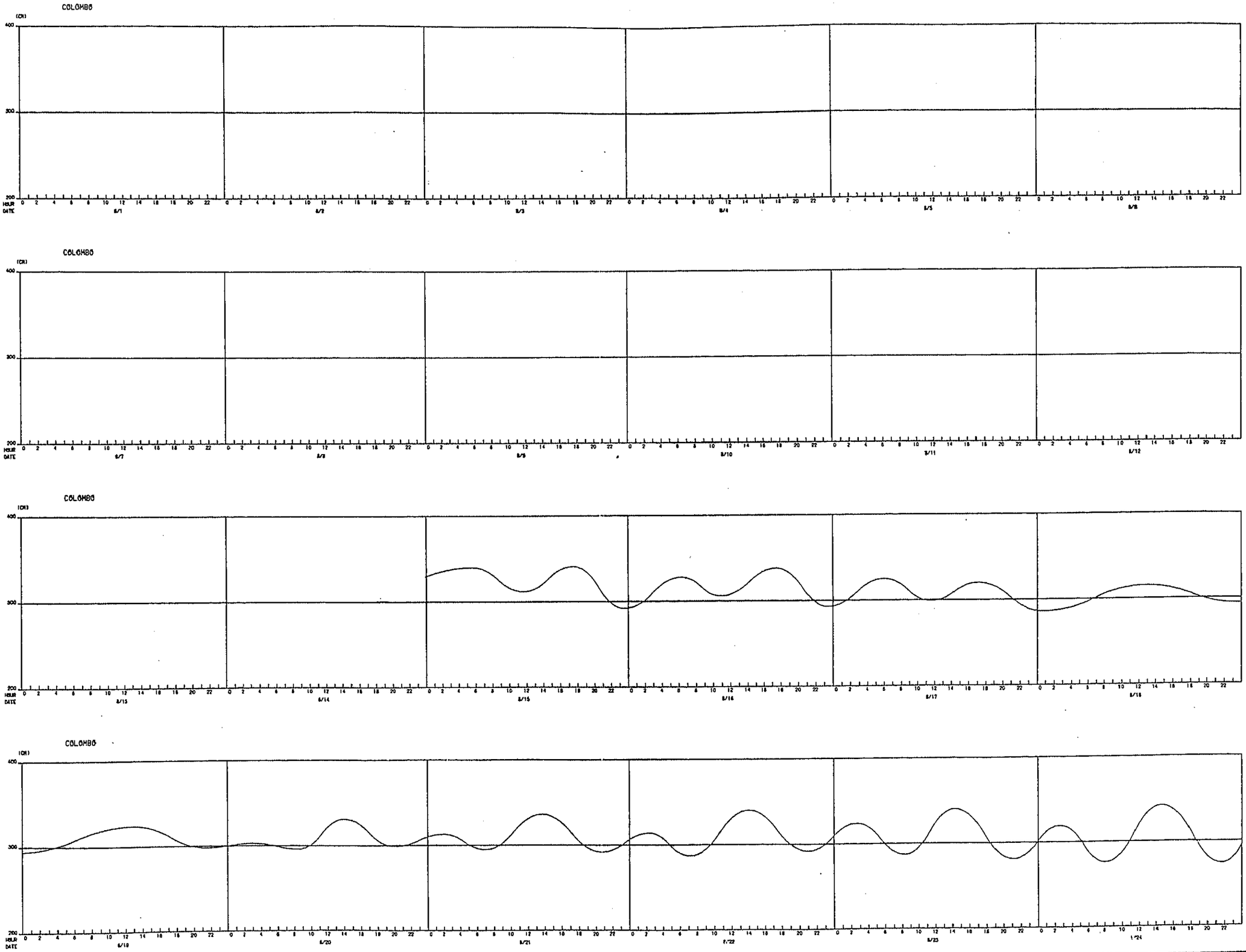


Fig. A8-5 Tide curve at Port of Colombo (1/2).

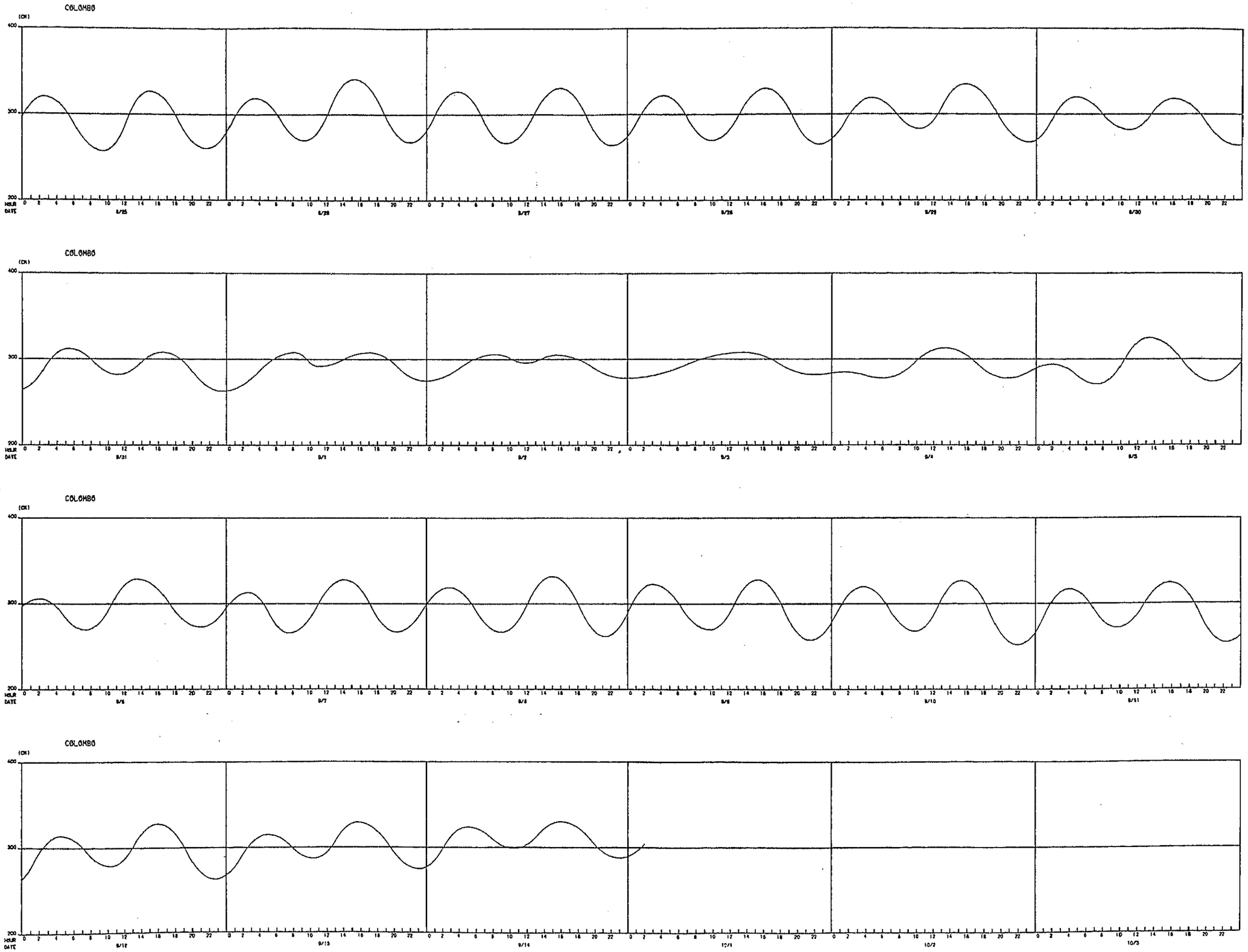


Fig. A8-6 Tide curve at Port of Colombo (2/2).

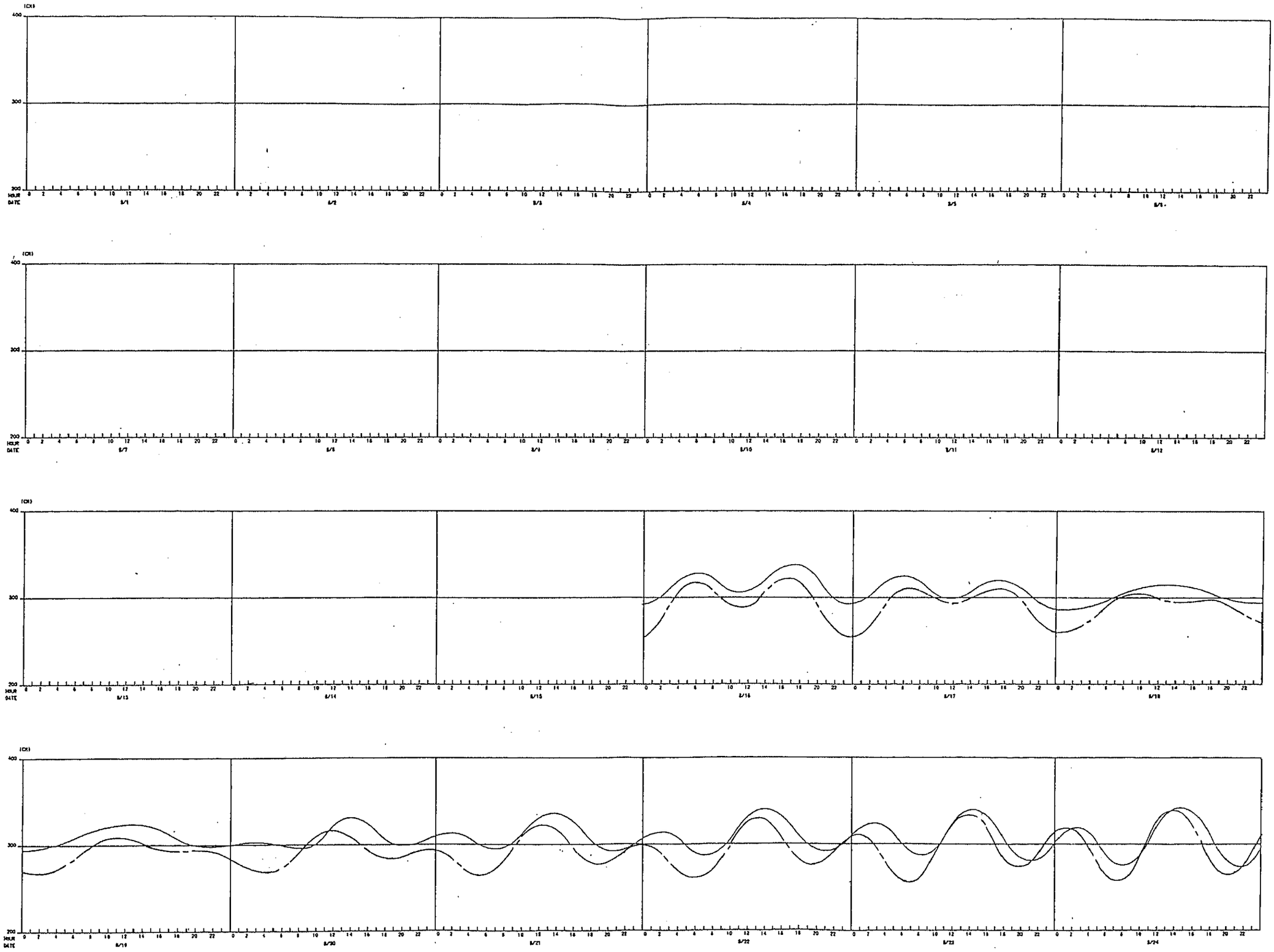


Fig. A8-7 Comparison of tide curves (1/2).

: Tide curve at Male' Island
: Tide curve at Port of Colombo

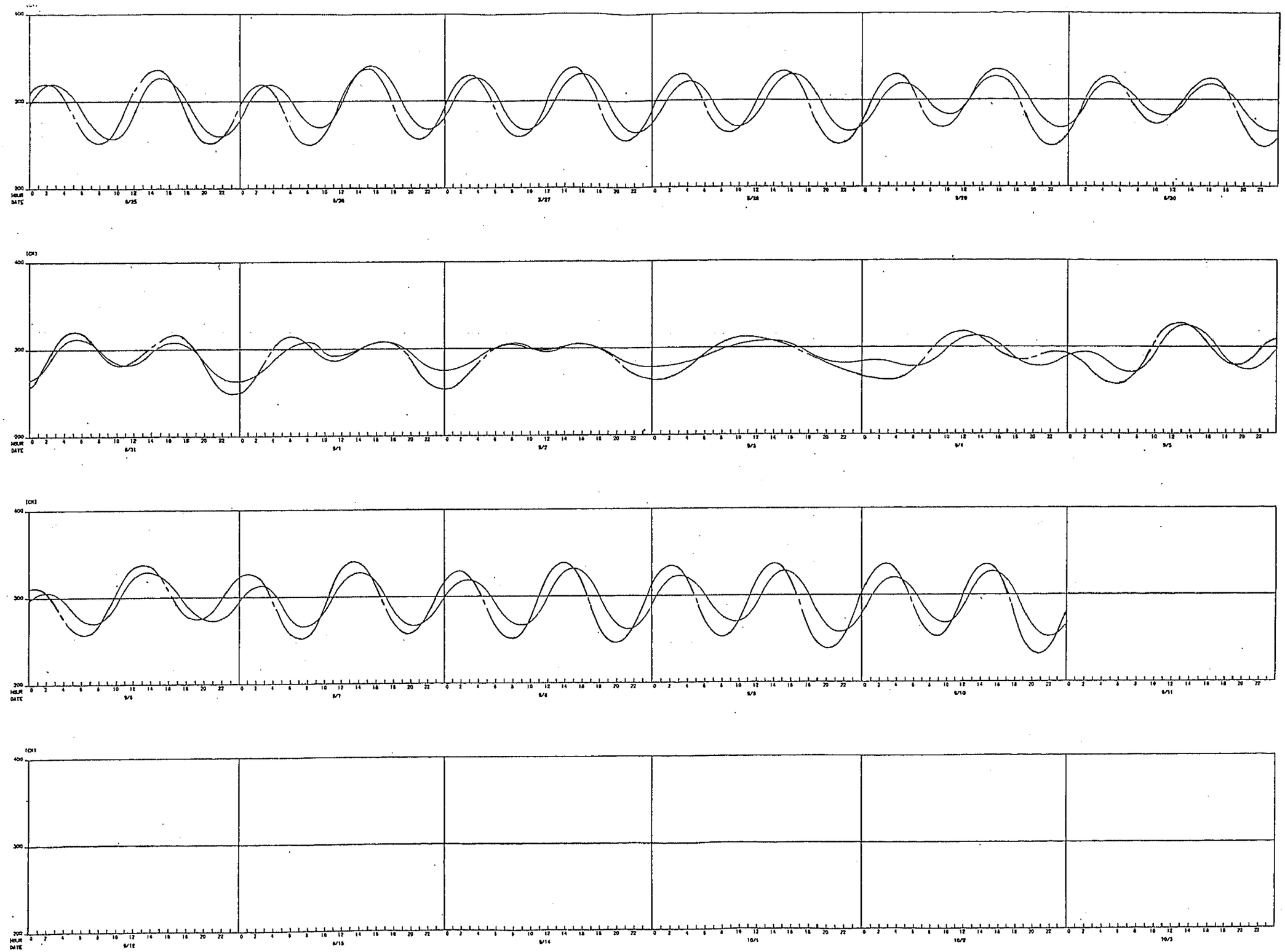


Fig. A8-8 Comparison of tide curves (2/2).

: Tide curve at Male' Island
: Tide curve at Port of Colombo

Table A8-3 Harmonic analysis of the tide [Male' (1/2)].

LIST ØF HARMØNIC CØNSTITUENTS ØF CØMPØNENT TIDE

NØ	SYMBØL	ARGUMENT (DEG)	NØDE FACTØR	ANGULAR SPEEU (DEG)	CØMPØNENT HØUR	PHASE ANGLE (DEG)
1	K2	275.12	0.75908	30.08214	0.99727	142.58
2	M2	334.27	1.03826	28.98410	1.03505	42.39
3	N2	303.50	1.03826	28.43973	1.05486	52.82
4	NU2	342.45	1.03826	28.51259	1.05217	16.60
5	MU2	311.67	1.03826	27.96822	1.07265	95.36
6	S2	357.02	1.00000	30.00000	1.00000	57.60
7	T2	141.23	1.00000	29.95894	1.00137	271.88
8	R2	32.81	1.00000	30.04106	0.99863	21.96
9	L2	200.90	0.83713	29.52847	1.01597	196.11
10	Ø1	107.95	0.84530	13.94304	1.07581	66.14
11	Q1	77.17	0.84530	13.39866	1.11951	154.36
12	P1	129.99	1.00000	14.95893	1.00275	296.97
13	M1	217.89	0.97530	14.49669	1.03472	258.30
14	J1	257.10	0.85814	15.58544	0.96244	103.73
15	K1	226.52	0.89859	15.04107	0.99727	191.75

HARMØNIC CØNSTANT SYMBØL	AMPLITUDE (CM)	PHASE LAG (DEG)
K2	3.44	57.70
M2	22.50	16.66
N2	4.37	356.32
NU2	0.86	359.05
MU2	0.54	47.03
S2	12.66	54.62
T2	0.75	53.10
R2	0.10	54.77
L2	0.63	37.01
Ø1	4.48	174.09
Q1	0.87	231.53
P1	3.67	66.96
M1	0.32	116.18
J1	0.35	0.83
K1	11.08	58.27

STANDARD SEA LEVEL 293.03 (CM)

Table A8-4 Harmonic analysis of the tide [Male'].

HARMØNIC ANALYSIS ØF THE TIDE (DARWIN'S METHØD)

STATIØN CALCULATIØN ØF HARMØNIC CØNTENTS IN MALE

EAST LØNGITUDE 73.510E
TIME ZØNE 5.0 HR
ØRIGIN ØF TIME 1987. 8. 11. 0. 0'CLØCK
ØBSERVATIØN PERIØD 31 DAYS
ANALYZING CØMPØNENT NANE M2 S2 Ø1 K1

ØRIGINAL INPUT DATA TABLE (UNIT CM)

TIME / DAY	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	308	318	327	322	305	285	264	251	246	254	272	292	315	332	344	343	329	308	233	266	252	251	265	280
1	298	312	322	329	323	306	284	266	255	256	265	281	307	325	340	342	334	316	290	270	252	247	252	266
2	286	304	318	**********	**********	**********	**********	**********	**********	260	266	276	297	314	330	336	334	324	306	284	262	250	249	255
3	276	291	310	321	327	323	314	299	283	274	274	280	294	308	322	330	332	324	308	289	268	252	244	248
4	261	276	294	307	308	320	314	305	292	282	279	280	290	302	313	322	325	323	313	296	277	264	252	252
5	260	272	286	300	310	316	317	312	306	296	290	290	293	300	310	315	321	320	315	304	288	273	261	256
6	258	266	277	289	300	306	311	310	308	304	300	294	294	296	304	306	308	310	308	301	292	283	269	262
7	261	263	270	277	285	292	299	302	304	303	303	301	298	295	295	296	296	297	295	294	290	286	278	273
8	270	268	268	270	272	278	288	293	300	306	309	310	308	304	302	298	294	294	293	294	294	293	288	284
9	280	278	276	272	270	274	279	283	292	301	311	316	316	312	305	296	290	288	285	286	290	292	293	294
10	289	287	279	271	266	266	268	276	285	296	308	315	321	318	310	302	291	284	278	278	285	291	295	299
11	299	294	289	279	269	262	261	266	277	288	304	317	327	329	324	312	299	288	278	276	280	288	298	304
12	308	308	300	293	278	268	259	260	268	284	301	319	331	334	332	323	307	294	280	274	276	283	294	305
13	315	318	314	304	289	274	262	258	254	277	296	312	330	338	338	328	312	295	278	269	266	272	287	300
14	314	320	319	310	296	279	260	252	255	268	286	302	321	332	338	332	315	297	270	258	252	257	272	288
15	306	314	319	314	298	280	262	253	250	262	280	297	316	327	337	336	324	307	286	268	258	260	270	284
16	304	316	328	330	320	304	283	318	260	262	277	291	310	323	336	338	327	311	288	270	256	255	263	277
17	298	314	327	330	325	312	296	278	266	264	274	285	302	317	330	334	328	312	290	272	256	251	254	267
18	287	304	320	330	329	319	302	286	273	270	273	282	297	310	322	326	324	314	296	276	259	250	250	257
19	274	292	310	322	327	324	311	298	283	275	274	281	292	304	315	322	322	317	300	283	264	253	247	252
20	266	281	298	312	319	322	316	307	292	286	282	284	292	300	310	315	316	312	302	288	272	259	251	249
21	256	268	282	295	306	311	312	309	301	293	288	288	293	299	302	307	309	308	301	292	278	268	258	254
22	256	262	271	282	294	300	304	306	304	303	300	298	298	299	303	305	304	303	300	294	286	279	271	266
23	264	264	266	270	278	286	295	302	306	310	312	310	308	307	306	302	298	295	295	293	290	286	281	276
24	272	268	266	264	266	270	276	287	298	305	312	316	315	312	307	300	290	288	286	287	290	292	292	294
25	290	284	276	266	260	258	263	273	278	301	314	322	326	324	318	308	295	287	281	281	286	293	301	307
26	310	307	297	282	268	260	255	260	276	295	314	327	336	336	330	319	301	286	275	274	277	290	302	312
27	322	324	317	303	281	265	253	252	262	282	304	321	336	339	332	319	298	280	263	257	261	272	290	306
28	322	328	324	314	292	273	258	251	255	270	290	309	329	338	336	325	302	280	258	250	248	259	278	296
29	316	328	332	326	310	291	268	256	254	262	281	300	320	331	334	327	308	286	261	245	239	244	261	281
30	304	321	335	332	320	302	281	264	255	256	273	291	313	326	333	330	315	294	267	245	232	234	247	266

Table A8-5 Harmonic analysis of the tide [Colombo (1/2)].

LIST ØF HARMØNIC CØNSTITUENTS ØF CØMPØNENT TIDE

NØ	SYMBØL	ARGUMENT (DEG)	NØDE FACTØR	ANGULAR SPEEU (DEG)	CØMPØNENT HØUR	PHASE ANGLE (DEG)
1	K2	277.91	0.75905	30.08214	0.99727	170.28
2	M2	259.16	1.03827	28.98410	1.03505	186.06
3	N2	189.74	1.03827	28.43973	1.05486	254.01
4	NU2	233.87	1.03827	28.51259	1.05217	210.08
5	MU2	164.44	1.03827	27.96822	1.07265	282.98
6	S2	354.02	1.00000	30.00000	1.00000	93.95
7	T2	135.31	1.00000	29.95894	1.00137	312.55
8	R2	32.73	1.00000	30.04106	0.99863	55.25
9	L2	164.60	0.83944	29.52847	1.01597	282.10
10	Ø1	31.39	0.84528	13.94304	1.07581	41.76
11	Q1	321.97	0.84528	13.39866	1.11951	113.31
12	P1	125.58	1.00000	14.95893	1.00275	303.61
13	M1	180.73	0.97043	14.49669	1.03472	250.28
14	J1	297.19	0.85813	15.58544	0.96244	129.55
15	K1	227.96	0.89858	15.04107	0.99727	200.91

HARMØNIC CØNSTANT SYMBØL	AMPLITUDE (CM)	PHASE LAG (DEG)
K2	3.80	88.19
M2	14.42	85.22
N2	2.80	83.75
NU2	0.55	83.94
MU2	0.35	87.42
S2	13.97	87.97
T2	0.82	87.86
R2	0.11	87.98
L2	0.40	86.69
Ø1	2.34	73.15
Q1	0.45	75.28
P1	3.00	69.19
M1	0.17	71.01
J1	0.18	66.74
K1	9.07	68.87

STANDARD SEA LEVEL 300.97 (CM)

Table A8-6 Harmonic analysis of the tide [Colombo (2/2)].

HARMØNIC ANALYSIS ØF THE TIDE (DARWIN'S METHØD)

STATIØN CALCULATIØN ØF HARMØNIC CØNSTANTS IN CØLØMBØ

EAST LØNGITUDE 79.510E
TIME ZØNE 5.5 HR
ØRIGIN ØF TIME 1987. 8. 14. 0. 0'CLØCK
ØBSERVATIØN PERIØD 31 DAYS
ANALYZING CØMPØNENT NANE M2 S2 Ø1 K1

ØRIGINAL INPUT DATA TABLE (UNIT CM)

TIME / DAY	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	296	306	318	330	337	340	340	336	329	320	317	313	314	321	330	337	339	340	339	335	324	310	298	293
1	293	300	310	318	323	328	328	325	318	316	313	308	310	315	324	333	337	337	337	334	325	316	303	295
2	294	299	307	313	318	324	324	322	316	308	305	302	300	300	305	312	320	318	318	315	310	304	297	291
3	287	288	292	306	310	310	310	309	308	312	315	307	308	308	310	308	310	312	308	305	303	298	296	294
4	296	296	298	300	301	303	305	305	310	314	317	320	323	323	323	322	327	324	307	304	300	300	299	300
5	300	303	302	303	302	300	298	296	298	299	305	315	323	328	330	329	323	316	308	303	299	300	303	303
6	308	312	313	310	306	300	298	294	295	300	307	315	325	334	335	330	325	316	306	300	294	293	293	300
7	308	313	313	312	308	298	292	288	292	296	304	315	329	338	340	338	332	332	312	301	294	293	296	303
8	313	320	323	323	317	310	298	290	287	292	300	313	326	338	340	339	333	323	307	297	285	282	282	290
9	298	310	318	319	314	304	292	283	276	279	286	298	315	332	338	342	338	326	308	295	283	275	274	284
10	297	307	317	317	314	305	291	277	265	260	262	268	287	307	320	326	322	316	303	285	270	262	261	270
11	283	298	313	318	318	310	298	286	275	270	274	286	303	320	334	341	340	334	322	302	284	269	268	274
12	286	303	315	324	327	323	310	296	282	279	278	283	294	307	323	329	331	324	315	300	283	268	264	268
13	280	293	306	318	322	318	312	298	283	274	270	264	288	307	316	323	329	328	313	303	286	272	266	267
14	275	288	303	313	318	318	313	303	302	294	283	285	296	310	318	327	334	332	324	312	298	283	273	269
15	274	286	299	310	317	320	316	307	304	294	283	282	287	297	304	309	318	318	312	303	293	281	270	265
16	266	275	288	299	306	311	308	304	298	293	285	282	285	294	298	306	307	307	305	300	290	280	269	264
17	263	270	283	291	298	303	306	304	306	301	296	292	293	298	300	304	307	307	306	300	296	288	282	277
18	274	276	282	288	293	297	299	299	304	303	300	298	296	302	301	303	302	300	298	293	290	285	282	279
19	278	280	282	287	289	290	291	292	297	302	300	304	307	309	308	302	298	292	288	285	283	282	283	284
20	283	285	285	285	282	280	279	279	293	294	297	303	307	313	312	310	302	294	287	282	279	278	279	285
21	290	294	295	291	287	280	275	272	277	283	294	307	317	323	322	316	308	298	287	280	275	274	280	290
22	297	303	306	305	297	288	279	270	270	280	290	304	317	325	328	327	319	305	293	280	274	272	276	287
23	297	308	313	312	304	294	280	268	270	270	280	295	313	323	328	326	318	305	290	276	268	267	270	282
24	295	308	317	319	314	302	288	275	270	267	273	288	307	320	328	331	326	311	298	280	267	262	264	274
25	290	305	317	323	320	312	300	281	278	271	273	282	297	317	326	328	325	315	300	280	267	262	264	274
26	283	298	313	318	320	314	305	290	280	270	270	275	293	308	320	327	327	316	304	297	270	258	252	258
27	272	287	303	313	318	316	307	295	287	273	272	276	287	303	313	322	323	315	302	290	275	260	252	255
28	266	280	296	307	313	313	308	300	296	287	280	283	295	307	315	323	327	323	313	300	290	275	263	263
29	270	285	297	307	313	315	313	307	304	294	290	290	295	310	317	324	328	323	315	310	300	290	280	275
30	283	296	306	314	322	324	320	315	311	305	302	300	305	313	320	328	330	327	325	318	310	303	292	298

Table A8-7 Comparison of semi-range of 4 dominant constituent tides.

4 dominant constituent tides	Male' Island			Port of Colombo					
	Observation by this study team	Observation by University of Hawaii	Data of Maritime Safety Agency, Japan	Observation by this study team	Observation by Sri Lanka Port Authority				
					1953	1954	1955	1956	Average
O1	0.04	0.07	0.05	0.02	0.04	0.02	0.03	0.03	0.03
K1	0.11	0.13	0.10	0.09	0.08	0.08	0.08	0.07	0.08
S2	0.13	0.13	0.11	0.14	0.10	0.12	0.12	0.12	0.12
M2	0.23	0.22	0.20	0.14	0.17	0.17	0.18	0.16	0.17

4 dominant constituent tides
O1 : Principle lunar semi-diurnal
K1 : Lunar-solar semi-diurnal
S2 : Principle solar semi-diurnal
M2 : Large lunar elliptic semi-diurnal

Table A8-8 Monthly mean sea level at Port of Colombo.

MONTHLY MEAN SEA LEVEL — PORT OF COLOMBO.
SRI LANKA.

MONTH \ YEAR	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
JANUARY	1·689	1·883	Readings not available	—	1·911	1.802	2.025	1.978	—	
FEBRUARY	1·780	1·823		—	1·765	1.805	2.087	1.848	1.911	
MARCH	1·804	1·859		—	1·770	1.795	1.960	1.928	1.992	
APRIL	1·668	1·934		1·793	1·662	1.774	1.866	1.792	1.979	
MAY	1·602	1·515		1·476	1·477	1.669	1.643	1.533	1.800	
JUNE	1·632	1·398		1·409	1·622	1.438	1.438	1.485	1.569	
JULY	1·518	1·236		1.164	1·451	1.538	1.336	1.306	1.424	
AUGUST	1·333	1·281		1.142	1·317	1.399	1.285	1.186	1.441	
SEPTEMBER	—	1·764		1·349	1·369	1.381	1.554	1.362	1.281	
OCTOBER	1·440	1·554		1·446	1·576	1.679	1.692	1.691	1.584	
NOVEMBER	1·928	1·917		1.887	1·888	2.056	1.819	1.888	1.938	
DECEMBER	2·024	2·162		2·085	1·933	2.119	2.139	1.964	2.041	

Readings are in Feet and decimals

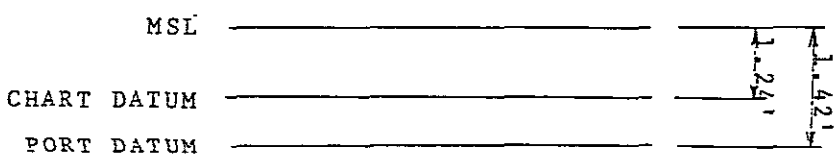


Table A8-9 Semi-range and phase lag of 4 dominant constituent tides.

4 dominant constituent tides	Male' Island		the Port of Colombo					
	Ovservation by this study team		Observation by Sri Lanka Ports Authorities					
	Semi-range (m)	Phase lag (degree)	Semi-range (m)					Mean phase lag (degree)
			1953	1954	1955	1956	Average	
O1	0.04	174.1	0.04	0.02	0.03	0.03	0.03	66.1
K1	0.11	58.3	0.08	0.08	0.08	0.07	0.08	25.0
S2	0.13	54.6	0.10	0.12	0.12	0.12	0.12	79.9
M2	0.23	16.7	0.17	0.17	0.18	0.16	0.17	59.8

Four dominant constituent tide O1: Principal linar semi-diurnal

K1: Lunar-solar semi-diurnal

S2: Principal solar semi-diurnal

M2: Large lunar elliptic semi-diurnal

APPENDIX IX

UNIT WEIGHT AND UNCONFINED COMPRESSIVE STRENGTH TEST DATA OF CORAL ROCK

APPENDIX IX UNIT WEIGHT AND UNCONFINED COMPRESSIVE STRENGTH TEST DATA OF CORAL ROCK

In order to clarify the physical properties of coral rock, the basic design study team brought two pieces of coral rock, sampled from the existing coral rock detached breakwaters, back to Japan. A total of four specimens were then prepared from the two rock samples and the following tests were conducted:

(1) Unit weight test

(2) Unconfined compressive strength test

These tests were carried out in accordance with JIS and test standards based thereon. The results of the tests are as shown below:

Samples		Unit Weight (g/cm^3)	Unconfined Compressive Strength (kg/cm^2)
No. 1	a	2.41	482
	b	2.28	318
No. 2	a	2.36	472
	b	2.31	346
Average		2.34	404.5

APPENDIX X

SHORELINE SURVEY AND SOUNDING DATA

APPENDIX X SHORELINE SURVEY AND SOUNDING DATA

(1) Execution period

From 9th August to 15th August, 1987

(2) Place of survey

See Fig. A10-1.

(3) Main equipment used

Table A10-1 shows the main equipments used for the survey.

Table A10-1 Main equipment used.

Equipment Name	Model	Performance	Purpose	Manufacturer
Theodolite	TM-10C	Effective diameter: 45mm Magnification: 30 x 10-second reading	Leading point setting	Sokkisha
Level	B2	Effective diameter: 40mm Magnification: 28 x Resolution: 3"	Levelling and sounding	Sokkisha
Telescopic staff		Effective length: 7m	Levelling and sounding	
Sextant		1-minute reading	Guiding	Tamaya
Echo-sounder	FE-4000		Sounding	Furuno Electric

(4) Method of survey

1) Leading point setting

Leading points were established with a theodolite and a measure rope to allocate survey lines.

Leading point No. 1 was set on the crest of the existing seawall at the eastern edge of the southern coast of Male' and 33 survey lines were placed on the shore along the southern coast toward the west at intervals of 50m. Fig. A10-2 shows the positions of leading points.

The elevation at each leading point was measured by levelling (longitudinal levelling).

2) Shoreline survey

The shoreline was surveyed every 10m and at change points of elevation in the transverse direction (from north to south) on the basis of the elevation of each leading point established by longitudinal levelling. A telescopic staff was carried and set up by the staff man for the survey, and the elevations of points were read from the level. Where the level could not be used because of the depth of water, the elevation was sounded by the telescopic staff.

3) Sounding

Sounding was conducted to measure the slope extending from the reef edge towards the sea. The sounding was carried out along four survey lines at leading point No. 1, 6, 15 and 30 using an echo-sounder on a small boat with a vibrator installed alongside. Fig. A10-3 shows the records.

4) Reference point survey

The levelling was executed in order to establish the relation between the elevation of each leading point for shoreline survey and the datum level. The levelling was performed going to and from between the B.M. near the tidal gauges installed by the study team and the temporary B.M. near leading point No.6 along the route as shown in Fig. A10-4. The precision of the survey was based on class D set by the Overseas Survey Regulations (for Development and Survey) of the Japan International Cooperation Agency.

5) Results of the survey

The results of the shoreline survey and sounding are summarized below:

a) The distance from the shoreline to the reef edge on the southern coast is approximately 100m to 150m, shorter in the east and longer in the west.

b) There is a detached breakwater made of coral rocks about 600m long, 7m wide of crest and 3m high, located some 30m to 50m landward from the reef edge. Along the landside of the breakwater, an approximately 1.5km-long channel about 30m to 40m wide and about 4m to 6m deep has been excavated towards the western edge of the southern coast.

c) The reef surface about 40m in width from the reef edge is comparatively flat with some concaves and convexes. There exists many coral rocks 0.2m to 2m in size scattered in the landward reef. This is conspicuous on the east side of the southern coast.

d) The slope from the reef edge to the sea is as steep as 40 to 55 degrees to the horizontal line. This angle becomes larger on the west side of the southern coast.

Fig. A10-5 shows the depth contour chart based on the results of the shoreline survey and sounding. The sectional profiles are attached in Paragraph II. The results of levelling and the relationship between levelling points are shown in Table A10-2 and Fig. A10-6, respectively.

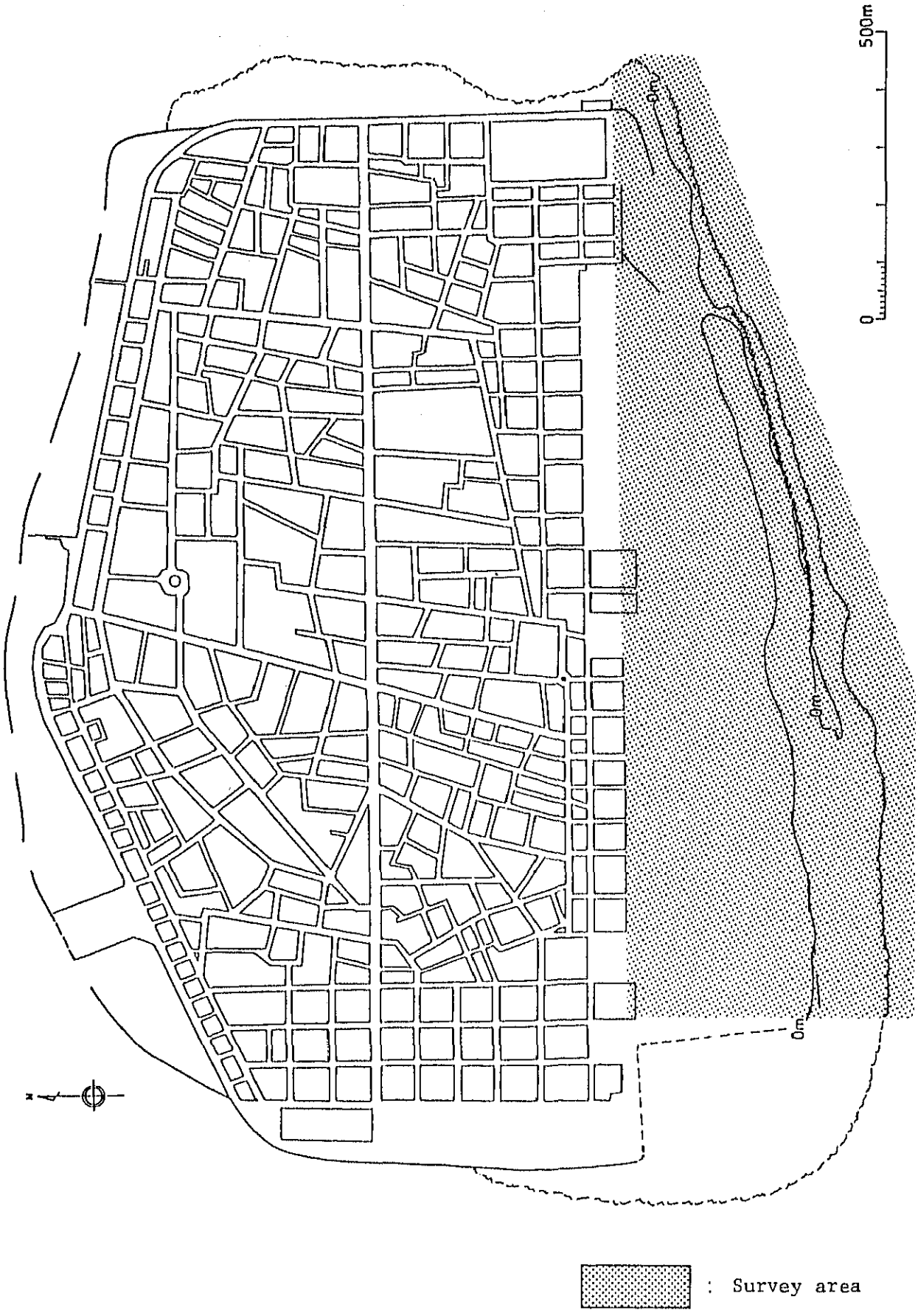


Fig. A10-1 Survey area.

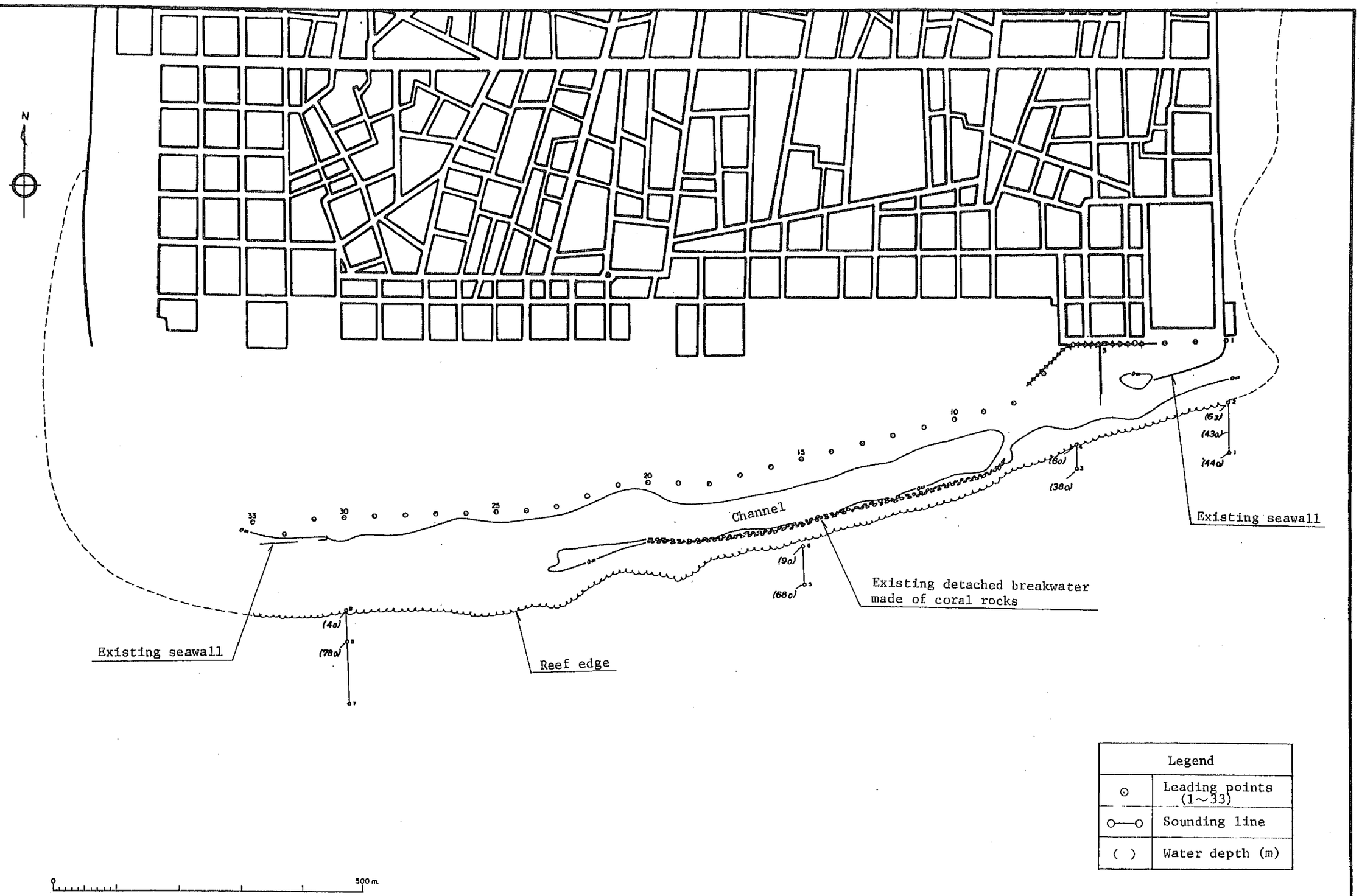


Fig. A10-2 Location of leading points.

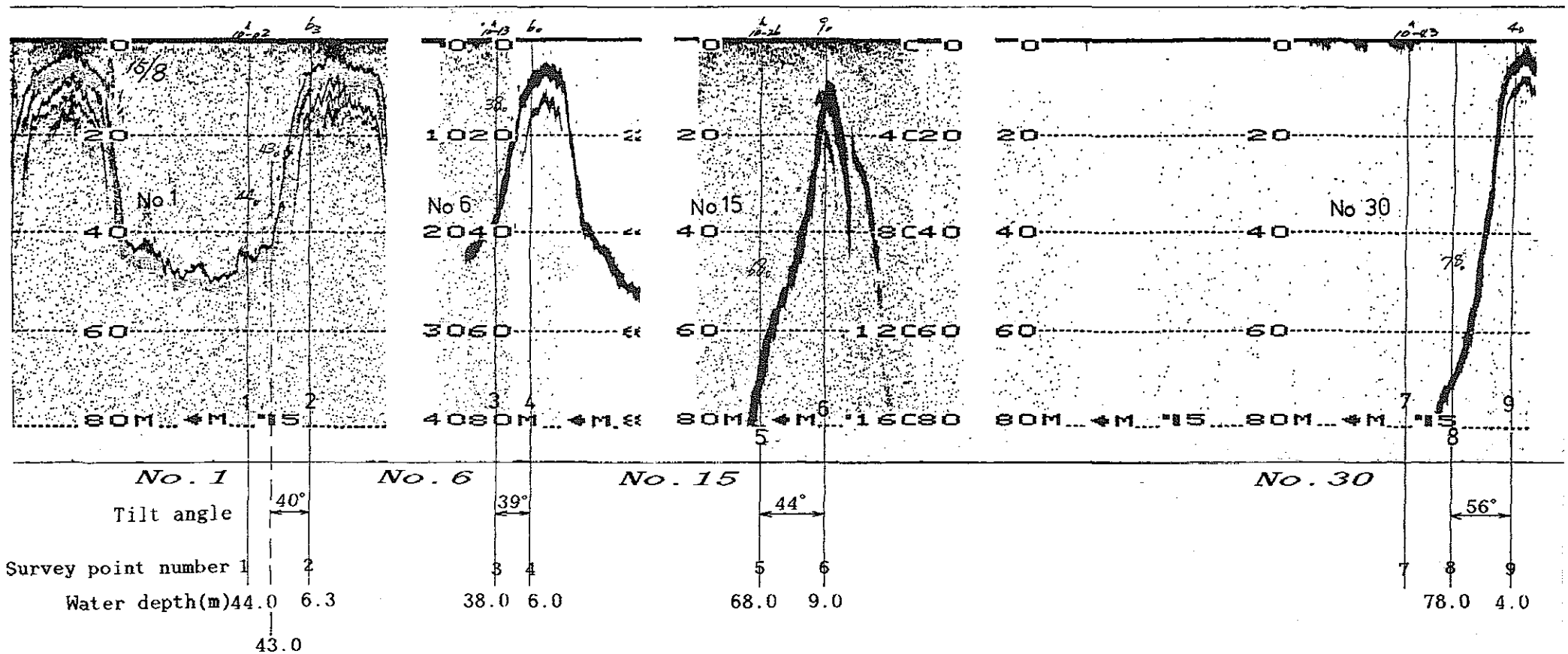


Fig. A10-3 Sounding record.

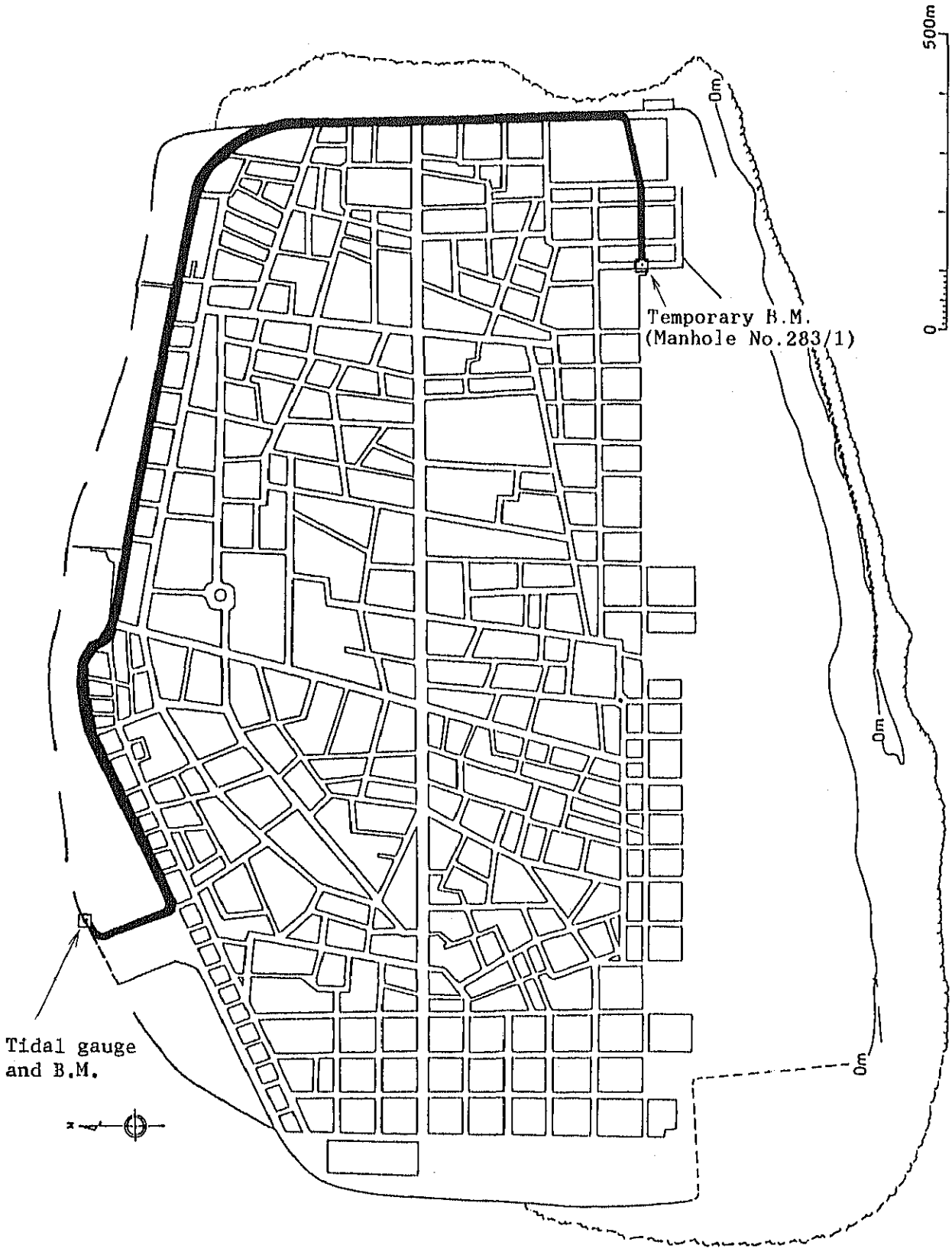


Fig. A10-4 Levelling route.

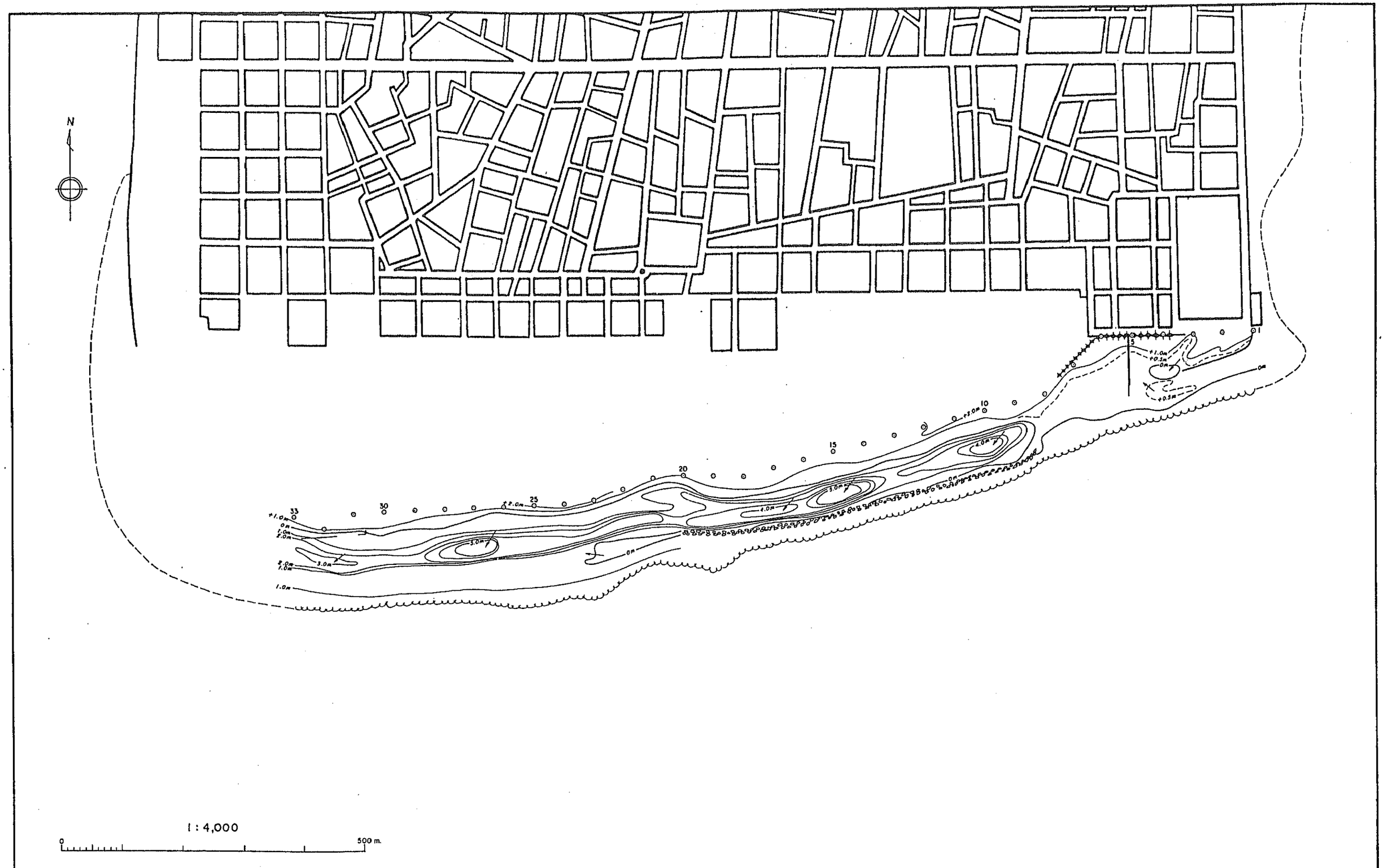


Fig. A10-5 Bathmetric contour chart.

DATUM LEVEL : NEARLY LOWEST LOW WATER

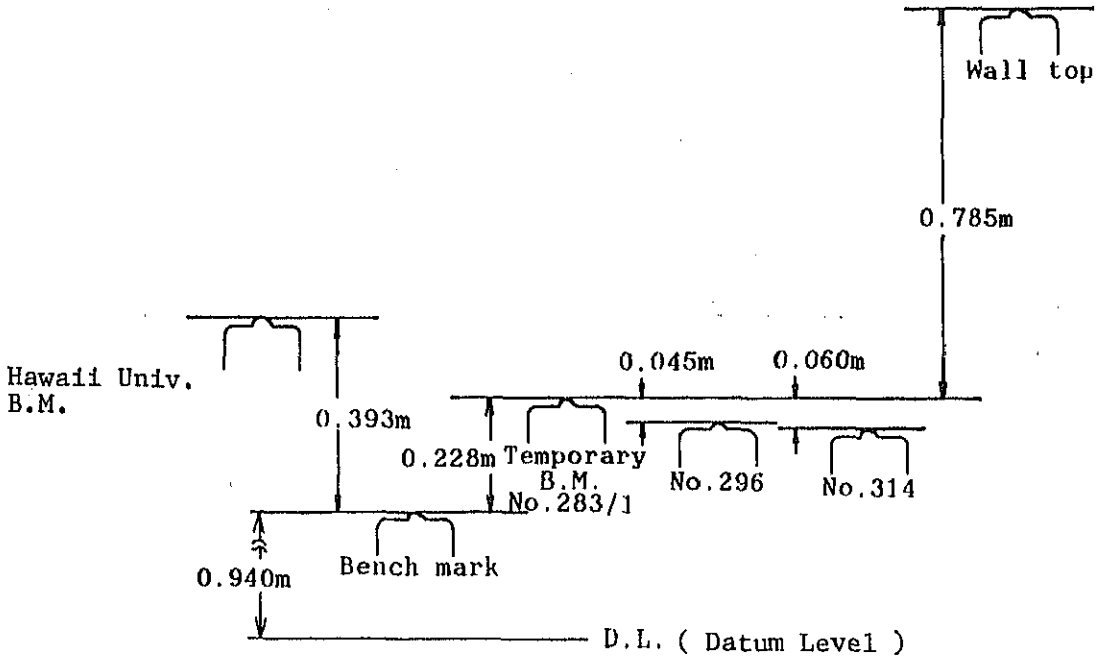


Fig. A10-6 Relationship among levels.

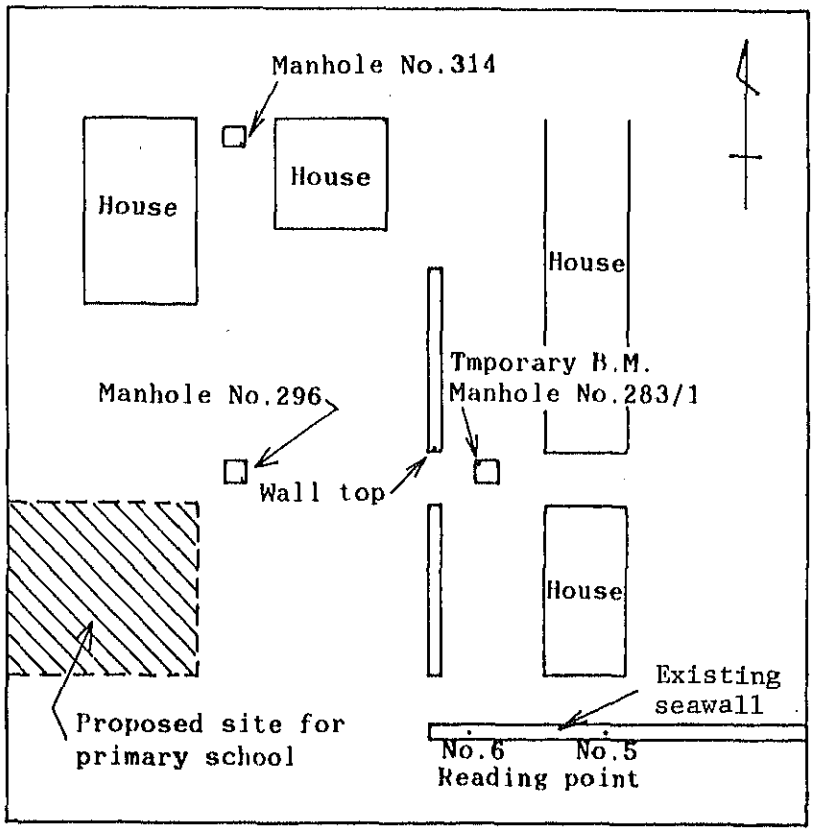
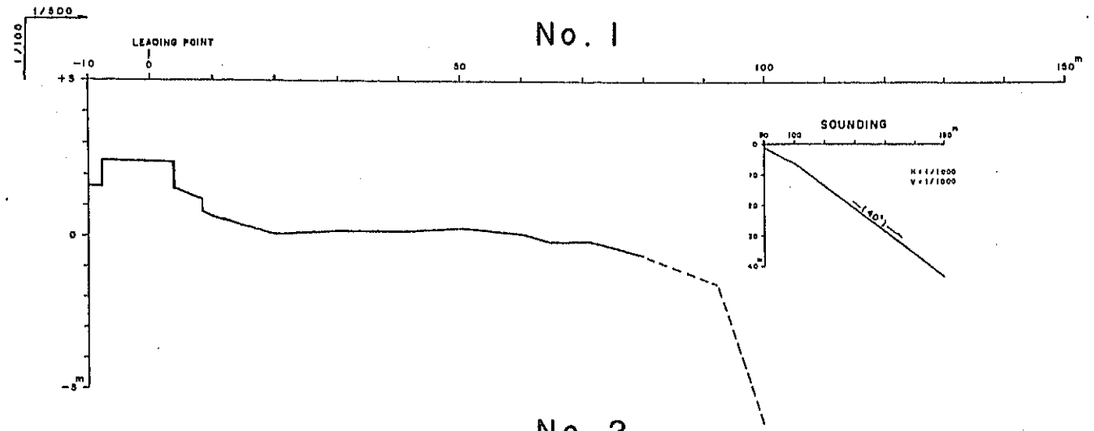


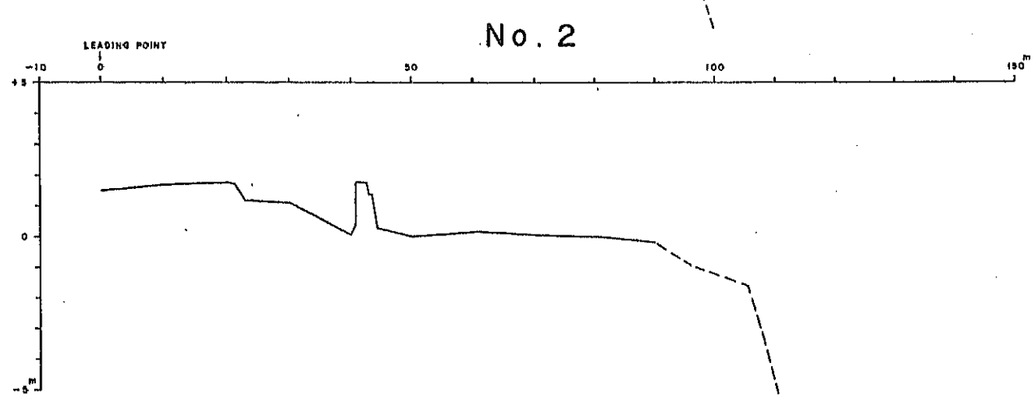
Fig. A10-7 Guide sketch around temporary B.M..

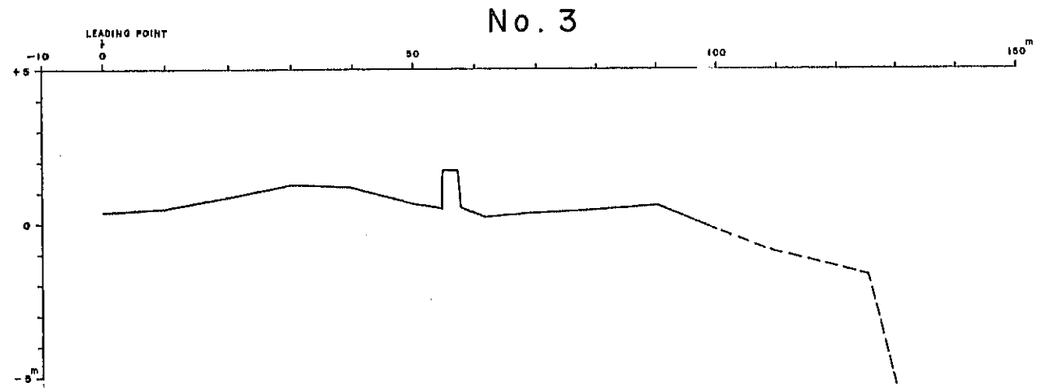
Table A10-2 List of levelling results.

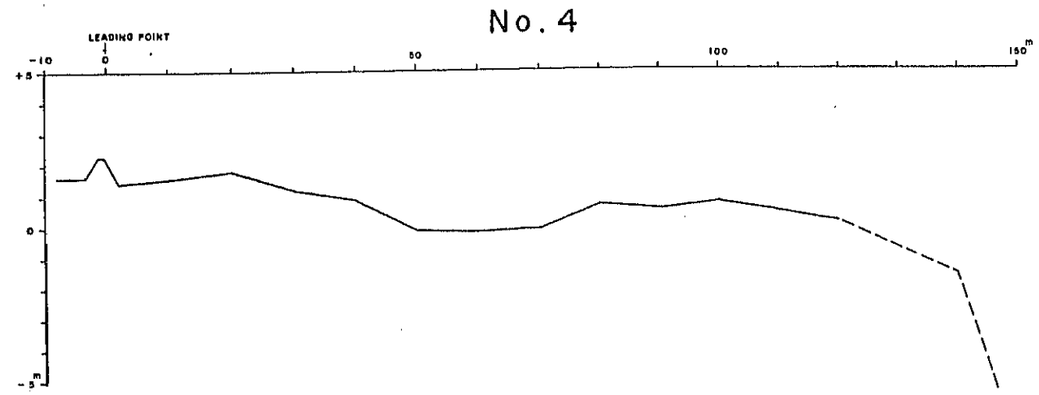
Point name	Level (D.L.)	Point name	Level (D.L.)	Point name	Level (D.L.)
B.M.	(m) 0.940	No. 8	(m) 1.22	No. 22	(m) 1.92
H.U. B.M.	1.333	No. 9	1.36	No. 23	2.59
Temporary B.M.	1.168	No. 10	1.14	No. 24	2.39
Manhole No. 296	1.123	No. 11	2.25	No. 25	1.99
Manhole No. 314	1.108	No. 12	1.49	No. 26	1.82
Wall top	1.953	No. 13	1.05	No. 27	1.57
		No. 14	1.25	No. 28	1.85
No. 1	2.44	No. 15	1.22	No. 29	1.64
No. 2	1.50	No. 16	1.12	No. 30	1.02
No. 3	1.39	No. 17	1.16	No. 31	1.67
No. 4	2.32	No. 18	1.24	No. 32	1.45
No. 5	2.43	No. 19	1.08	No. 33	1.53
No. 6	2.34	No. 20	0.94		
No. 7	1.34	No. 21	1.66		
Note	D.L. (Datum level): Nearly lowest low water No.1~No.33 : Leading points H.U. : Hawaii University B.M. : Bench mark				

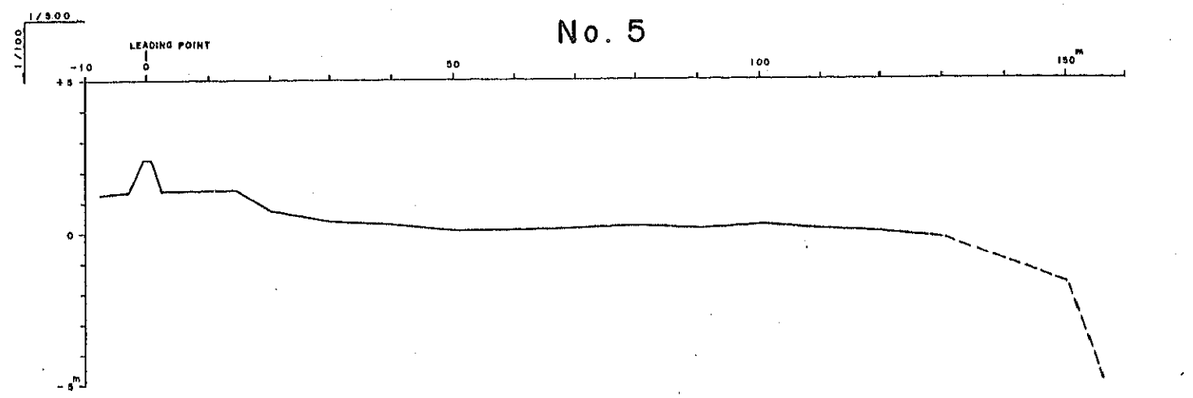
II Sectional Profiles

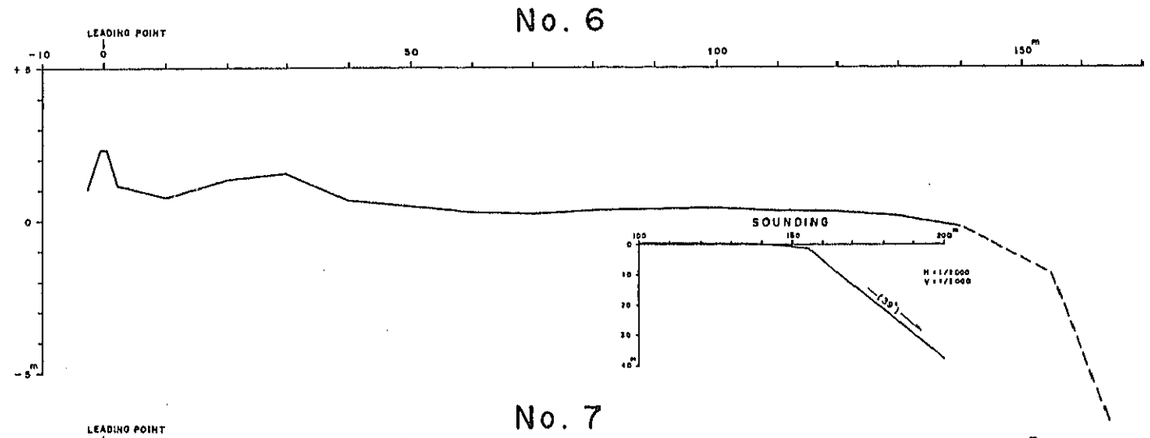


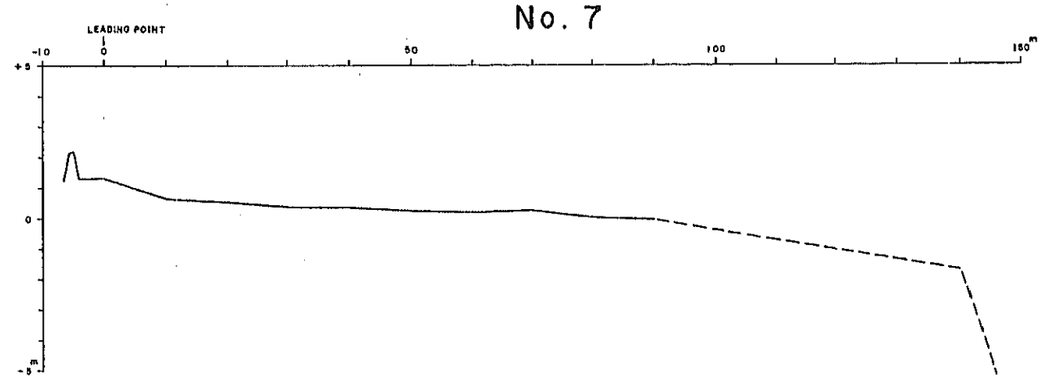


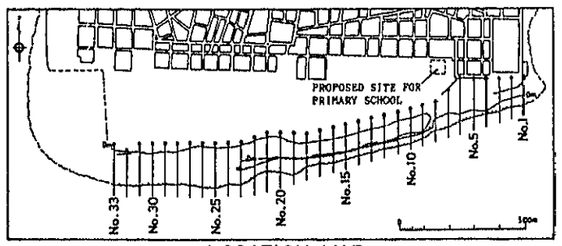








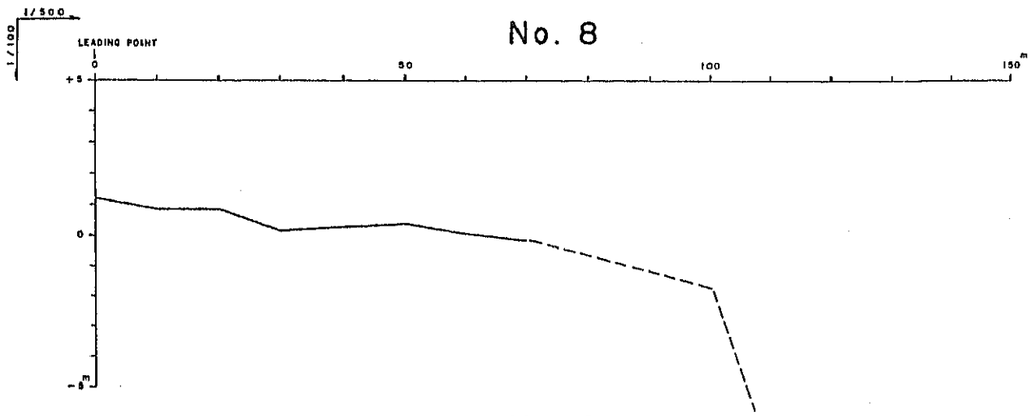


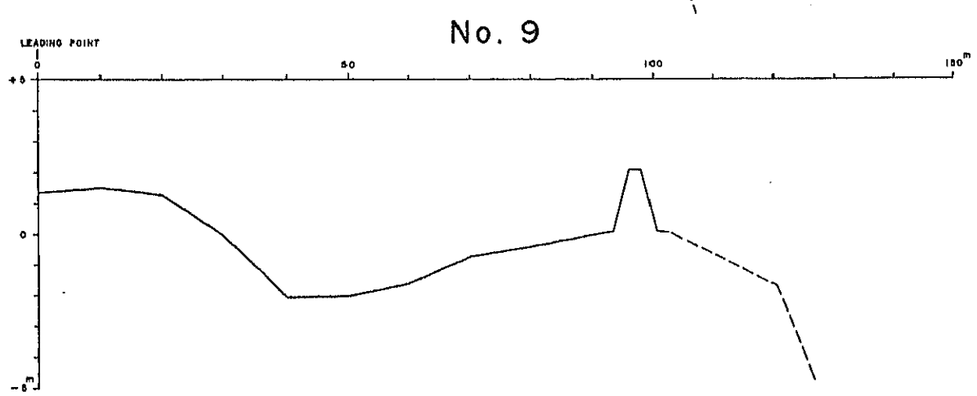


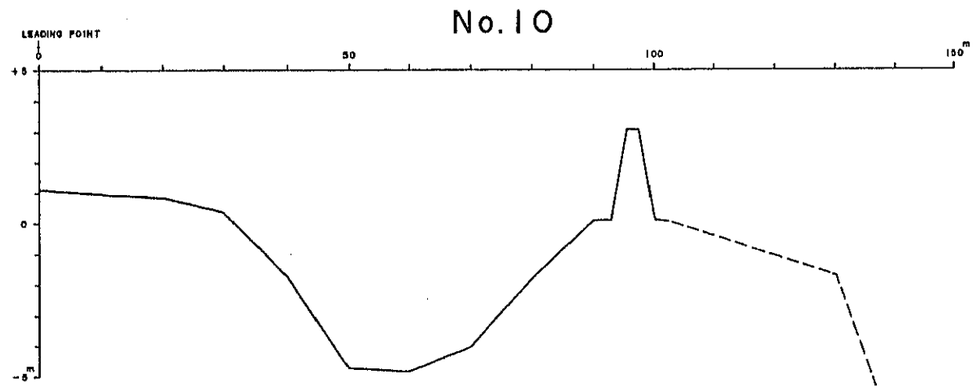
LOCATION MAP
NOT TO SCALE

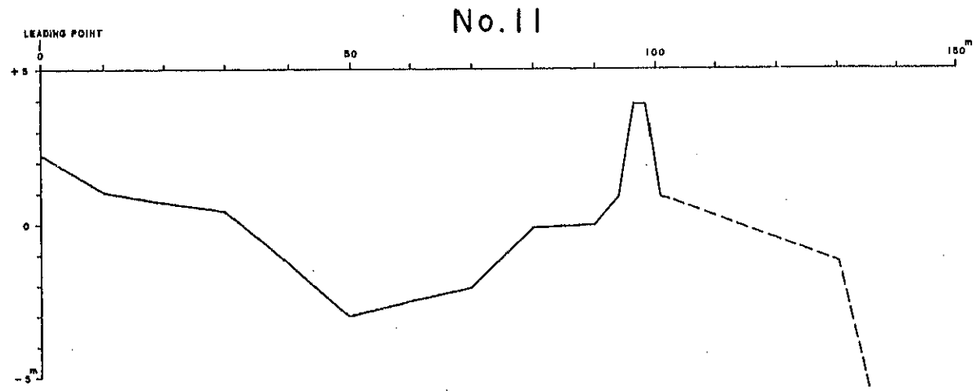
THE PROJECT OF CONSTRUCTING BREAKWATERS ON SOUTHERN COAST OF MALE			
SECTIONAL PROFILES (1 / 5)			
Date	NOV. 05 , 1987	Drawing No.	JMS - 01
JAPAN INTERNATIONAL COOPERATION AGENCY			

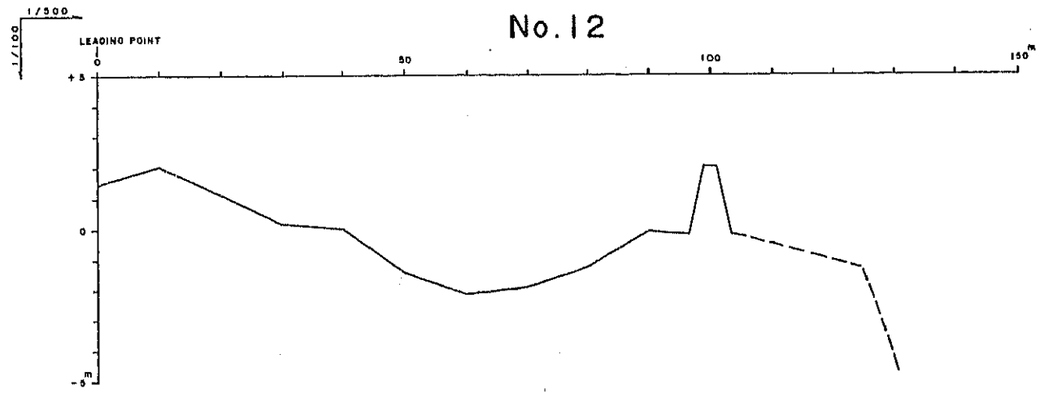
DATUM LEVEL : NEARLY LOWEST LOW WATER

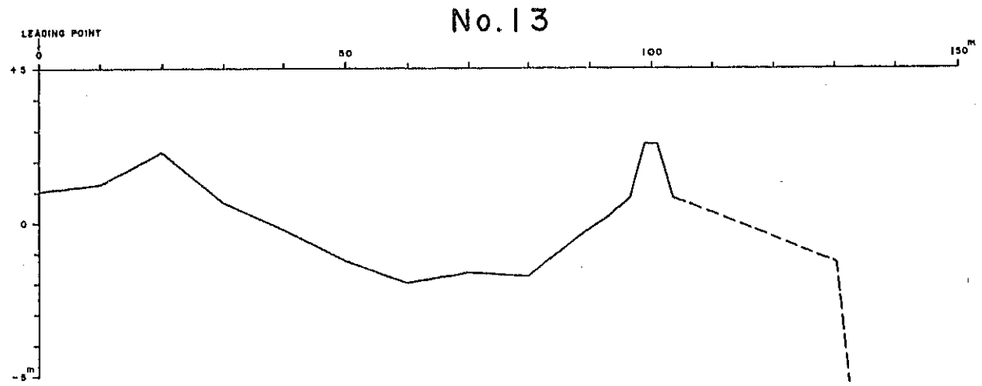


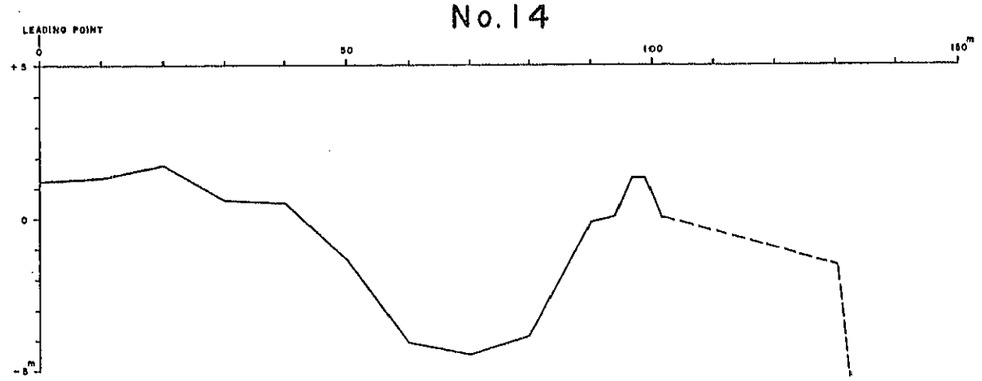


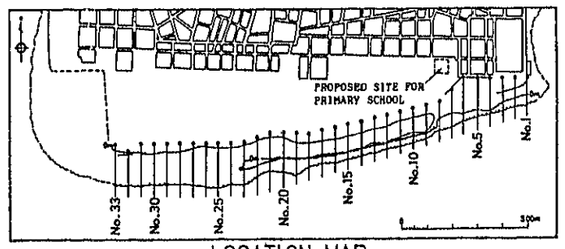








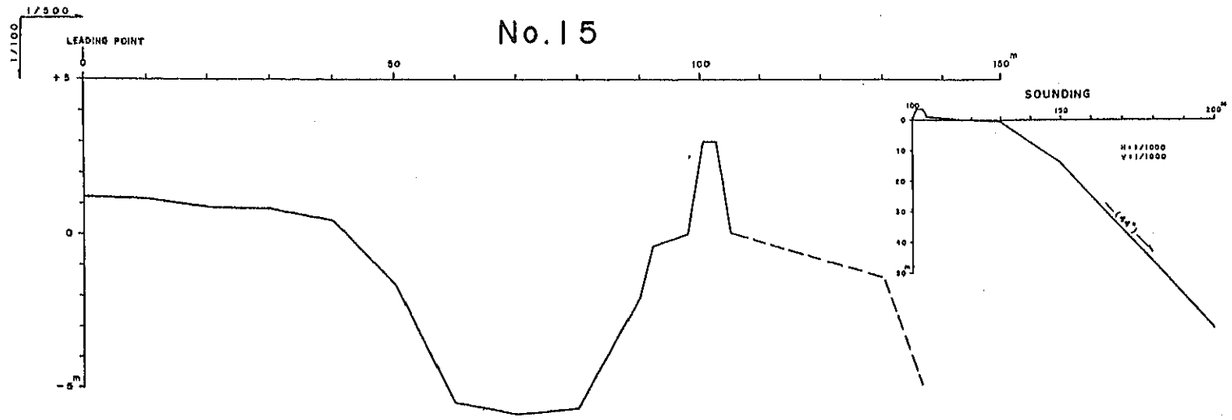


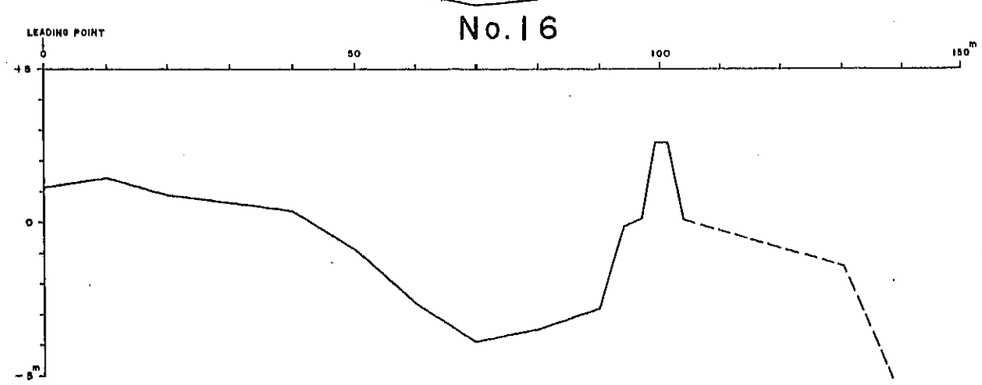


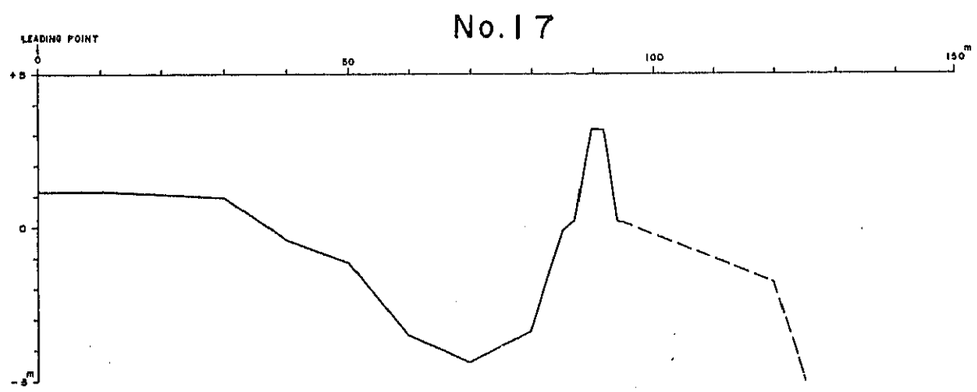
LOCATION MAP
NOT TO SCALE

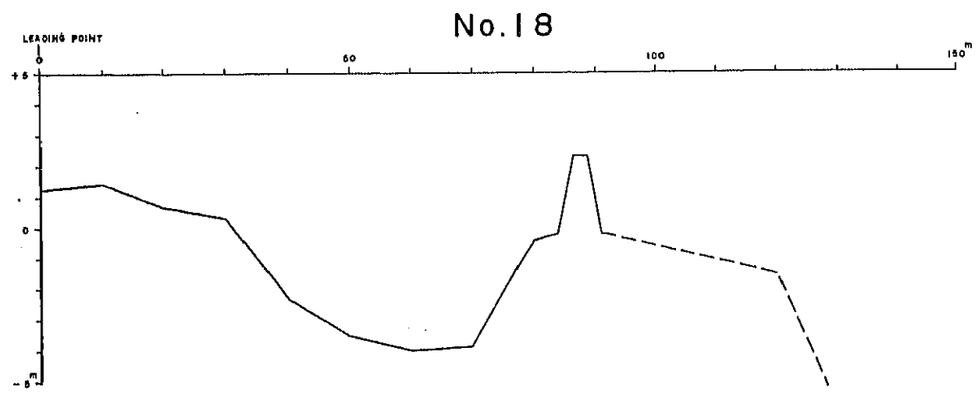
THE PROJECT OF CONSTRUCTING BREAKWATERS ON SOUTHERN COAST OF MALE			
SECTIONAL PROFILES (2 / 5)			
Date	NOV. 05 , 1987	Drawing No.	JMS - 02
JAPAN INTERNATIONAL COOPERATION AGENCY			

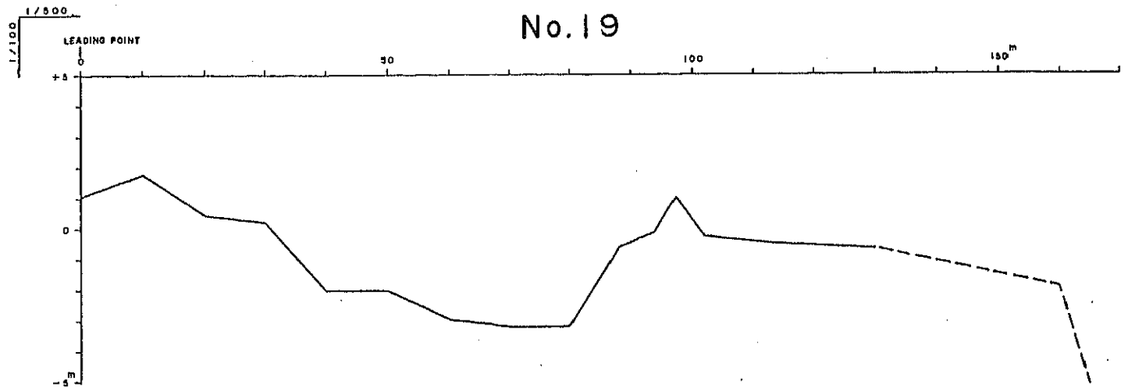
DATUM LEVEL : NEARLY LOWEST LOW WATER

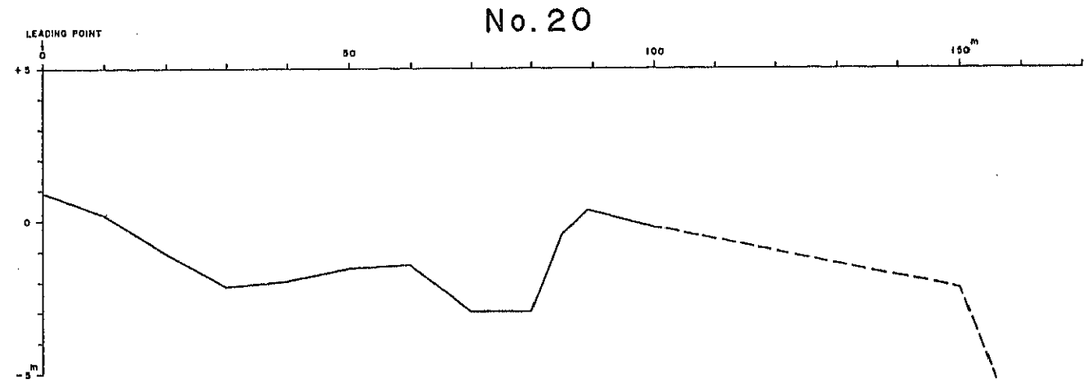


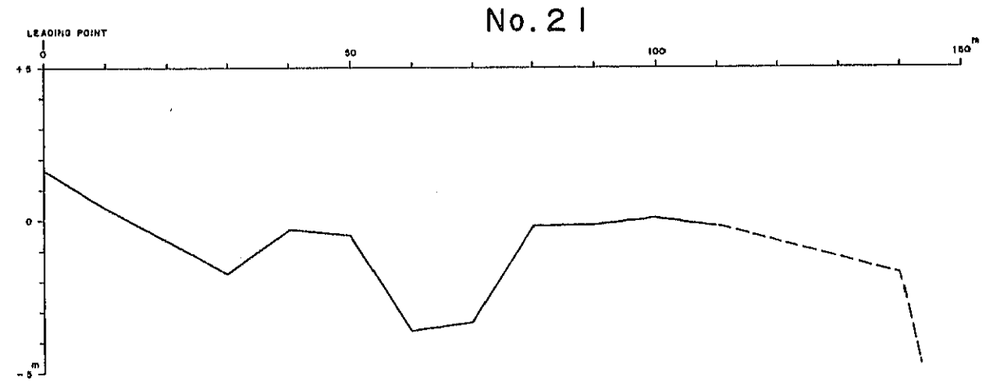


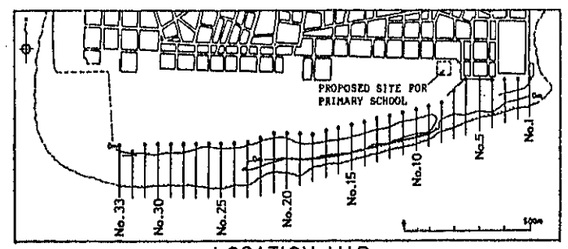








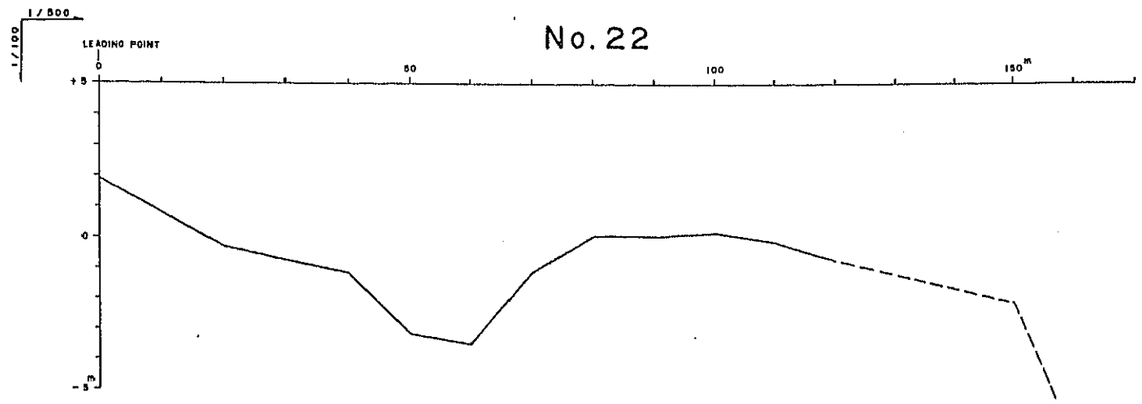


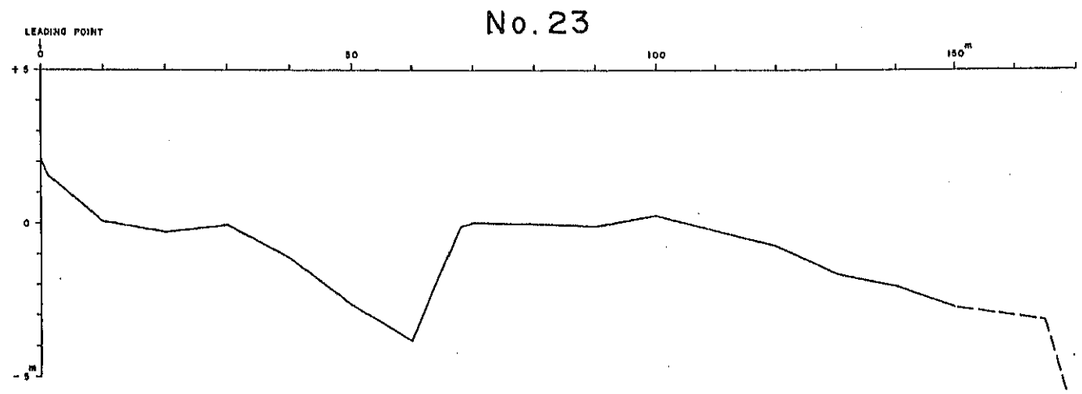


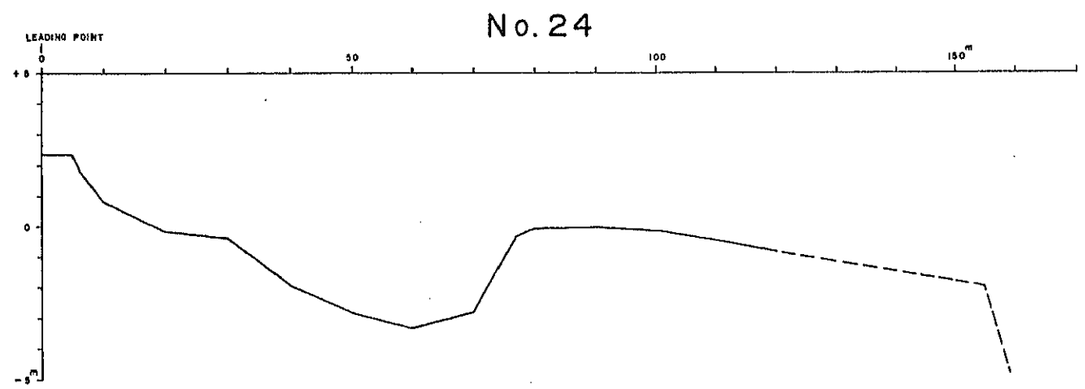
LOCATION MAP
NOT TO SCALE

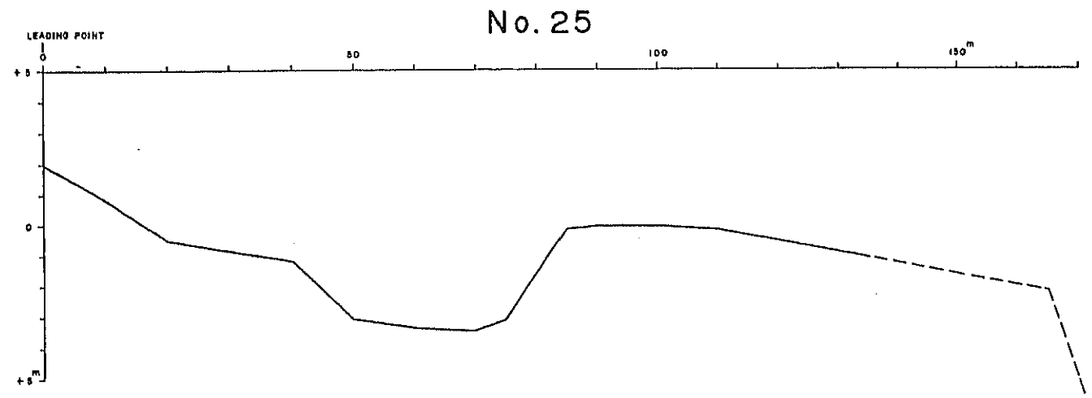
THE PROJECT OF CONSTRUCTING BREAKWATERS ON SOUTHERN COAST OF MALE			
SECTIONAL PROFILES (3 / 5)			
Date	NOV, 05 , 1987	Drawing No.	JMS - 03
JAPAN INTERNATIONAL COOPERATION AGENCY			

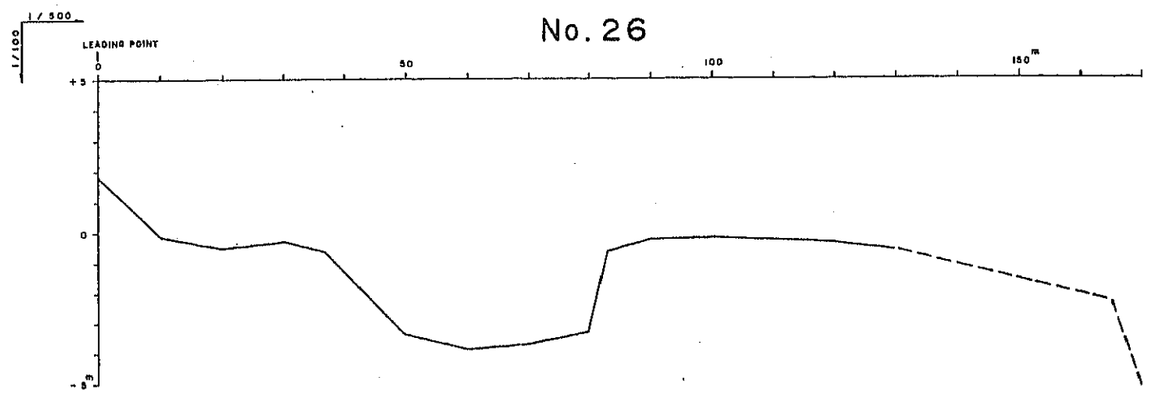
DATUM LEVEL : NEARLY LOWEST LOW WATER

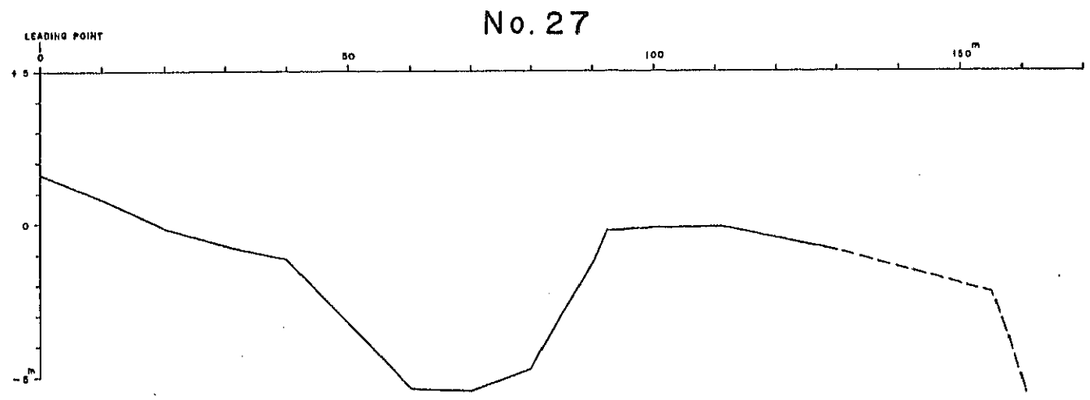


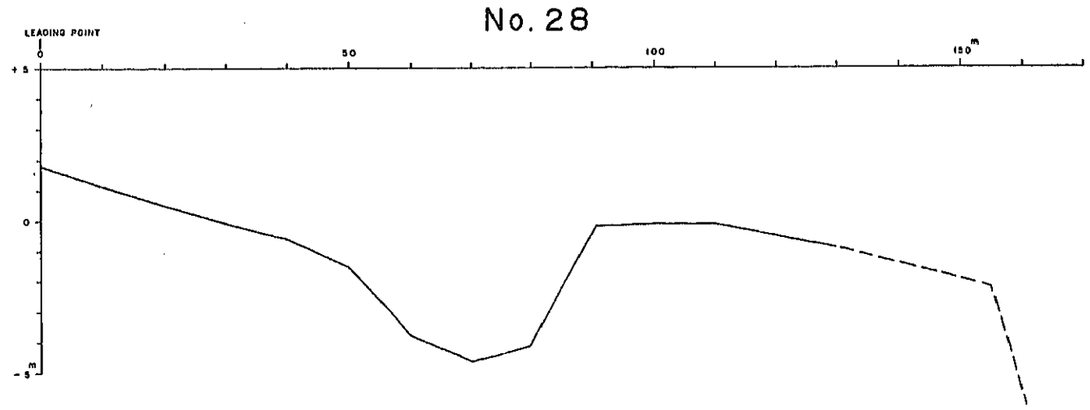


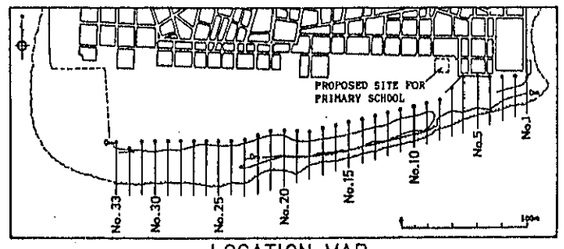








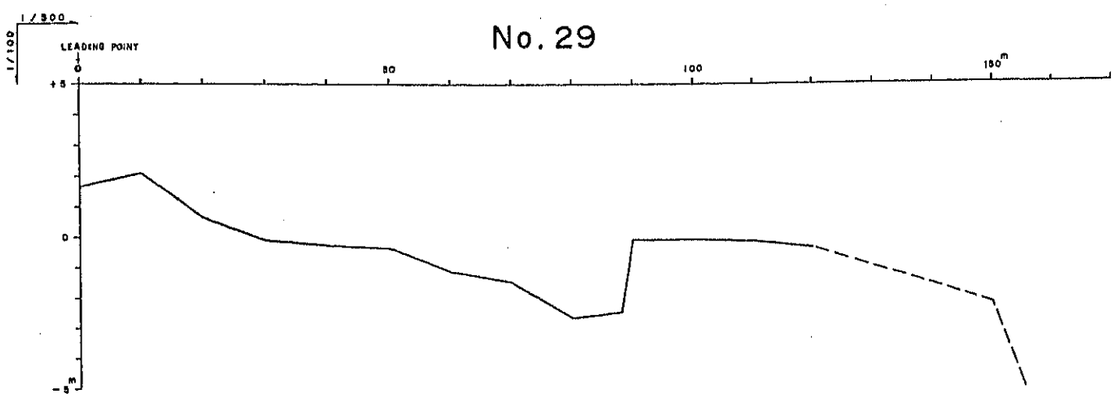


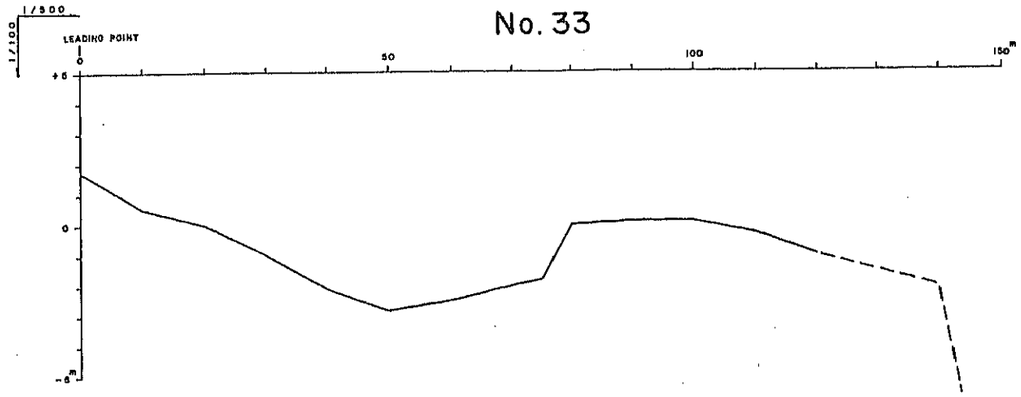


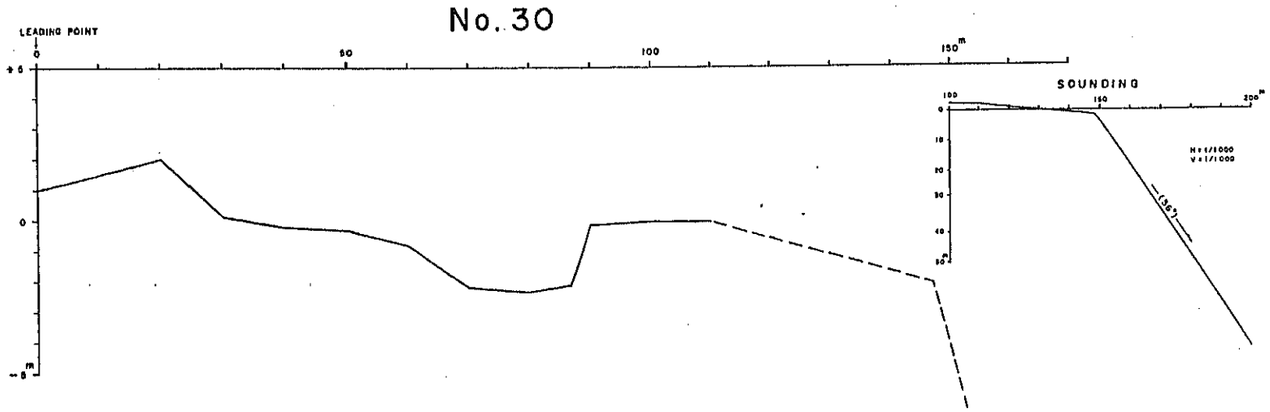
LOCATION MAP
NOT TO SCALE

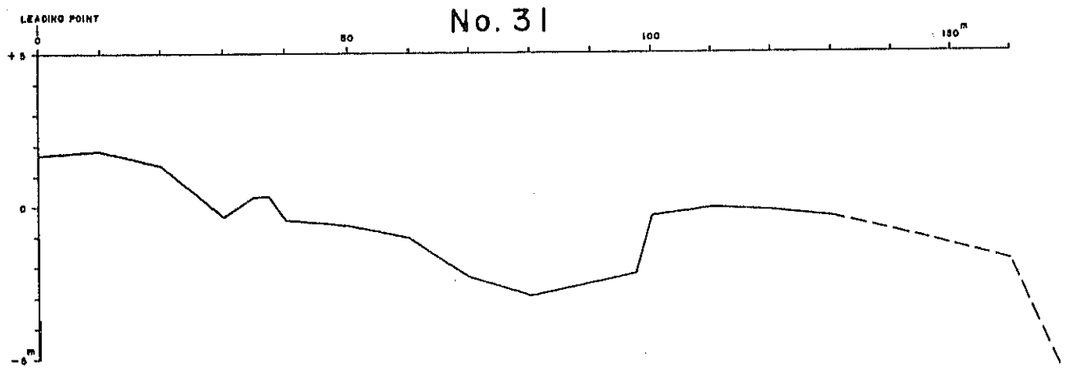
THE PROJECT OF CONSTRUCTING BREAKWATERS ON SOUTHERN COAST OF MALE			
SECTIONAL PROFILES (4/5)			
Date	NOV. 05, 1987	Drawing No.	JMS - 04
JAPAN INTERNATIONAL COOPERATION AGENCY			

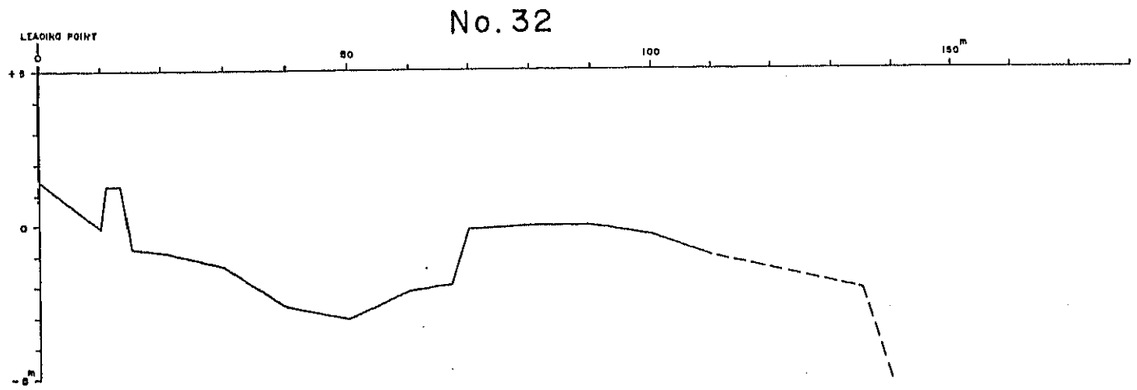
DATUM LEVEL : NEARLY LOWEST LOW WATER

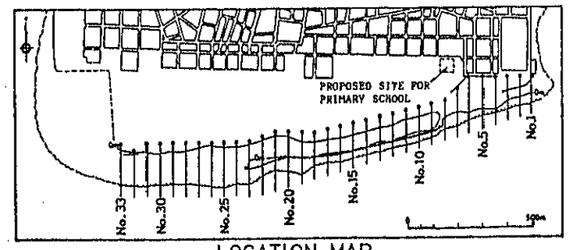












LOCATION MAP
NOT TO SCALE

THE PROJECT OF CONSTRUCTING BREAKWATERS ON SOUTHERN COAST OF MALE			
SECTIONAL PROFILES (5/5)			
Date	NOV, 05, 1987	Drawing No.	JMS-05
JAPAN INTERNATIONAL COOPERATION AGENCY			

DATUM LEVEL : NEARLY LOWEST LOW WATER

APPENDIX XI

TRACE SURVEY DATA

(ON TIDAL WAVE DISASTER IN APRIL, 1987)

APPENDIX XI TRACE SURVEY DATA (ON TIDAL WAVE DISASTER IN APRIL, 1987)

(1) Execution date

8th August, 1987

(2) Place of survey

Three places shown in Fig. A11-1.

(3) Main equipment used

Table A11-1 shows the main equipments used.

Table A11-1 Main equipments used.

Equipment Name	Model	Performance	Remarks
Level	B2	Effective diameter: 40mm Magnification: 28 x Resolution: 3"	Automatic level
Telescopic staff		Effective length: 7m	

(4) Method of survey

Traces of the flooding that occurred as a result of the high tidal waves of April 10th to April 15th, 1987 could not be observed because the flooded houses and damaged walls had been repaired and repainted. Consequently, a trace survey was conducted on the basis of photographs taken at the time of the high tide, and information gathered from residents. The elevation of traces were recorded by levelling with an automatic level and telescopic staff.

(5) Results of the survey

Table A11-2 shows the elevations of the traces due to the high tide at each survey point.

Table A11-2 Results of the survey.

Survey Point	Elevation of Traces (m)
A	DL + 1.73
B	DL + 1.60
C	DL + 1.63

The elevation of traces was highest (1.73) at point A, and the elevation were almost equal at points B (1.60) and C (1.63).

These results confirm the fact that the tidal wave came from an eastern or southern direction and this coincides with the contents of the report by the Japanese expert team.

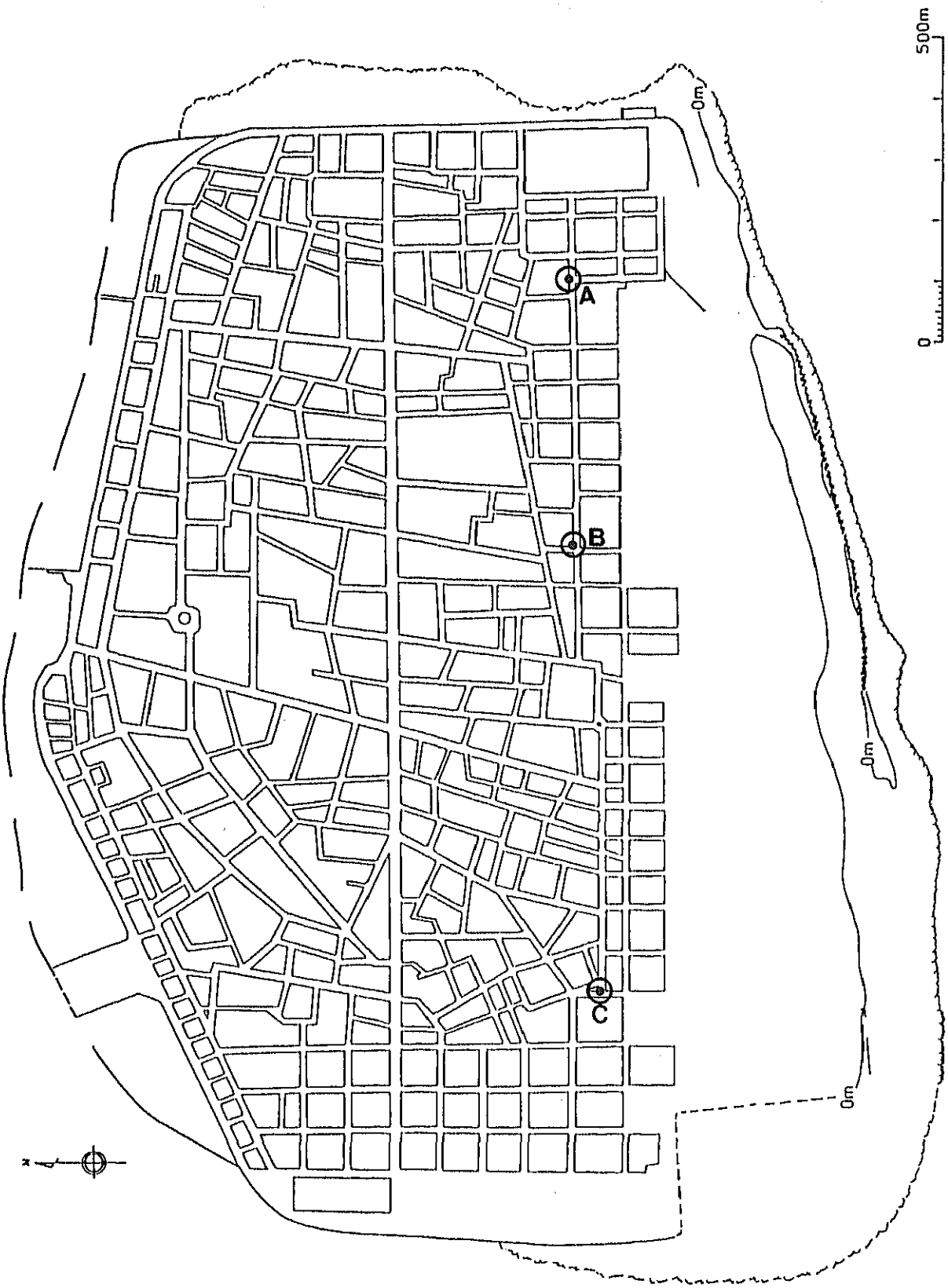


Fig. A11-1 Location of trace survey.

APPENDIX XII

BREAKER HEIGHT SURVEY DATA

(ON TIDAL WAVE DISASTER IN APRIL, 1987)

APPENDIX XII BREAKER HEIGHT SURVEY DATA (ON TIDAL WAVE DISASTER IN APRIL, 1987)

(1) Execution date

8th August, 1987

(2) Place of survey

See Fig. A12-1.

(3) Main equipment used

Table A12-1 shows the main equipments used for the survey.

Table A12-1 Main equipments used.

Equipment Name	Model	Performance	Manufacturer
Theodolite	TM-10C	Effective diameter: 45mm Magnification: 30 x 10-second reading	Sokkisha
Level	B2	Effective diameter: 40mm Magnification: 28 x Resolution: 3"	Sokkisha
Telescopic staff		Effective length: 7m	
Measure tape		100m	

(4) Method of survey

The breaker height of the tidal wave was estimated on the basis of a photograph taken at the time of the disaster. The procedure was as follows:

1) The camera with which the above photograph was taken was installed at the exact place, height and angle from which the photograph was taken. By adjusting the camera lens, it was possible to make the reading correspond with those of the photograph.

2) The height (h_2) from the ground surface to the centre of lens of the camera fixed in the above position was measured.

3) The camera was removed and replaced with a theodolite.

4) The same elevation of the top of the wave appeared in the photograph and was marked onto the walls of nearby houses to measure the angle (θ) of the elevation.

5) The distances from the place where the theodolite was installed to the point where the high tidal wave is supposed to have broken was measured. The ground elevation h_3 at the place where the theodolite was installed was established by levelling from the temporary B.M.

The height above the Datum Level was then calculated using the equation shown in Table A12-2.

(5) Results of the survey

Table A12-2 shows the breaker height, H, from the Datum Level.

Table A12-2 Results of the survey.

Distance (S)	Elevation Angle (θ)	h_1 = Stan θ	h_2	h_3	$H = h_1+h_2+h_3$
150mm	1° 6' 10"	2.88m	1.5m	DL + 1.92m	DL + 6.3m

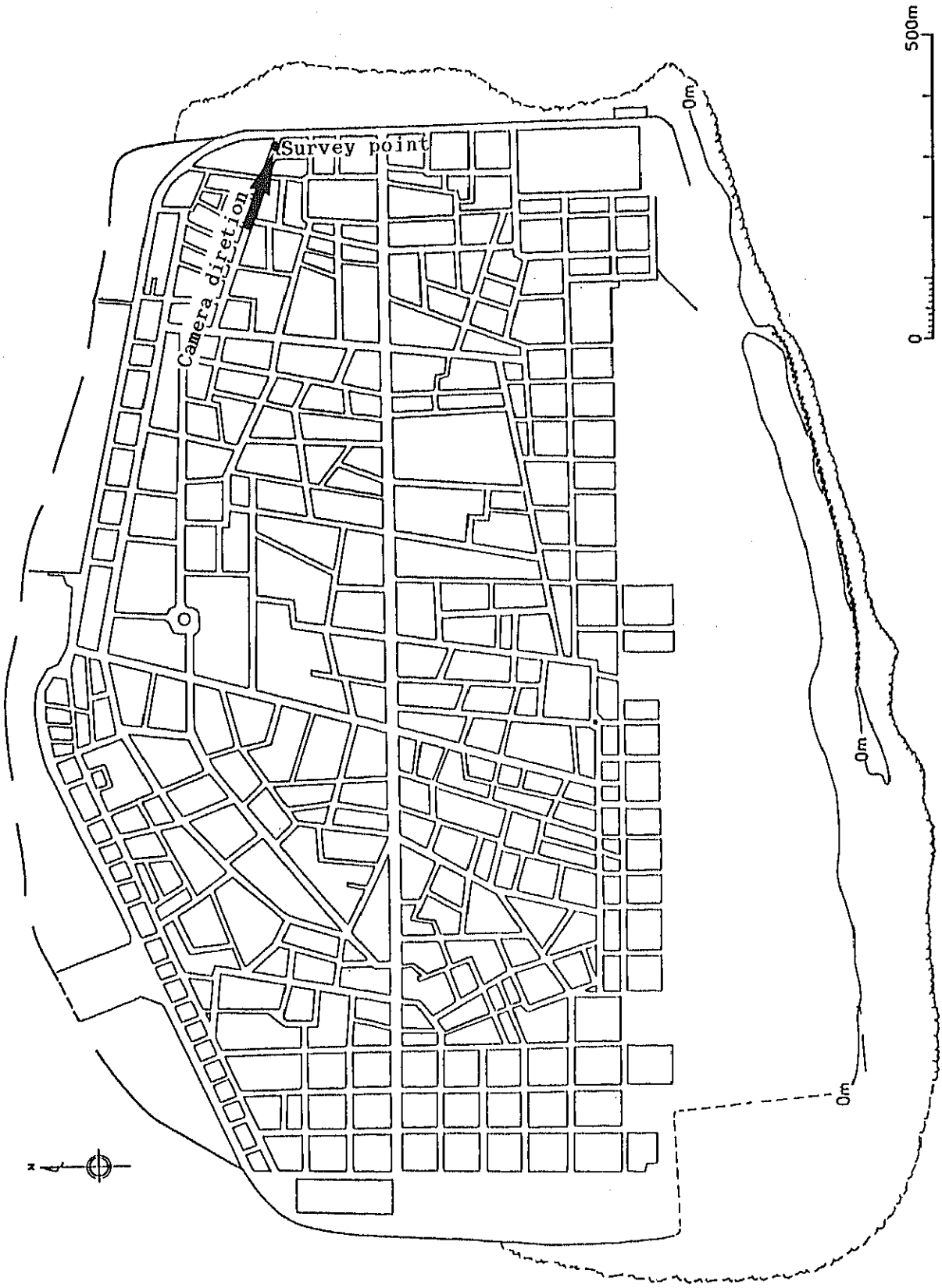


Fig. A12-1 Location of breaker height survey.

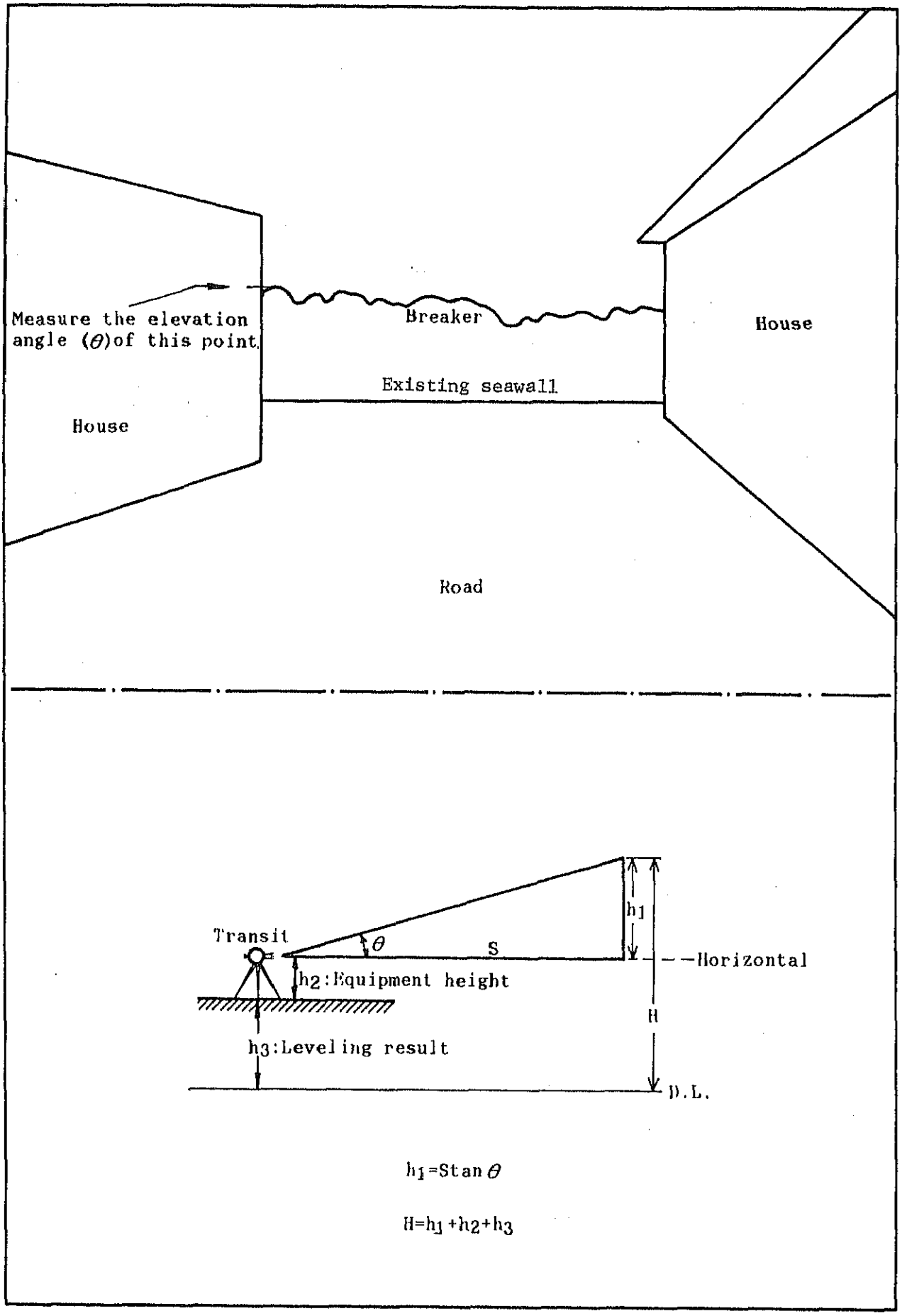


Fig. A12-2 Diagram of breaker height survey.

APPENDIX XIII

BREAKDOWN OF COST TO BE BORNE BY

THE GOVERNMENT OF MALDIVES

APPENDIX XIII BREAKDOWN OF COST TO BE BORNE BY THE GOVERNMENT OF MALDIVES

(1) The major works to be undertaken by the Government of Maldives are as follows.

- o Provision of accessible roads to the Project site both from the main road and from the temporary office.
- o Provision of electricity, telephone and other incidental facilities to the temporary office.

(2) The cost of the works to be undertaken by the Maldives is calculated based on the following conditions. The works are executed under the direct control of the DPWL by DPWL staff and using DPWL construction machinery.

o Date of estimation	: Sepember, 1987
o Execution method	: Under the direct control of the DPWL
o Depreciation of construction machinery	: Nil
o Personnel expense	: Nil
o Equipment and materials procured in the Maldives	: Estimated unit price in the Maldives based on the unit price in singapore
o Expense of land expropriation	: Nil
o Foreign exchange rate	: US$1.00 = ¥147.44 = MRF 9.55 = S$2.11

(3) Calculation of Construction Cost

1) Provision of accessible roads to the Project site, both from the main road and from the temporary office

This construction work shall be executed under the direct control of the DPWL and the construction cost is calculated to be zero since there will be no need to purchase the materials.

2) Provision of electricity, telephone and other incidental facilities to the temporary office

The unit price of the materials for the power distribution and telephone lines to be extended to the temporary offices from the distribution line and telelphone line nearest to the temporary offices has been estimated using the estimated unit price in the Maldives based on the unit price in Singapore.

Categories	Unit	Q'ty	Unit Price	Amount
Cable, 125mm²	m	150	¥2,451/m	¥368,000
Cable conduit (FEP), ϕ65mm	m	140	¥723/m	¥101,000
Telephone cable, 1.2mm x 3 pairs	m	150	¥132/m	¥20,000
Cable conduit (FEP), ϕ30mm	m	140	¥381/m	¥53,000
Protective concrete	m³	0.9	¥8,040/m³	¥7,000
Total				¥549,000

APPENDIX XIV

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APPENDIX XIV REFERENCES

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