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ASEAN-US Cooperative Program
on Marine Sciences:

Coastal Resources Management Project

Association of Southeast Asian Nations
United States Agency for International Development
International Center for Living Aquatic Resources Management

The goal of the Coastal Resources Management Project (CRMP) is to increase existing capabilities within the Association of Southeast Asian Nations (ASEAN) region to develop and implement comprehensive, multidisciplinary and environmentally sustainable CRM strategies through: • analyzing, documenting and disseminating information on trends in coastal resources development; • increasing awareness of the importance of CRM policies and identifying, and where possible, strengthening existing management capabilities; • providing technical solutions to coastal resources use conflicts; • promoting institutional arrangements that bring multisectoral planning to coastal resources development.

The CRMP, funded by the United States Agency for International Development (USAID), is being executed by the International Center for Living Aquatic Resources Management (ICLARM). The CRMP's Project Steering Committee, composed of representatives from each of the ASEAN nations, is responsible for establishing overall project policy direction and overseeing and evaluating project activities and performance.

The CRMP has two components. The first is the development of site-specific CRM plans in the respective ASEAN countries. This component includes resource assessment, cooperative research and planning activities.

The second component is information dissemination and manpower development through:

- publications: a regular regional newsletter; technical reports generated from in-country pilot site activities, reviews, monographs, training manuals, workshop and conference proceedings; educational materials in the form of booklets and leaflets produced in various languages and audiovisuals.
- training activities: short-term training courses in CRM: principles; remote sensing applications; methodologies; socioeconomic analysis; information research and management; postgraduate and on-the-job training in CRM.
- technical workshops and policy seminars

These activities are coordinated through the following national institutions in the ASEAN nations: • Brunei Darussalam—Department of Fisheries; • Indonesia—Indonesian Institute of Sciences; • Malaysia—Ministry of Science, Technology and Environment; • Philippines—Philippine Council for Agriculture and Resources Research and Development; • Singapore—Science Council of Singapore; • Thailand—Office of the National Environment Board.

For more information on the project, contact: The Project Coordinator, ASEAN/USAID Coastal Resources Management Project, ICLARM, MC P.O. Box 1501, Makati, Metro Manila, Philippines.

Cable: ICLARM MANILA, Telex: (ITT) 45658 ICLARM PM; (EASTERN) 64794 ICLARM PN. Tel.: 818-0466, 818-9283, 817-5163, 817-5255. ICLARM FAX no.: (63-2) 819-3329 Makati. Attn: ICS 406 (Globe Mackay, Makati).

ASEAN-US CRMP WP 87/14

Feasibility of Shrimp Culture

#25

FEASIBILITY OF SHRIMP CULTURE IN BRUNEI DARUSSALAM

CATALINO R. DELA CRUZ, Ph.D.

Central Luzon State University
Nueva Ecija 2320, Philippines

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INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

Manila, Philippines

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EXECUTIVE SUMMARY

The US-ASEAN Coastal Resources Management Project Team assessed the feasibility of brackish pond aquaculture development in Brunei. More than 2000 ha are identified as high priority sites for fishfarm development.

Designs of brackishwater aquaculture farms with *P. monodon* as the target species, are prepared together with estimates of development costs. The pond culture systems studied considered appropriate for Brunei are earthen ponds for semi-intensive culture, concrete-lined earthen ponds and fully concreted pond walls, both for intensive culture system.

Feasibility analysis consists of technical feasibility (resource feasibility, biological feasibility, environmental suitability, and manpower availability), market potential, financial analysis on the three culture systems, and institutional feasibility. The following are obtained from the analysis:

1. Shrimp culture in Brunei is technically feasible with certain constraints to be overcome. Insufficient technical manpower both in the managerial and technical levels have to be solved by hiring technically qualified expatriates for an interim period, who will initially develop or operate the farm including training of farm personnel until they are capable of operating the farm themselves.

2. Market potential indicates that some 728 tons of shrimp is necessary to make the country attain self-sufficiency in shrimp supply. Excess production may be exported. However, world market seems to be approaching already the ceiling as is the case in Japan, a major shrimp importer. The price trend is also projected to fluctuate downward.

3. Financial analysis is based on three fishfarm designs/constructions and culture system schemes. Two construction schemes, the concrete walled ponds and concrete-lined ponds are operated intensively, while the third scheme consisting of earthen ponds, is operated semi-intensively. All the three schemes have varying degree of profitability. The most profitable is the concrete-lined earthen ponds with internal rate of return (IRR) of 15.21 per cent, followed by concrete walled ponds with IRR of 11.04 per cent, and the least IRR of 5.0 per cent went to the earthen ponds.

The cash payback period for the three schemes is relatively slow, 6.4 to 15.8 years. The shortest payback period goes to the concrete-lined ponds while the longest went to the earthen ponds.

Other profitability tests, such as rate of return on investment, benefit-cost ratio, and net present value are all in favor of the concrete-lined ponds. Hence, it has the most promising prospects for development in Brunei.

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Without the generous assistance provided by them and many other people, the author could have had considerable difficulty in preparing this report.

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FEASIBILITY OF SHRIMP CULTURE IN BRUNEI DARUSSALAM

by

Catalino R. dela Cruz[1/]

1. BACKGROUND/INTRODUCTION

Previous consultants (ULG Consultants, Ltd., 1983; Chua, 1985; Huszar Brammah and Associates, et al, 1986; and Primary Production Department and Specs, 1987) have reported several freshwater and brackishwater areas in Brunei Darussalam to have potentials for pond aquaculture development. The reports included some feasibility analyses based on specific culture systems and species such as mussel culture in raft, pond polyculture of freshwater giant shrimp (*Macrobrachium rosenbergii*) and carps, and cage culture of seabass (*Lates calcarifer*). The Fisheries Department of Brunei has already embarked on a pilot scale floating cage farm of seabass at Serasa Bay. As a start seabass are being grown for development into broodstock for future breeding.

The feasibility of introducing brackishwater pond aquaculture into the country with marine shrimps as the target species has yet to be determined. Nevertheless, the seemingly attractive profitability of shrimp culture as reported in neighboring countries, particularly shrimp prawn or *Penaeus monodon*, has probably encouraged the Fisheries Department to decide for the establishment of a multi-species hatchery with grow-out ponds for shrimp and seabass as a support to an anticipated aquaculture industry.

In line with the national policy to diversify economy and the desire to develop the industry, the Fisheries Department collaborated with the ASEAN Coastal Resources Management Project (CRMP) in assessing the economic feasibility of shrimp culture in Brunei Darussalam. The study was undertaken in April to June 1987.

1/ Team member (Aquaculture Engineer), joint US-ASEAN Coastal Resources Management Project/Fisheries Department (Brunei Darussalam) Team.

2. METHODOLOGY

2.1 Selection of sites.

High priority sites for development was chosen among the identified sites recommended in the 20 years Master Plan and that by ULG Consultants, Ltd (1983). The ASEAN CRMP Team conducted field investigation, ascertained the suitability of identified potential sites, and matched these with appropriate use or culture systems such as sites for hatchery, semi-intensive or intensive pond culture, and cage culture. The selection was based on the following criteria, among others: 1) availability and extent of land area, 2) quality of brackishwater at the site, 3) availability of freshwater for salinity regulation, 4) relationship between land elevation and tidal fluctuation, 5) extent of vegetation, and 6) availability of infrastructure (road, power, etc). The decision on prioritization on sites were firmed up by using points and ranking system.

2.2 Pond culture system

For the purpose of determining the feasibility of brackishwater pond aquaculture, the team concentrated on developing designs/plans of fishfarms for semi-intensive and intensive culture systems with shrimp (especially *P. monodon*) as the main cultured species. Considering of the small land area of the country and the limited mangrove area that the government might be willing to allocate for conversion into fishfarm, and the limited manpower available, the extensive culture method of shrimp farming was not considered in the present feasibility analysis.

3. TECHNICAL FEASIBILITY OF THE CULTURE SYSTEMS

The technical feasibility of the culture systems is evaluated based on resource availability, biological feasibility, environmental suitability and technical manpower availability.

3.1 Resource availability

Table 1 shows that there are considerable land area which can be developed for pond aquaculture. At least 2060 ha may be developed into semi-intensive shrimp culture. Of these, about 2000 ha of mangroves in the Labu/Temburong River areas may be developed for the purpose. Some 37 ha are identified for intensive culture system.

The present setback of the Labu/Temburong sites is the lack of infrastructure facilities in the area such as roads and electricity. Access to the area is through the rivers by boat. However, it was gathered that construction of road linking Brunei-Muara and Temburong District through Sarawak will soon begin.

Although freshwater for salinity regulation seems to be limited judicious timing in pumping water for filling or replacement of pond water can be done to minimize the problem.

3.2 Biological feasibility

Shrimp prawn (*Penaeus monodon*) has already been proven as a suitable pond culture species. It is being successfully raised in extensive, semi-intensive and intensive culture systems in Taiwan, the Philippines, Indonesia, Malaysia, and other countries. Wickins (1986) reported that Taiwan's production is 4-11 tons/ha per year under semi-intensive culture and 12.6-27 tons/ha per year in intensive culture system with 1.5-2 crops per year. The stocking densities are 10-15 and 15-40 postlarvae/m². In the Philippines, shrimp prawn production from Atlas Fertilizer Corporation's intensive farm may be placed at 9-17 tons/ha per year at density of 15-20 postlarvae/m² and 2.6 crops per year (Mancebo, 1986 talk given at the Fishfarmers National Conference on Prawn Farming Technology, Manila). The present profitability in shrimp production is very attractive especially in countries with cheap labor and fishfarm development costs, as well as production inputs.

In Brunei, aquaculture industry is virtually non-existent. If aquaculture is to be developed most production inputs such as feeds fertilizers, lime and others have to be imported. Seed stock may be assumed to be locally available when hatcheries are already established. Since Brunei is a tropical country, fish growth may be assumed to be same as in neighboring countries under normal conditions when culture practices and inputs are properly administered. The production scheme for semi-intensive and intensive culture systems analyzed for Brunei is given in Table 2.

3.3 Environmental suitability

3.3.1 *Water quality*.

The water quality parameters measured during site investigation were dissolved oxygen (D.O.), salinity, pH, and temperature. These parameters were measured within the river stretches where the sites are located. In general, the values obtained to describe water quality are:

Parameter	*Measured value (Surface to buttom)*
D.O., mg/l	4 - 6
Temperature, °C	29.0-30.2
pH	7.2-8.5
Salinity, ppt	20 - 35

The above values closely agreed with the previous reports. Salinity was observed to fluctuate widely in the Labu/Temburong river areas following heavy rains at the river headwaters. Salinity dropped to 4-5 ppt at the first meter depth from the water surface but remains high at 24 ppt near the bottom of the river. Under this condition, pumping water at some depth needs to be done to obtain the proper salinity desired to be maintained in the ponds.

High water turbidity was also observed at the Labu/Temburong site following heavy rains. This was also observed in the Batu Marang site. This suggests that some kind of sediment or silt trap is needed to minimize pond siltation.

Overall, the water quality in the various river systems of Brunei is within the range of desired quality for brackish aquaculture. The desirable values of parameters for shrimp culture are: D.O., at least 3-4 mg/l; temperature, 25-30°C; pH, 7-8.5, and salinity, 10-25 ppt. Although freshwater is insufficient, the situation will probably improve when the planned construction of some reservoirs and irrigation systems by the government soon becomes a reality.

3.3.2 *Tidal fluctuation and soil characteristic.*

The relationship between tidal fluctuation and land elevation is very important where the filling of ponds depends on incoming tidal flow. The semi-intensive culture system studied operates partly on this principle. Therefore, the available one-year tidal predictions from the Admiralty Tide Table (1987) was analyzed and compared with the land elevation of the Labu/Temburong site. The analyzed tide levels for Muara Port which is used as basis for the Labu/Temburong site is given in Table 3.

Table 3. Tide levels for Muara Port referred to chart datum.

Tide		Height, m
Highest astronomical tide		2.7
Mean higher high water	(Mean spring tide)	2.2
Mean lower low water	(Mean spring tide)	0.4
Tidal range		1.8
Mean lower high	(Mean neap tide)	1.8
Mean higher low water	(Mean neap tide)	0.8

The land elevation at the site was determined to be 1.7 m. The tidal range of 1.8 m falls within the desirable range of 1.5 to 2.0 m., The 1.8 m. range can easily fill the ponds to one meter depth if pond bottom elevation is fixed at 1.0 m from the chart datum.

The soil texture at the Labu/Temburong site is clayey up to one meter deep. The soil auger available did not have extension rod so that attempt to determine the soil texture beyond the first meter depth was in vain. For fishfarm it is desirable to know the soil texture up to 2 m. or more. The clay soil in the Labu/Temburonng site is suitable for constructing dikes and will hold water even without impervious lining.

The possible acidity problem at the site has not been investigated. Should this occur, aside from liming there are already some techniques that can alleviate this problem (PCARRD, 1983).

The sites selected for intensive culture system may not depend anymore on tidal fluctuation to fill the ponds. These sites usually are slightly elevated and may not be reached by incoming tidal flow. In this situation filling of ponds is done by pure water pumping whereas drainage can be effected with ease anytime. Thus, water management provides better control and effectiveness.

Even soil texture in the site does not have to be clayey to hold water. Sandy soil can be used as long as there is lining provided to prevent water leakage. Plastic lining is usually provided in the construction of sewage oxidation pond in Brunei.

Because of the non-dependence on tidal fluctuation and soil texture fishfarms can be located in areas conveniently close to commercial centers where infrastructure facilities are available. The potential problem on soil acidity can also be eliminated by using pond bottom soil layer obtained from an outside source free of acidity problem.

3.4 Availability of technical manpower.

At present, neither the government nor the private sectors have acquired the necessary technical know-how in developing and operating commercial size fishfarms. Likewise, there is insufficient manpower both at the managerial and technical levels. That means that the government has to develop sufficient core of technically-trained manpower in aquaculture to be able to borrow foreign technology for adoption in the country. This seems to be a major constraint at the moment. This situation is further compounded by the fact that semi-intensive and intensive shrimp cultures require high level technology and the risks are also high. These need technically qualified and well-experienced managers and production staff in order to be successful.

If pilot or commercial fishfarms have to be established by the government or local investors, the manpower problem can be solved by hiring qualified expatriates up to a certain period. As this requires large outlay, a special fund is needed to cover the overhead cost for expatriates. This cost is not included in the feasibility analysis because it would affect very significantly the viability of the project.

4. MARKET POTENTIAL

Historically, Brunei had been exporting shrimps/prawns to Singapore and Malaysia. However, in 1973 restrictions were imposed until export in 1981 was reduced to about 40 tons or just 5 per cent of the total shrimps marketed. Since 1982, shrimp export was prohibited as a means to ensure adequate supplies for the local market (Hussain, Brammah and Associates, et al, 1986, BP No. 5).

But even with export ban, the local shrimp supply did not meet self-sufficiency. In 1985, the local production of fresh shrimp was 555.21 metric tons while the import was 727.96 metric tons or a total of 1283.17 metric tons (Brunei Statistical Yearbook 1984/85). This means that 56.7 per cent is being imported to satisfy annual demand.

Aquaculture can therefore be harnessed to help the country attain self-sufficiency in shrimp supply. Shrimp farms need to produce only about 728 metric tons to achieve self-sufficiency. If farms' average production is a low 1000 kg/ha per year this means that only 728 ha is necessary to be developed. This area is reduced to about 146 ha if all farms practice semi-intensive culture with average annual production of five metric tons; and further reduced to 73 ha if operated intensively with ten metric tons production. It is obvious that the aggregate area identified for pond aquaculture is much more than enough to push the country to self-sufficiency in shrimp supply. If these areas are all developed, then export market should be developed.

When shrimp supply attains sufficiency level, it is likely that local market price will drop. Exporting part of the shrimp produced is an alternative to counter price decrease. But this should carefully consider the trend in world market demand and price of shrimp.

The accelerated growth of the shrimp industry has resulted in a growing consensus that the market for shrimp may have been or nearly saturated, contrary to the general belief that the demand for shrimp is seemingly unlimited. In Japan, which absorbs a sizeable portion of the world's shrimp production, the amount of imported shrimp has reached its ceiling (Hirasawa, 1984). Such is the case, further increases in shrimp production may result to the downward fluctuation of prices severely affecting the economics of shrimp farming. Existing culture techniques are capital intensive in general. Unless technological advances are made which will result to the reduction of production costs while at the same time maintaining or even increasing the level of production, prospective investors in shrimp production should carefully evaluate the prospects of shrimp farming in the light of the current and future economic trends.

5. FINANCIAL ANALYSIS

This section presents a financial evaluation of shrimp farming under Brunei conditions in semi-intensive earthen pond culture system and intensive culture in concrete walled ponds and concrete-lined earthen ponds.

5.1 Fishfarm design.

Detailed plan/designs of fishfarms for semi-intensive and intensive culture systems are developed. The investment and operating costs are estimated for each system which served as bases for financial analyses.

5.1.1 *Semi-intensive culture system.*

This consists of a 10 hectare (water area) fishfarm composed of 20 units earthen grow-out ponds with 0.5 ha/unit. The layout and design of components are shown in appendix Figures 1 to 7. The design elevations of pond bottom, dikes, and gates are fitted to the prevailing tidal characteristics in Port Muara and land elevation on the Labu/Temburong site.

5.1.2 *Intensive culture system.*

This system has two design/construction schemes. One scheme has pond partitions made of earthen dikes lined with concrete, while the other scheme has reinforced concrete walls as pond partitions. The farm area for each scheme is five hectares. Both schemes have pond bottom lined with thick gauge plastic, which is overlain by a layer of good quality clayey soil.

The layouts and designs of the two schemes (see Appendix, Figures 8 to 10, and Figures 11 to 13), may be constructed on site having pervious soil as well as one slightly elevated areas that may not be effectively reached by tidal fluctuation. Obviously, concrete-lined earthen pond needs large quantity of soil fill whereas the concrete walled pond need very little soil fill such as the amount needed for road fill.

5.2 Capital investment costs

Presented in Tables 4 to 6 are the different capital investment items and their corresponding values for semi-intensive and intensive systems. The capital items are classified into non-depreciable and depreciable categories.

The non-depreciable investment item, in this case, pond construction, comprises about 84-86 per cent of the total investment cost. Total pond development cost (pond construction + pond bottom plastic lining) is highest for intensive system in concrete walled ponds at Brunei dollars $ 934,713/ha while concrete-lined earthen ponds require $ 658,170/ha. A semi-intensive system needs a total of $ 213,429/ha for pond development.

The depreciable capital items are so classified because they have a definable useful life. In effect, such items "wear out" or depreciate with use. These items vary depending upon the culture system and the nature of pond construction, although there are production items common to all systems, such as vehicles. The major depreciable capital item for intensive shrimp culture is the pond plastic lining comprising about 77 per cent of the total.

Other depreciable items include buildings, pumps, nets, buckets, boxes, etc. In computing for the depreciation cost, the straight-line method is used where the acquisition or initial costs is divided by the estimated life span. Salvage value of the items are assumed to be zero. The depreciation cost is estimated to spread out the cost of the capital throughout its useful life and is considered a fixed, non-cash expense item (McCoy and Boutwell, 1976).

The total investment cost for the different systems are as follows: $ 231,429/ha for semi-intensive; $ 964,113/ha for intensive in concrete walled ponds; and $ 687,570/ha for intensive in concrete-lined earthen ponds.

5.3 Estimated costs and production revenues.

In this analysis, constant prices are assumed for simplicity of presentation; and assuming that if there may be changes in the general price level, no changes in relative price will occur; that is, prices of inputs and outputs will change at approximately the same rate.

Production costs and expenses vary between the semi-intensive and intensive systems. However, production expenses for intensive shrimp farming in both concrete walled ponds and concrete-lined ponds are assumed to be the same.

The estimated annual quantities of material inputs and costs per hectare of shrimp culture are presented in Appendix, Table 18. Expenses for the purchase of shrimp fry/seed are the major production cost item comprising about 43 per cent and 59 percent of the total input cost for semi-intensive and intensive systems, respectively. Expenses for line (if there is acid sulfate problem) is the next major production cost of semi-intensive system comprising about 28 per cent while feed costs rank second for intensive system contributing about 38 per cent of the total. Other production expenses include electricity (for intensive system), gasoline and oil expenses and teaseed cake purchases. Total costs for material inputs are $56,760 per ha for semi-intensive system and $ 159,390/ha for intensive system. In addition to expenses for material inputs, labor costs, miscellaneous expenses for general operation, and repairs and maintenance costs also contribute to the total variable or operating expenses. Additional expense estimates are presented in Appendix, Tables 19 and 20.

Costs are generally classified into fixed or variable. Fixed costs are those that are incurred whether production is carried out or not. In this analysis, fixed costs consists of depreciation and interest on cash operating expenses. The latter is classified as a fixed non-cash expense to represent the opportunity cost of capital since the investor's own money is used. Interest is calculated at four per cent of the total variable expenses to approximate the interest earnings the money would generate if it were deposited in a bank savings account in Brunei. Variable costs are those expenses necessary if production is carried out.

The estimated production and corresponding value is presented in Appendix, Table 21. The production trend shows an increasing pattern with the first year's production representing only 50 per cent of the full output potential of the operations. The maximum productive capacity of the systems is assumed to have been achieved by the fifth year when the people working in the farm shall have gained sufficient experience.

5.4 Budget analysis

In the analysis of the three shrimp farming systems, the financial projections are representative of the first five years of operation. These financial statements estimate the future profitability, cash requirements, and expected financial condition of the projects.

The projected income statements for the different systems are shown in Tables 7 to 9. The income statement lists down the income or revenue (sales) and the corresponding costs and expenses. For all systems, expenses for shrimp fry/seed, feeds and labor constitute about 70-80 per cent of the total cost. It is therefore extremely important that high quality seeds and feeds are obtained when buying these items. Hiring of manpower should also be done with careful screening. The total production cost per unit area for intensive shrimp culture is about three times greater than the production cost per unit area for semi-intensive system. Estimated average total cost in a five-year operation for intensive system is about $223,735/ha which represents an average production cost of approximately $ 15/kg of shrimp. For semi-intensive system, average total production cost is $ 80,260 per ha for an average production cost of about $ 18/kg.

During the first year of operation, all systems incurred net losses due to the relatively low production assumed. However, positive net incomes in succeeding years are obtained from intensive system as the operation becomes more efficient. The semi-intensive system still incurs losses during the second year even with a 25 per cent increase in the production level.

In most aquaculture enterprises, large initial capital outlays are required. Expenses for the different inputs are incurred throughout the culture period while cash revenues tend to progressively increase. When a new producer starts his operation, consideration must be given to means of providing the needed expenses for the operation until funds become available from the project. An enterprise that is economically viable in the long run must not have cash flow shortages in the short run.

The projected cashflow statements for the different systems indicate the availability of cash for their continued operations (Tables 10 to 12). The initial total cash inflow requirement is provided by the investor's owned capital for a 100 per cent equity. This also corresponds to the total project cost calculated by the sum of the total capital investment and the total cash expense requirements for the first year of operation. Comparison for the total project costs (total investment and total variable costs) for the different systems is shown in Table 13.

Further analysis also shows the project's highly favorable net worth as shown by the projected balance sheets (Tables 14 to 16).

5.5 Profitability analysis

An assessment of the commercial profitability of the project is necessary as basis for the final choice of an investment project from the given alternatives. The financial measures are classified into first level indicators (not discounted) such as payback period and rate of return on investment (ROI). While these indicators can be used to rank investment alternatives, they do not measure the true profitability of projects because they fail to consider the timing of incomes and expenses (Shang, 1981). The second level of financial measures are known are discounted indicators because they take into consideration the timing of incomes and expenses. The reasons for discounting is to take into consideration the decrease in the future value of money, that is, the present value of money is greater than its future value. These discounted indicators include benefit-cost (B/C ratio), net present value (NPV, and internal rate of return (IRR).

Based from the analysis, the cash payback period of the project alternatives are relatively long with values of 15.8 years for the semi-intensive; 8.9 years for the concrete walled ponds, and 6.4 years for the concrete-lined ponds. The long payback period for the semi-intensive earthen ponds is largely due to the cost contributed by applying lime to correct projected acidity problem. When there is no acidity problem, the cash payback period is 7.6 years.

The ROI, which represents the earning of the investment, is highest for the concrete-lined ponds at 15.73 per cent, followed by the concrete walled ponds with ROI of 11.23 per cent. The semi-intensive system earns only about $0.06 for every dollar of investment or 6.32 per cent ROI.

The discounted measures provide a more accurate indication of the profitability of investment alternatives. The three projects have B/C ratios ranging from 1.03 to 1.18. The NPV, which measures present value of the future benefits forthcoming from the project including the residual value of investment, is highest for concrete-lined ponds with NPV of $ 1,365,455; followed by concrete walled ponds with NPV of $ 1,172,421; and lowest for semi-intensive system with NPV of $ 188,239. The higher the net present value, the more desirable a project becomes. Between the two pond designs for intensive shrimp farming, the concrete-lined pond design has a higher NPV because it is more profitable via-a-vis the initial investment cost. In other words, even with less amount of investment, it can generate benefits the same as a concrete walled pond design which required higher initial investment.

The internal rate of return or IRR is perhaps the most widely used indicator of profitability because it is a dynamic measure. The IRR measures the true profitability of a project. Enterprises with IRR greater than the opportunity cost of capital is considered profitable, the higher it is the better. The percentage in excess of the opportunity cost of capital represents pure profit. Based from the analysis made, concrete-lined ponds for intensive culture system has the highest IRR (15.21 per cent), followed by concrete walled ponds (11.04 per cent) and semi-intensive systems with 5.0 per cent. Without liming, the IRR of semi-intensive system is 14.6 per cent. Shown in Table 17 is the summary of the financial and profitability tests. Full details of calculations of financial measures are presented in Appendix, Table 22 to 24.

Based from the analysis made, intensive system in concrete-lined ponds is the obvious choice for investment. It has the highest profitability among the three schemes considered. The intensive system in concrete walled ponds, while profitable based from the analysis and assumptions made, does not exhibit stable viability. In short, adverse changes in input and output prices will result to decreased profitability. For example, a decrease in the price of shrimp from $20 to $18/kg will reduce both the investment earning by 50 per cent ($0.13 to $0.06) and the IRR by about 10 per cent and a benefit-cost ratio of 1.10.

The semi-intensive system is barely able to pay for its cost with a B/C ratio of 1.03 and IRR of 5.0 per cent. A 10 per cent decrease in output prices or increase in fry and feed cost will render the operation unprofitable. However, it is indicated elsewhere that the cost of lime is the main factor that pulled down the profitability of earthen ponds. If the anticipated problem on occurrence of acid sulfate soil is quickly neutralized then the cost item for lime will become minimal and this will improve the profitability of the semi-intensive earthen ponds considerably.

6. INSTITUTIONAL FEASIBILITY

The development of pond aquaculture also needs government institutional and policy support. Prospective investors should have certain degree of assurance and fair chance to recover their investments from the business.

A positive indication of government support to future aquaculture investors is the planned construction of multi-species hatchery assource of fish/shrimp seeds. Manifestation of support can be further strengthened if a demonstration fishfarm for brackishwater pond aquaculture is also established. Likewise, technical backstopping of investors through dependable and aggressive extension service has to evolve.

A government policy that would very likely deter aquaculture development is the current policy on land tenure. The duration of Temporary Occupational Lease (TOL) is three years. This is a very short time indeed since from the feasibility analysis, the shortest payback period on fishfarm investment is at least 6.4 years under smooth and productive fishfarm operation.

7. CONCLUSION AND RECOMMENDATION.

The feasibility analysis shows that shrimp culture in Brunei Darussalam is economically feasible. The most profitable among the fishfarm design/construction and culture system schemes analyzed is the concrete-lined earthen ponds.

However, the constraint on manpower availability both in the managerial and technical levels have to be overcome. An immediate short-term solution is to hire technically qualified and experienced expatriates, who will supervise shrimp farm development, operate, and train the local counterpart personnel on the whole range of operation and management of the farm.

As a visible technical support of the government to prospective investors, it is desirable to establish even a modest shrimp farm demonstration facility where adaptive research/trails as basis for extension recommendations may be conducted. The area may be 15-20 ha, which will include space for physical facilities and future expansion. The site should be close to existing amenities such as roads, electricity, and water. The possible site for this purpose is Serasa, Batu Marang or Tg. Lumut. However, these sites should have further investigation, including the chance of obtaining the desired area from the government.

The policy on land tenure may have to be modified in order to accommodate the slow payback period of investment from shrimp farm development. The prospective investors will be more attracted to invest money if tHey have longer security of tenure.

The projected trend on world market demand and down fluctuation of market price should be evaluated carefully by the decision makers in the government. This is one major consideration whether the country should venture in commercial shrimp culture just to attain self-sufficiency level in supply or develop more areas for world export.

Should the country decide to venture in shrimp pond production, this would redound to better food security and less dependence on food supply from other countries.

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Table 1. Sites selected for shrimp culture by the ASEAN CRMP Team

Location	Suitability	Remark
1. Belait River	Semi-intensive culture	Located beside the river about 5 km from the mouth; about 5-10 ha for marine shrimp
2. Kg. Seribangun LA 1/58, 2/58 Pte 4/69 Gaz. 5274 P634 SL between 5274 and LA 1/58	Intensive culture	About 10 ha for marine shrimp
3. Seri Kenangan Lots 3367, 1869 1882	Hatchery and intensive culture	Prawn and seabass about 10 ha
4. Jambatan Tutong Kg Senekaran Pte 377, 378, 1271 Between 1271 and 4169SL	Intensive culture	Shrimp, about 5 ha
5. Kg. Keramut	Hatchery and intensive	Prawn and seabass, about 10 ha
6. Kg. Danau	Hatchery	Shrimp, about 2 ha; further investigation suggested.
7. Kg. Batu Marang	Semi-intensive culture	Shrimp, about 10 ha
8. Tg. Lumut	Semi-intensive culture	Shrimp, about 40 ha; further investigation suggested
9. Labu River	Extensive and semi-intensive culture	At least 1000 ha for shrimp; presently far from existing infrastructure facilities
10. Temburong River	Extensive and semi-intensive culture	At least 1000 ha for shrimp; presently far from existing infrastructure facilities

Table 2. Assumptions used for the different culture systems analyzed for Brunei Darussalam

Item	Semi-intensive Earthen Pond	Intensive Concrete-lined Earthen Pond	Intensive Concrete-Walled Pond
Stocking density	5-10/square meter	20-30/sq. meter	20-30/sq. meter
Feed	Commercial	Commercial	Commercial
Water management	Tidal + pump Daily exchange of 10-20 per cent	Pump + aeration 50 per cent replacement and frequency of 15-17 times/crop	Pump + aeration 50 per cent replacement and frequency of 15-17 times/crop
Pond size	0.5 ha/unit	0.25 ha/unit	0.25 ha/unit
Pond development cost/ha	213,429	658,170	934,713
Culture period	120 days; 2.5 crops per year	120 days; 3 crops per year	120 days; 3 crops per year
Harvest size	30-35 grams	30-35 grams	30-35 grams
Survival rate	70 per cent	70 per cent	70 per cent
Production/year	3-6 tons	9-18 tons	9-18 tons

Table 4. Investment analysis for a 10-ha semi-intensive farming of shrimp (*P. monodon*) under Brunei conditions

Item	Unit	Year Life	No. of Units	Cost/Unit ($)	Total Cost ($)	Annual[1] Depreciation ($)
Pond development	ha.	-	10	213,429	2,134,290	-
Farm building	sq.m.	15	100	500	50,000	3,333
Equipment:						
Pump and engine pipe house	each	5	2	25,000	50,000	10,000
Nets, buckets, boxes, etc.		2			10,000	5,000
Vehicles (pick-up):						
4-wheeled	each	10	1	25,000	25,000	2,500
6-wheeled	each	10	1	45,000	45,000	4,500
TOTAL INVESTMENT					2,314,290	
TOTAL DEPRECIABLE INVESTMENT					180,000	25,333
INVESTMENT PER HECTARE					231,429	

[1] Computed using straight-line method with zero salvage value.

Table 5. Investment analysis for a 5-ha intensive farming of shrimp (*P. monodon*) in concrete-lined earthen ponds under Brunei conditions

Item	Unit	Year Life	No. of Units	Cost/Unit ($)	Total Cost ($)	Annual[1] Depreciation ($)
Pond development						
pond construction	ha.	-	5	558,170	2,790,850	-
pond plastic lining	ha.	5	5	100,000	500,000	100,000
buildings (office, living quarters, storage)	sq.m.	15	70	500	35,000	2,335
Equipment:						
Axial flow pump with motor	each	5	2	5,000	10,000	2,000
Paddlewheel aerators (2 hp)	each	5	40	675	27,000	5,400
Nets, buckets, boxes, etc.		2			5,000	2,500
Vehicles (pick-up)						
4-wheeled	each	10	1	25,000	25,000	2,500
6-wheeled	each	10	1	45,000	45,000	4,500
TOTAL INVESTMENT					3,437,850	
TOTAL DEPRECIABLE INVESTMENT					647,000	119,235
INVESTMENT PER HECTARE					687,570	

[1] Computed using straight line method with zero salvage value.

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Table 6. Investment analysis for 5-ha intensive farming of shrimp (*P. monodon*) in concrete-walled ponds under Brunei conditions

Item	Unit	Year Life	No. of Units	Cost/Unit ($)	Total Cost ($)	Annual[1] Depreciation ($)
Pond development:						
pond construction	ha.	-	5	834,713	4,173,565	-
pond plastic lining	ha.	5	5	100,000	500,000	100,000
buildings (office, living quarters, storage)	sq.m.	15	70	500	35,000	2,335
Equipment:						
Axial flow pump with motor	each	5	2	5,000	10,000	2,000
Paddlewheel aerators (2 hp)	each	5	40	675	27,000	5,400
Nets, buckets, boxes, etc.		2			5,000	2,500
Vehicles (pick-up):						
4-wheeled	each	10	1	25,000	25,000	2,500
6-wheeled	each	10	1	45,000	45,000	4,500
TOTAL INVESTMENT					4,820,565	
TOTAL DEPRECIABLE INVESTMENT					647,000	119,235
INVESTMENT PER HECTARE					964,113	

[1] Computed using straight-line method with zero salvage value.

Table 7. Projected income for a 10-ha. semi-intensive farming of shrimp (*P. monodon*)

Item	Yr 1	Yr2	Yr 3	Yr 4	Yr 5
Income:					
Sales	600,000	750,000	900,000	1,050,000	1,200,00
Less: Costs					
Variable:					
Shrimp fry/seed	243,750	243,750	243,750	243,750	243,750
Salaries/Wages:					
Farm manager	36,000	36,000	36,000	36,000	36,000
Technicians/ laborers	90,000	90,000	90,000	90,000	90,000
Hired laborers	27,000	27,000	27,000	27,000	27,000
Security Guards	19,200	19,200	19,200	19,200	19,200
Feeds, FCR=1.6:1	144,000	144,000	144,000	144,000	144,000
Lime	160,000	160,000	160,000	160,000	160,000
Gasoline and Oil	3,600	3,600	3,600	3,600	3,600
Teaseed cake	11,250	11,250	11,250	11,250	11,250
Repair and Maintenance	18,000	15,466	13,933	11,400	9,866
Miscellaneous	5,000	5,000	5,000	5,000	5,000
Fixed:					
Depreciation	25,333	25,333	25,333	25,333	25,333
Interest on operating costs (except depreciation) 4%	23,912	23,810	23,749	23,648	23,586
TOTAL COSTS	807,045	804,409	802,815	800,181	798,585
NET INCOME	-207,045	-54,409	97,185	249,819	401,415

Table 8. Projected income for a 5-ha. intensive farming of shrimp (*P. monodon*) on concrete-lined earthen ponds

Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Income:					
Sales	900,000	1,350,000	1,732,500	1,732,500	1,800,000
LESS: Costs					
Variable:					
Shrimp fry/seeds	468,750	468,750	468,750	468,750	468,750
Salaries/wages:					
Farm manager	36,000	36,000	36,000	36,000	36,000
Technicians/ laborers	54,000	54,000	54,000	54,000	54,000
Hired laborers	13,500	13,500	13,500	13,500	13,500
Security Guards	19,200	19,200	19,200	19,200	19,200
Feeds, FCR = 2:1	300,600	300,600	300,600	300,600	300,600
Electricity:					
Water pump	7,275	7,275	7,275	7,275	7,275
Aerators	10,575	10,575	10,575	10,575	10,575
Gasoline and oil	1,000	1,000	1,000	1,000	1,000
Teaseed cake	6,750	6,750	6,750	6,750	6,750
Repairs and maintenance	64,700	52,776	41,353	29,429	18,006
Miscellaneous	2,000	2,000	2,000	2,000	2,000
Fixed:					
Depreciation	119,235	119,235	119,235	119,235	119,235
Interest on operating costs (except depreciation) 4%	39,374	38,897	38,440	37,963	37,506
TOTAL COSTS	1,142,959	1,130,561	1,118,678	1,106,777	1,094,397
NET INCOME	- 242,959	219,439	613,822	625,723	705,603

Table 9. Projected income for a 5-ha. intensive farming of shrimp (*P. monodon*) in concrete-walled ponds

Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Income					
Sales	900,000	1,350,000	1,732,500	1,732,500	1,800,000
LESS: Costs					
Variable:					
Shrimp fry/seeds	468,750	468,750	468,750	468,750	468,750
Salaries/wages:					
Farm manager	36,000	36,000	36,000	36,000	36,000
Technicians/ laborers	54,000	54,000	54,000	54,000	54,000
Hired laborers	13,500	13,500	13,500	13,500	13,500
Security Guards	19,200	19,200	19,200	19,200	19,200
Feeds, FCR = 2:1	300,600	300,600	300,600	300,600	300,600
Electricity					
Water pump	7,275	7,275	7,275	7,275	7,275
Aerators	10,575	10,575	10,575	10,575	10,575
Gasoline and Oil	1,000	1,000	1,000	1,000	1,000
Teaseed Cake	6,750	6,750	6,750	6,750	6,750
Repairs and maintenance	64,700	52,779	41,353	29,429	18,006
Miscellaneous costs	2,000	2,000	2,000	2,000	2,000
Fixed:					
Depreciation	119,235	119,235	119,235	119,235	119,235
Interest on operating costs (except depreciation) 4%	39,374	38,897	38,440	37,963	37,506
TOTAL COSTS	1,142,959	1,130,561	1,118,678	1,106,777	1,094,397
NET INCOME	- 242,959	219,439	613,822	625,723	705,603

Table 10. Projected cash flow budget for a 10-ha. semi-intensive farming of shrimp (*P. monodon*)

Item	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr5
CASH INFLOW						
Equity	3,072,090	-	-	-	-	-
Sales	-	600,000	750,000	900,000	1,050,000	1,200,000
Total Cash Inflow	3,072,090	600,000	750,000	900,000	1,050,000	1,200,000
CASH OUTFLOW						
Pond dev't costs	2,134,290	-	-	-	-	-
Other investment costs	180,000	-	-	10,000	-	10,000
Variable costs	-	757,800	755,266	753,733	751,200	749,666
Total Cash Outflow	2,314,290	757,800	755,266	763,733	751,200	759,666
NET CASH INFLOW	757,800	-157,800	- 5,266	136,267	298,800	440,334
Plus: CASH BALANCE BEG'G	-	757,800	600,000	594,734	731,001	1,029,801
CASH BALANCE ENDING	757,800	600,000	594,734	731,001	1,029,801	1,470,135

Table 11. Projected cash flow budget for a 5-ha. intensive farming of shrimp (*P. monodon*) in concrete-lined earthen ponds

ITEM	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
CASH INFLOW						
Equity	4,422,200	-	-	-	-	-
Sales	-	900,000	1,350,000	1,732,500	1,732,500	1,800,000
Total Cash Inflow	4,422,200	900,000	1,350,000	1,732,500	1,732,500	1,800,000
CASH OUTFLOW						
Pond development costs	3,290,850	-	-	-	-	-
Other investment costs	147,000	-	-	5,000	-	5,000
Variable costs	-	984,350	972,429	963,003	951,079	939,656
Total Cash Outflow	3,437,850	984,350	972,429	968,003	951,079	944,656
NET CASH INFLOW	984,350	- 84,350	377,571	76,497	78,421	85,344
Plus: CASH BALANCE BEG'G	-	984,350	900,000	1,277,571	2,042,068	2,823,489
CASH BALANCE ENDING	984,350	900,000	1,277,571	2,042,068	2,823,489	3,678,833

Table 12. Projected cash flow budget for a 5-ha. intensive farming of shrimp (*P. monodon*) in concrete walled ponds

ITEM	Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
CASH INFLOW						
Equity	5,804,915	-	-	-	-	-
Sales	-	900,000	1,350,000	1,732,500	1,732,500	1,800,000
Total Cash Inflow	5,804,915	900,000	1,350,000	1,732,500	1,732,500	1,800,000
CASH OUTFLOW						
Pond development costs	4,673,565	-	-	-	-	-
Other investment costs	147,000	-	-	5,000	-	5,000
Variable costs	-	984,350	972,429	963,003	951,079	939,656
Total Cash Outflow	4,820,565	984,350	972,429	968,003	951,079	944,656
NET CASH INFLOW	984,350	- 84,350	377,571	764,497	781,421	855,344
Plus: CASH BALANCE BEG'G	-	984,350	900,000	1,277,571	2,042,068	2,823,489
CASH BALANCE ENDING	984,350	900,000	1,277,571	2,042,068	2,823,489	3,678,833

Table 13. Comparison of investment required for semi-intensive and intensive farming of shrimp (*P. monodon*) under Brunei conditions

Culture system	Pond design	Shrimp farm area, ha	Total invesment cost/ha ($)	Total variable cost/ha ($)	Total Project cost/ha ($)
Semi-intensive	Earthen pond	10	231,429	75,780	307,209
Intensive	Concrete-lined earthen pond	5	687,570	196,870	884,440
Intensive	Concrete walled pond	5	964,113	196,870	1,160,983

Table 14. Projected balance sheet for a 10-ha semi-intensive farming of shrimp (*P. monodon*)

Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
ASSETS:					
Current Assets:					
Cash	600,000	594,734	731,001	1,029,801	1,470,135
Fixed Assets:					
Pond dev't	2,134,290	2,134,290	2,134,290	2,134,290	2,134,290
Other investment items	154,667	139,334	114,001	98,668	73,335
TOTAL ASSETS	2,888,957	2,868,358	2,979,292	3,262,759	3,677,760
LIABILITIES AND EQUITY					
Liabilities	-	-	-	-	-
Equity	2,888,957	2,868,358	2,979,292	3,262,759	3,677,760
TOTAL LIABILITIES AND EQUITY	2,888,957	2,868,358	2,979,292	3,262,759	3,677,760

Table 15. Projected Balance Sheet for a 5-ha. Intensive Farming of Shrimp (*P. monodon*) in Concrete-Lined Earthen Ponds

Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
ASSETS					
Current Assets:Cash	900,000	1,277,571	2,042,068	2,827,489	3,678,833
Fixed Assets:					
Pond development	2,790,850	2,790,850	2,790,850	2,790,850	2,790.850
Other Investment items	527,765	413,530	294,295	180,060	60,825
TOTAL ASSETS	4,218,615	4,431,951	5,127,213	5,794,399	6,530,508
LIABILITIES AND EQUITY					
Liabilities	-	-	-	-	-
Equity	4,218,615	4,431,951	5,127,213	5,794,399	6,530,508
TOTAL LIABILITIES AND EQUITY	4,218,615	4,431,951	5,127,213	5,794,399	6,530,508

Table 16. Projected Balance Sheet for a 5-ha. Intensive Farming of Shrimp (*P. monodon*) in Concrete Walled Ponds

Item	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
ASSETS:					
Current Assets:Cash	900,000	1,277.571	2,042,068	2,823,489	3,678,833
Fixed Assets:					
Pond Construction	4,173,565	4,173,565	4,173,565	4,173,565	4,173,565
Other investment items	527,765	413,530	294,295	180,060	60,825
TOTAL ASSETS	5,601,330	5,864,666	6,509,928	7,177,114	7,913,223
LIABILITIES AND EQUITY					
Liabilities	-	-	-	-	-
Equity	5,601,330	5,864,666	6,509,928	7,177,114	7,913,223
TOTAL LIABILITIES AND EQUITY	5,601,330	5,864,666	6,509,928	7,177,114	7,913,223

Table 17. Comparison of profitability of semi-intensive and intensive farming of shrimp (*P. monodon*) under Brunei conditions.

Profitability indicator	Semi-intensive Earthen Pond	Intensive Concrete Walled	Intensive Concrete-lined
Cash payback period (years)	15.80	8.91	6.40
Rate of return on investment, ROI (%)	6.32	11.23	15.73
Benefit-Cost ratio (B/C)	1.03	1.13	1.18
Net Present Value, NPV ($)	188,239	1,172,421	1,365,455
Internal rate of return, IRR (%)	5.00	11.04	15.21

Table 18. Estimated annual quantity and cost of material inputs per hectare of shrimp farming (*P. monodon*) by culture system

Input	Unit	Cost/Unit ($)	Semi-Intensive Qty	Semi-Intensive Cost ($)	Intensive[a/] Qty	Intensive[a/] Cost ($)
		(0.10-0.15)				
Shrimp fry/seed	pcs.	0.125	195,000	24,375	750,000	93,750
Feed	kg.	2.00	7,200	14,400	30,060	60,120
Electricity	kw-hr	0.15	-		23,800	3,570
Gasoline and oil	L	0.20	1,800	360	1,000	200
Teaseed cake	kg	3.00	375	1,125	450	1,350
Lime	ton	200.00	80	16,000	-	-
Miscellaneous				500	-	400
TOTAL				56,760		159,390

[a/] The same for concrete walled ponds and concrete-lined earthen.

Table 19. Manpower and salary requirements for shrimp farming (*P. monodon*) by culture system

Manpower	Mo. Salary ($)	Semi-Intensive Number	Semi-Intensive An. Salary ($)	Intensive*/ Number	Intensive*/ An. Salary ($)
Farm Manager	3,000	1	36,000	1	36,000
Technician/laborer	1,500	5	90,000	3	54,000
Additional Hired Laborer	30/man-day	900	27,000	450	13,500
Security Guards	800	2	19,200	2	19,200

*/The same for fully-concreted ponds and concrete-lined earthen ponds

Table 20. Calculation of repairs and maintenance cost of depreciable investment items for semi-intensive and intensive farming (concrete walled ponds and concrete-lined earthen ponds) of shrimp (*P. monodon*)

Investment Item	BEGINNING VALUE ($) Yr 1	2	3	4	5
Buildings: Semi-intensive	50,000	46,667	43,334	40,001	36,668
Intensive[a]	35,000	32,665	30,330	27,995	25,660
Equipment:					
Axial flow pump with motor[a]	10,000	8,000	6,000	4,000	2,000
Paddlewheel aerators[a]	27,000	21,600	16,200	10,800	5,400
Pump and engine plus house[b]	50,000	40,000	30,000	20,000	10,000
Pond plastic lining[a]	500,000	400,000	300,000	200,000	100,000
Nets, buckets, boxes, etc:					
Semi-intensive	10,000	5,000	10,000	5,000	10,000
Intensive[a]	5,000	2,500	5,000	2,500	5,000
Vehicles	70,000	63,000	56,000	49,000	42,000
TOTAL:					
Semi-intensive	180,000	154,667	139,334	114,001	98,668
Intensive[a]	647,000	527,765	413,530	294,295	180,060
Repair and Maintenance Cost (10% of Total)					
Semi-intensive	18,000	15,466	13,933	11,400	9,866
Intensive[a]	64,700	52,776	41,353	29,429	18,006

[a] The same for both pond systems of intensive farming (concrete walled and concrete-lined)
[b] For semi-intensive farming only

Table 21. Projected annual production and value per hectare of shrimp (*P. monodon*) by culture system

Year	Price/kg ($)	Semi-Intensive Prod. (kg)	Semi-Intensive Value ($)	Intensive[a] Prod. (kg)	Intensive[a] Value ($)
1	20	3,000	60,000	9,000	180,000
2	20	3,750	75,000	13,500	270,000
3	20	4,500	90,000	17,325	346,500
4	20	5,250	105,000	17,325	346,500
5	20	6,000	120,000	18,000	360,000

[a] Production is the same for concrete-walled ponds and concrete-lined earthen ponds.

Table 22. Calculation of financial and profitability measures for a 10-ha semi-intensi farming of shrimp (*P. monodon*)

Year	Total Income ($)	Total Cost[a] ($)	Discount Factor (4)[d]	Discounted Income ($)	Discounted Costs ($)
1	600,000	3,072,090[b]	0.9615	576,900	2,953,814
2	750,000	755,266	0.9246	693,450	698,319
3	900,000	753,733	0.8890	800,100	670,069
4	1,050,000	751,200	0.8548	897,540	642,126
5	3,407,625[c]	749,666	0.8219	2,800,727	616,150
TOTAL				5,768,717	5,580,478

[a] Excluding interest and depreciation

[b] Including initial investment cost of $2,314,290

[c] Including residual values of pond development ($2,134,290) and other investment items ($73,335)

[d] $\frac{1}{(1+.04)^n}$

1. Benefit-Cost (B/C) Ratio = $\frac{5,768,717}{5,580,478}$ = 1.03

2. Net Present Value (NPV) = 5,768,717 = 5,580,478 = 188,239

3. Internal Rate of Return (IRR)

Year	Net Income	Discount Factor 15%	Discount Factor 10%	Discounted Net Income 15%	Discounted Net Income 10%
1	-2,472,090	0.8696	0.9091	-2,149,729	-2,247,377
2	-5,266	0.7561	0.8264	3,982	4,352
3	146,267	0.6575	0.7513	96,171	109,890
4	298,800	0.5718	0.6830	170,854	204,080
5	2,657,959	0.4972	0.6209	1,321,537	1,650,327
Total				-557,185	278,327

$$IRR = 10 + \frac{5 \quad (-278,728)}{-278,728 + 557,185} = 5.00\%$$

4. Cash Payback Period

Year	Cash Net Income
1	-157,800
2	-5,266
3	146,267
4	298,800
5	450,334
Total	732,335

$$\text{Cash Payback Period} = \frac{2,314,290}{732,335/5}$$

$$= 15.8 \text{ years}$$

5. Rate of Return on Investment (ROI)

$$\text{ROI} = \frac{146,467}{2,314,290}$$

$$= 0.0632$$

$$= 6.32\%$$

Table 23. Calculation of financial and profitability measures for a 5-ha intensive farming of shrimp (*P. monodon*) in concrete-lined earthen ponds

Year	Total Income ($)	Total Cost[a] ($)	Discount Factor (4%)[d]	Discounted Income ($)	Discounted Costs ($)
1	900,000	4,422,200[b]	0.9615	865,350	4,251,945
2	1,350,000	972,429	0.9246	1,248,210	899,108
3	1,732,500	963,003	0.8890	1,540,192	856,110
4	1,732,500	951,079	0.8548	1,480,941	812,982
5	4,651,675[c]	939,658	0.8219	3,823,212	772,305
Total				8,957,905	7,592,450

[a]Excluding interest and depreciation

[b]Including initial investment cost of $3,437,850

[c]Including residual values of pond development ($2,790,850) and other investment items ($60,825)

[d] $\frac{1}{(1 + .04)^n}$

1. Benefit-Cost (B/C) Ratio = $\frac{8,957,905}{7,592,450}$ = 1.18

2. Net Present Value (NPV) = 8,957,905 - 7,592,450 = 1,365,455

3. Internal Rate of return (IRR)

Year	Net Income	Discount Factor 15%	Discount Factor 10%	Discounted Net Income 15%	Discounted Net Income 10%
1	-3,522,200	0.8696	0.9091	-3,062,905	-3,202,032
2	377,571	0.7561	0.8264	285,481	312,025
3	769,497	0.6575	0.7513	505,944	578,123
4	781,421	0.5718	0.6830	446,816	533,710
5	3,712,017	0.4972	0.6209	1,845,615	2,304,791
Total				20,951	526,617

$$IRR = 10 + \frac{5(526,617)}{526,617 + 20,951} = 15.21\%$$

4. Cash Payback Period

Year	Net Cash Income
1	-84,350
2	377,571
3	769,497
4	781,421
5	860,342
Total	2,704,481

$$\text{Cash Payback Period} = \frac{3,437,850}{2,704,481/5}$$

$$= 6.36 \text{ years}$$

5. Rate of Return on Investment (ROI)

$$\text{ROI} = \frac{540,896}{3,437,850}$$

$$= 0.1573 \text{ or } 15.73\%$$

Table 24. Calculation of financial and profitability measures for a 5-ha intensive farming of shrimp (*P. monodon*) in concrete walled

Year	Total Income ($)	Total Cost[a] ($)	Discount Factor (4%)[d]	Discounted Income ($)	Discounted Costs ($)
1	900,000	5,804,915[b]	0.9615	865,350	5,581,426
2	1,350,000	972,429	0.9246	1,248,210	899,108
3	1,732,500	963,003	0.8890	1,540,192	856,110
4	1,732,500	951,079	0.8548	1,480,941	812,982
5	6,034,390[c]	939,656	0.8219	4,959,665	772,303
Total				10,094,358	8,921,929

[a] Excluding interest and depreciation

[b] Including initial investment cost of $4,820,565

[c] Including residual value of pond development ($4,173,565) and other investment items ($60,825)

[d] $\frac{1}{(1 + .04)^n}$

1. Benefit-Cost (B/C) Ratio $= \frac{10,094,350}{8,921,929} = 1.13$

2. Net Present Value (NPV) = 10,094,350 - 8,921,929 = 1,172,421

3. Internal Rate of Return (IRR)

Year	Net Income	Discount Factor 15%	Discount Factor 10%	Discounted Net Income 15%	Discounted Net Income 10%
1	-4,904,915	0.8696	0.9091	-4,265,314	-4,459,058
2	377,571	0.7561	0.8264	285,481	312,025
3	771,497	0.6575	0.7513	507,259	579,626
4	781,421	0.5718	0.6830	446,816	533,710
5	5,094,734	0.4972	0.6209	2,533,102	3,163,320
				-492,656	129,623

$$IRR = 10 + \frac{5(129,623)}{129,623 + 492,656} = 11.04$$

4. Cash Payback Period

Year	Cash Net Income
1	-84,350
2	377,571
3	771,497
4	781,421
5	860,344
Total	2,706,463

$$\text{Cash Payback} = \frac{4,820,565}{2,706,483/5}$$

$$= 8.91 \text{ years}$$

5. Rate of Return on Investments (ROI)

$$\text{ROI} = \frac{541,297}{4,820,565}$$

$$= .1123 \text{ or } 11.23\%$$

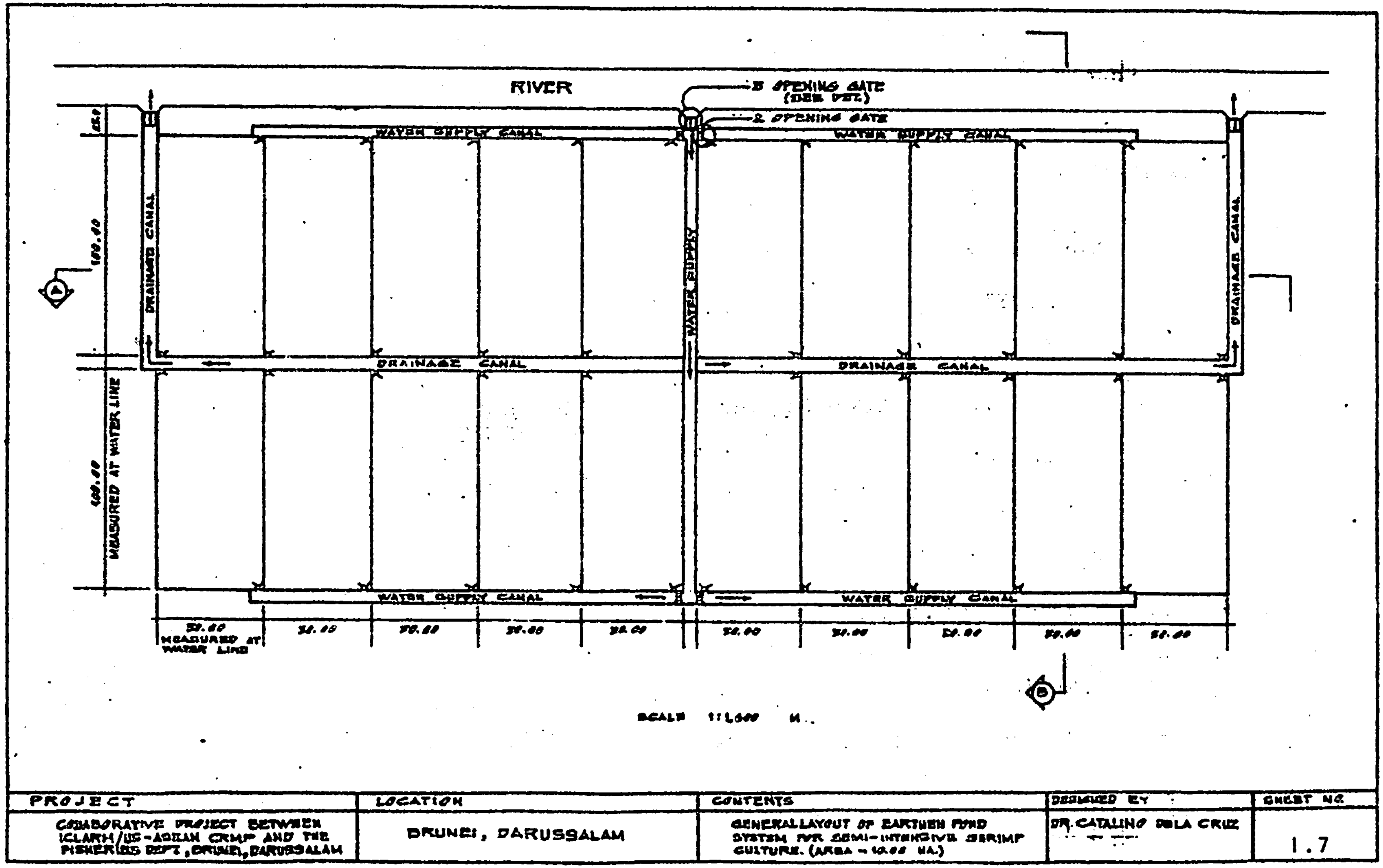


Fig. 1. Layout of earthen pond.

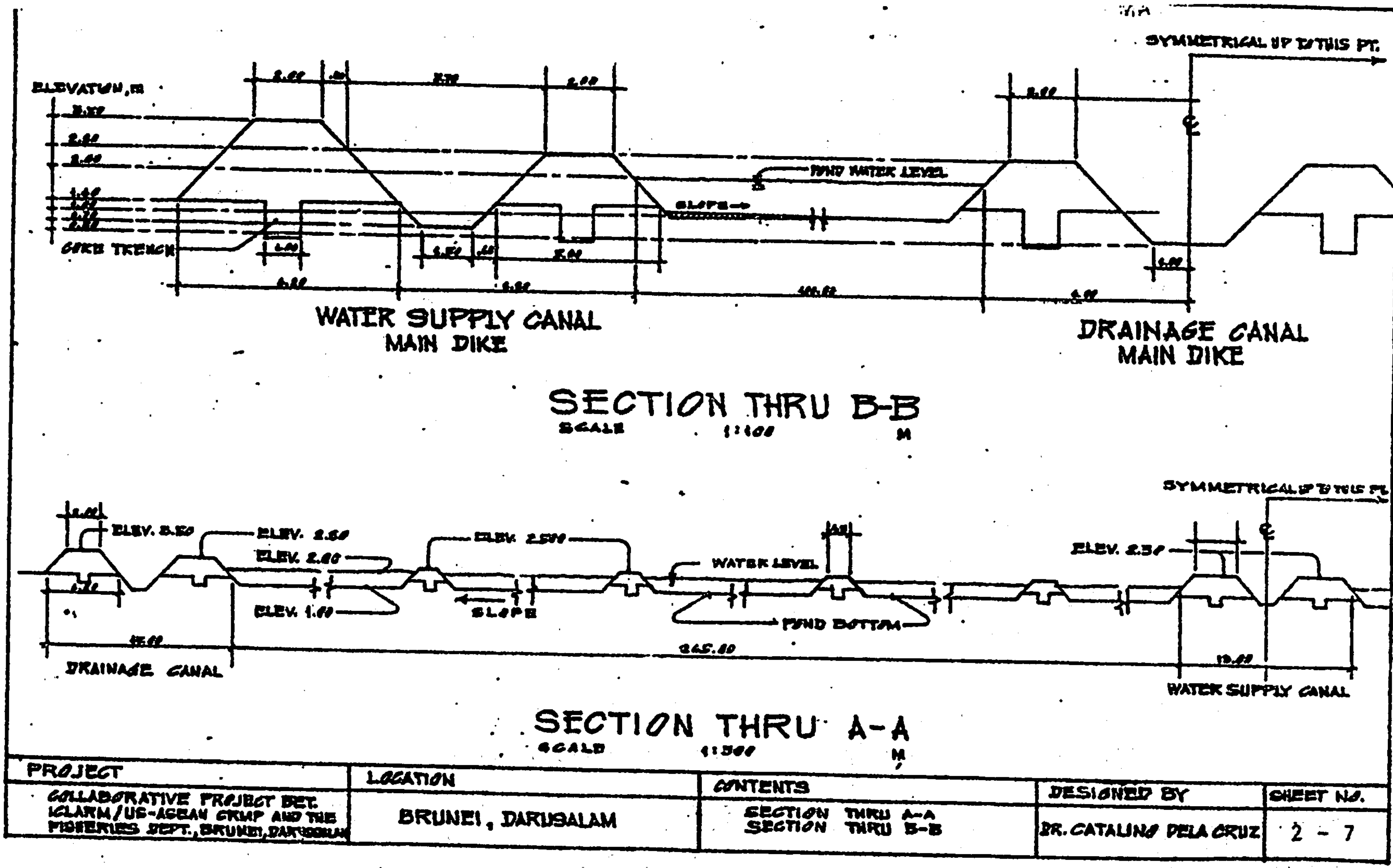


Fig. 2. Design elevation and cross-sections of earthen ponds.

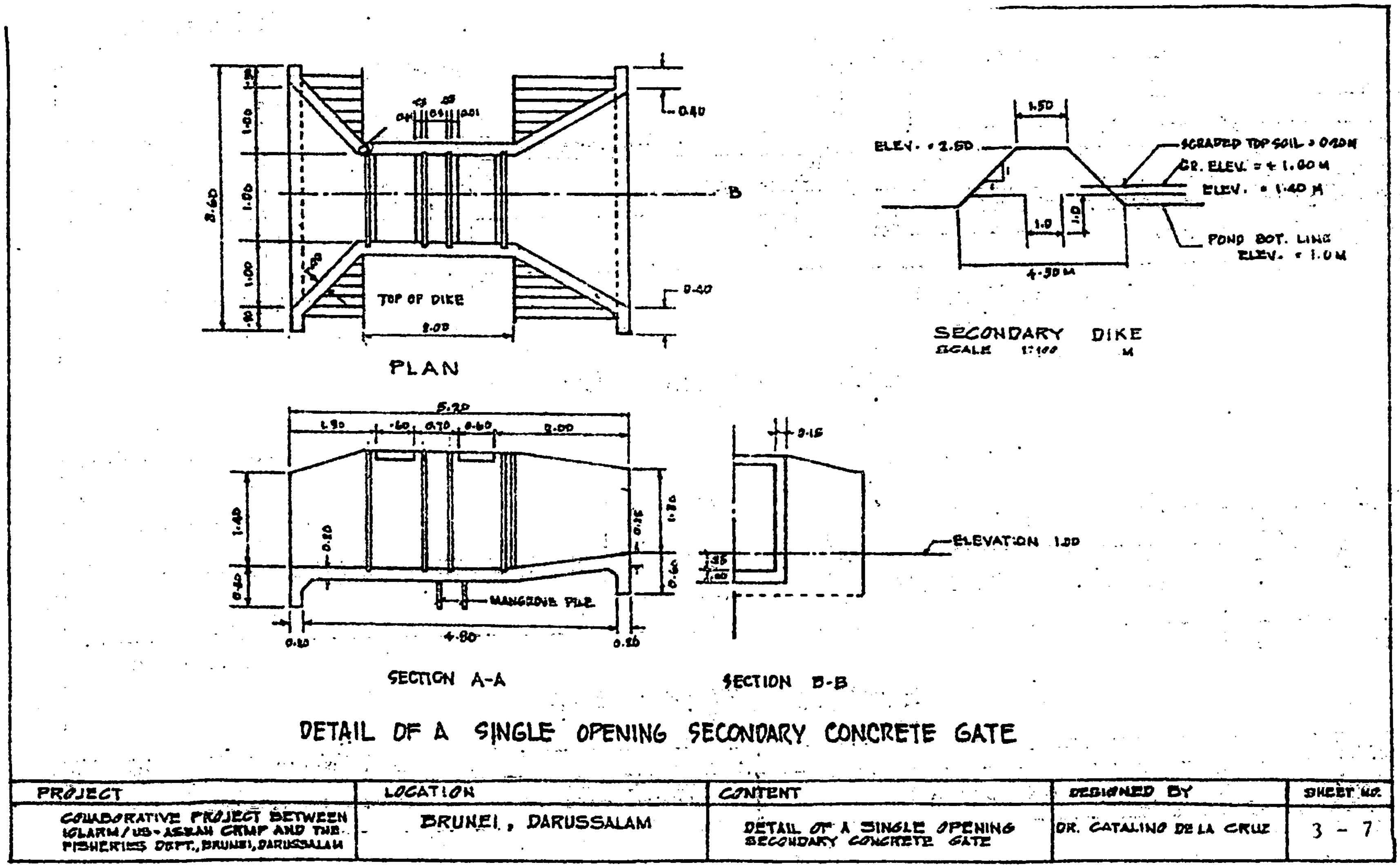


Fig. 3. Detail of a single opening, secondary concrete gate for earthen ponds

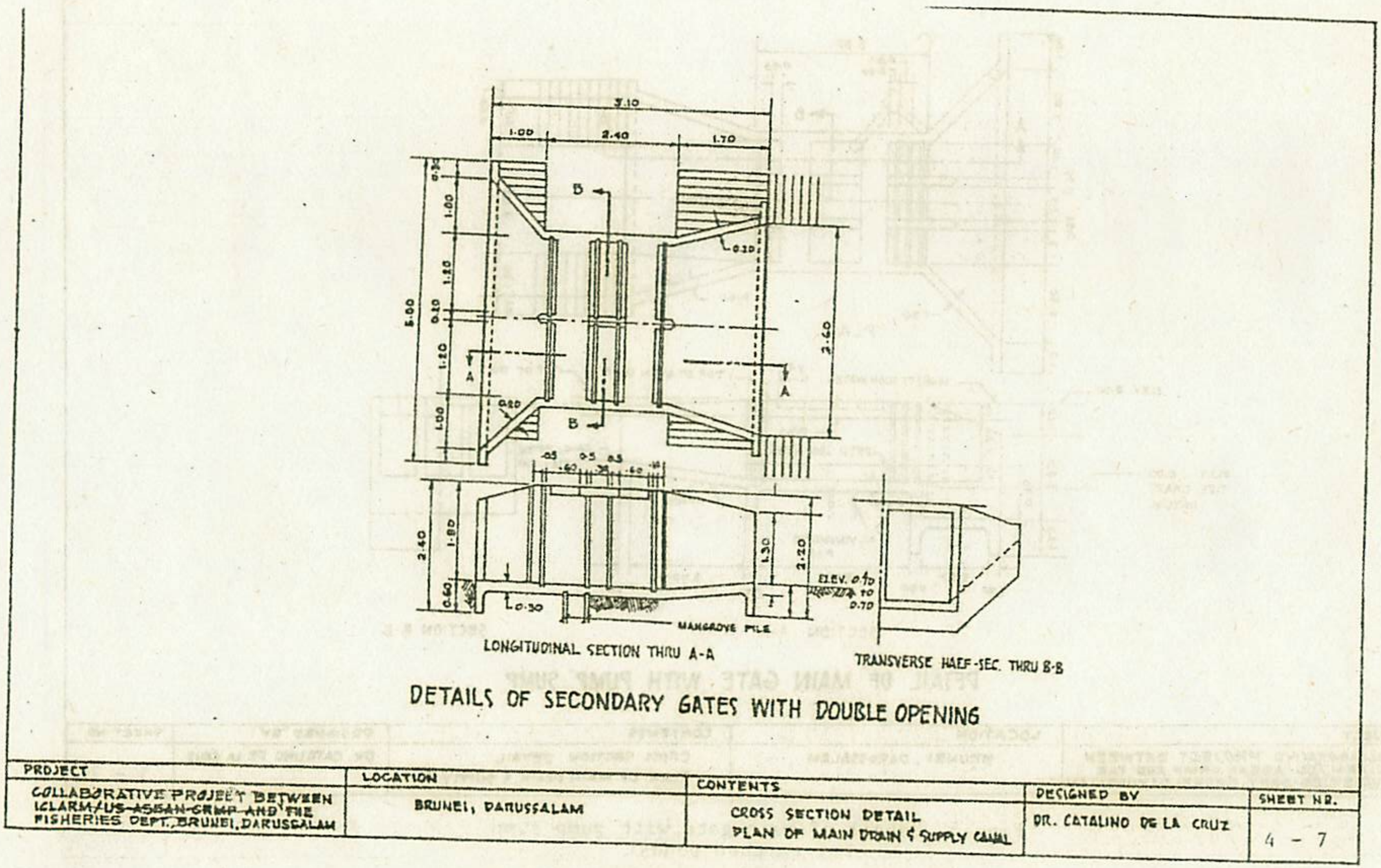
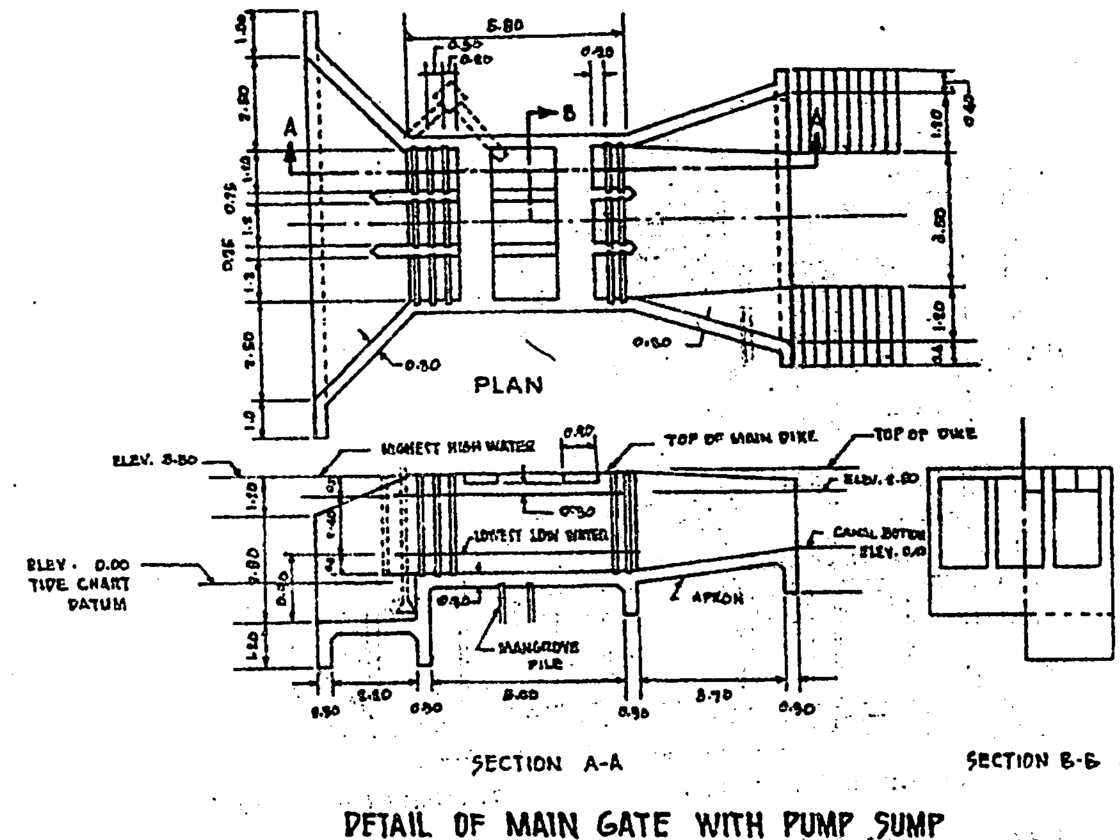


Fig. 4. Details of secondary gates
with double opening for earthen ponds



PROJECT	LOCATION	CONTENTS	DESIGNED BY:	SHEET NO
COLLABORATIVE PROJECT BETWEEN ICLARM/US-ASEAN CRMP AND THE FISHERIES DEPT., BRUNEI, DARUSSALAM	BRUNEI, DARUSSALAM	CROSS SECTION DETAIL PLAN OF MAIN DRAIN & SUPPLY CANAL	DR. CATALINO DE LA CRUZ	5 - 7

Fig. 5. Detail of main gate with pump sump - For earthen ponds.

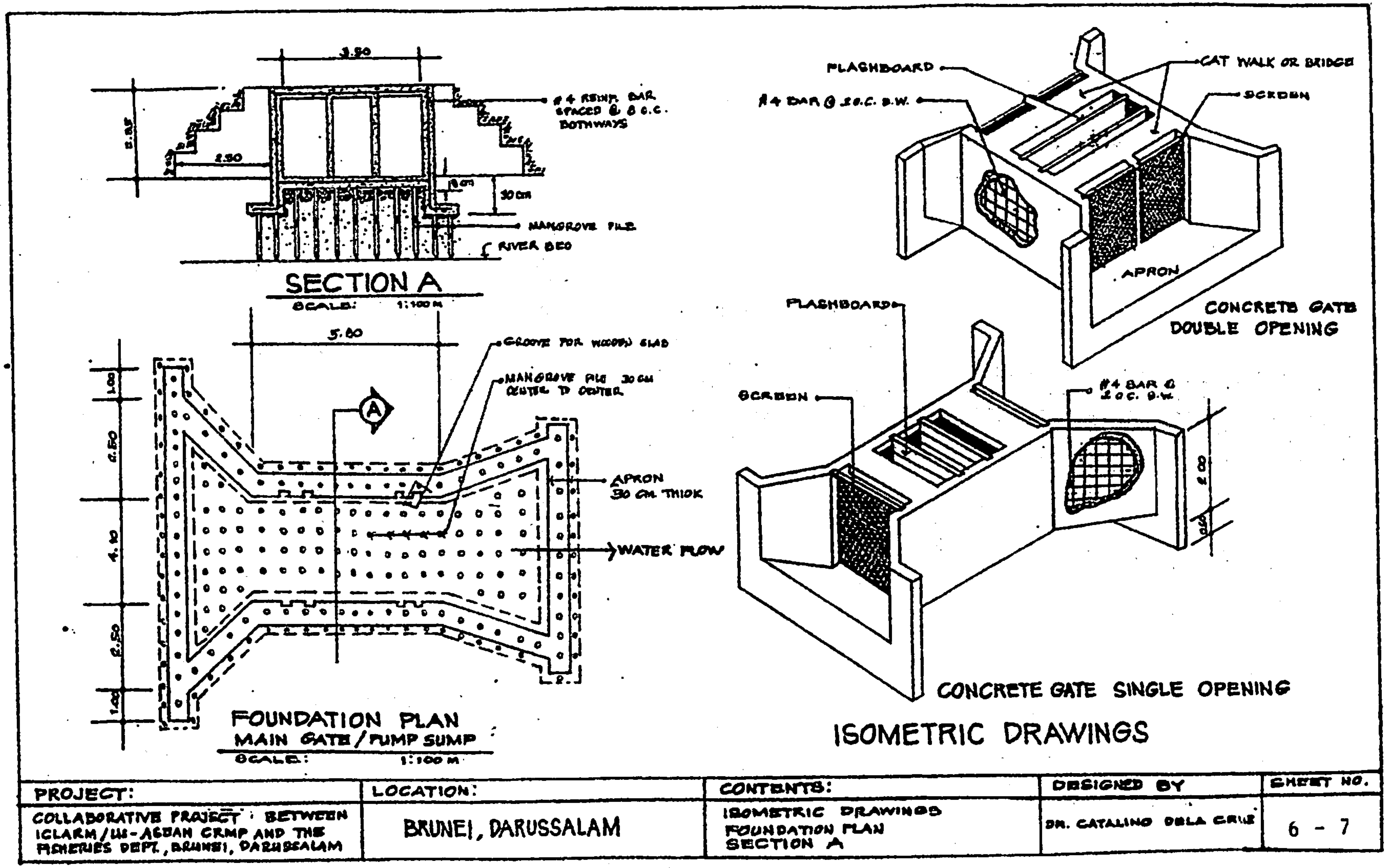


Fig. 6. Typical Foundation plan of gates and isometric drawings
- For earthen ponds.

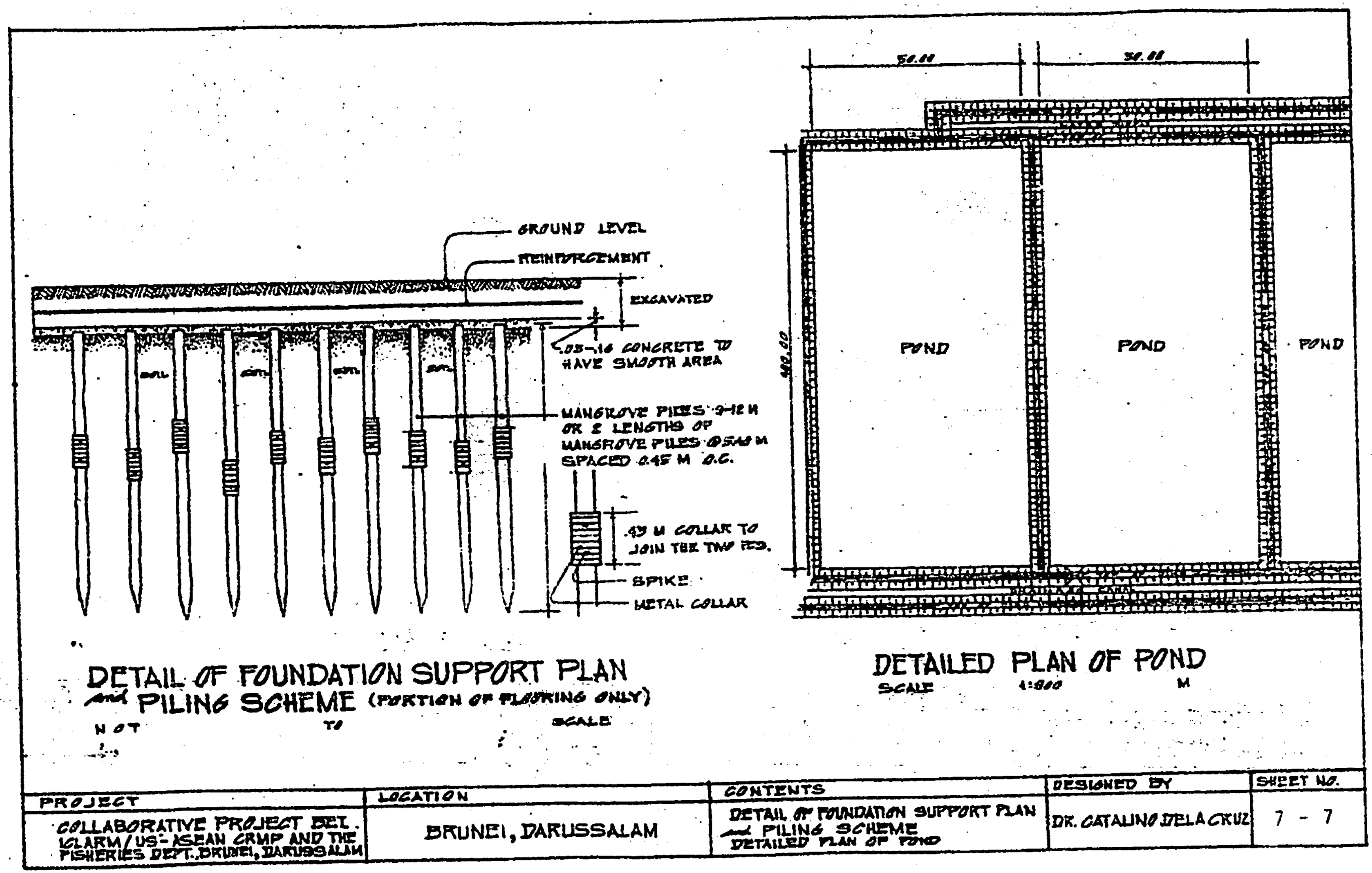


Fig. 7. Cross section of gate foundation plan and plan of earthen ponds.

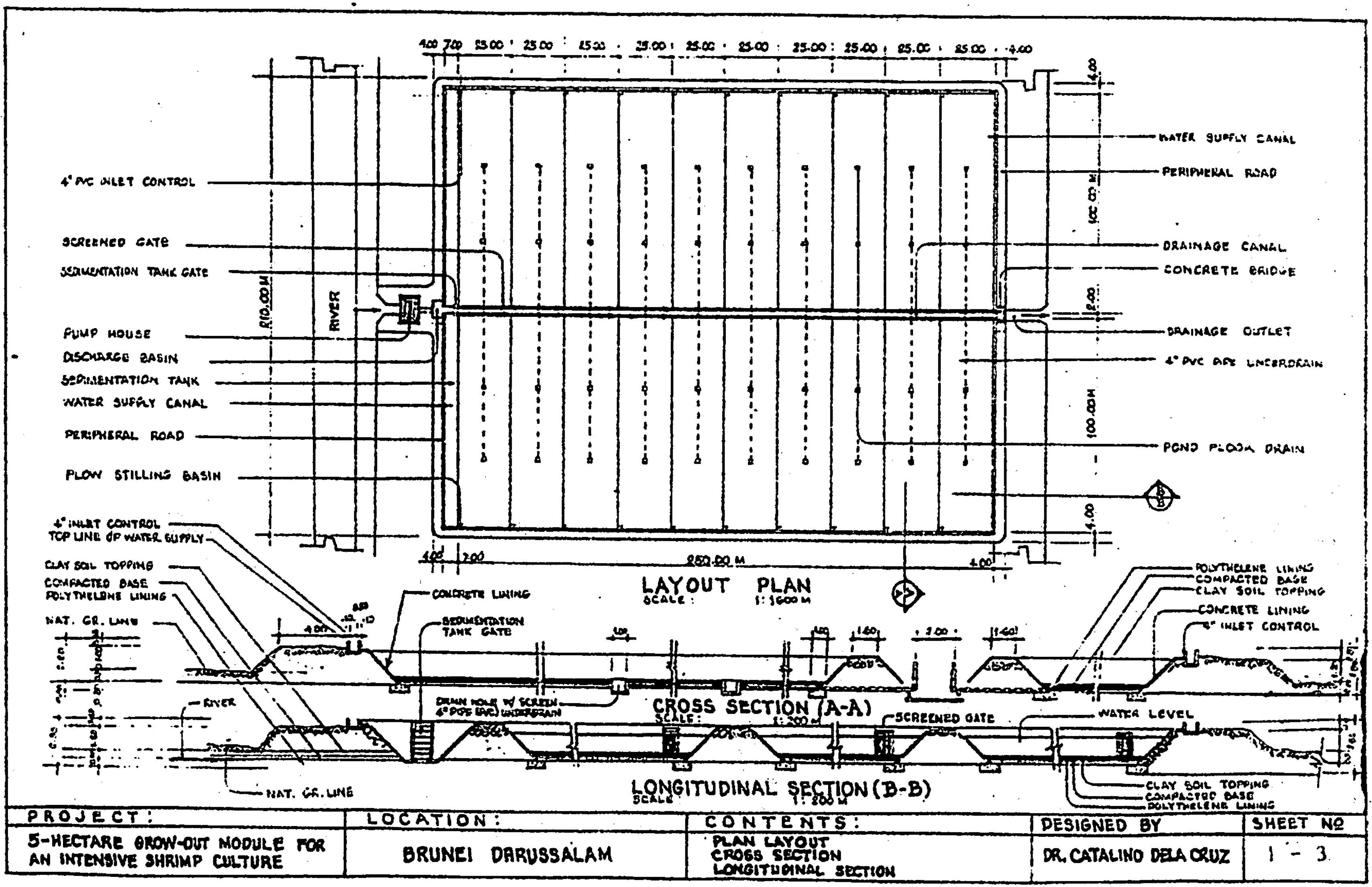


Fig. 8. Layout and cross-section of earthen ponds lined with concrete

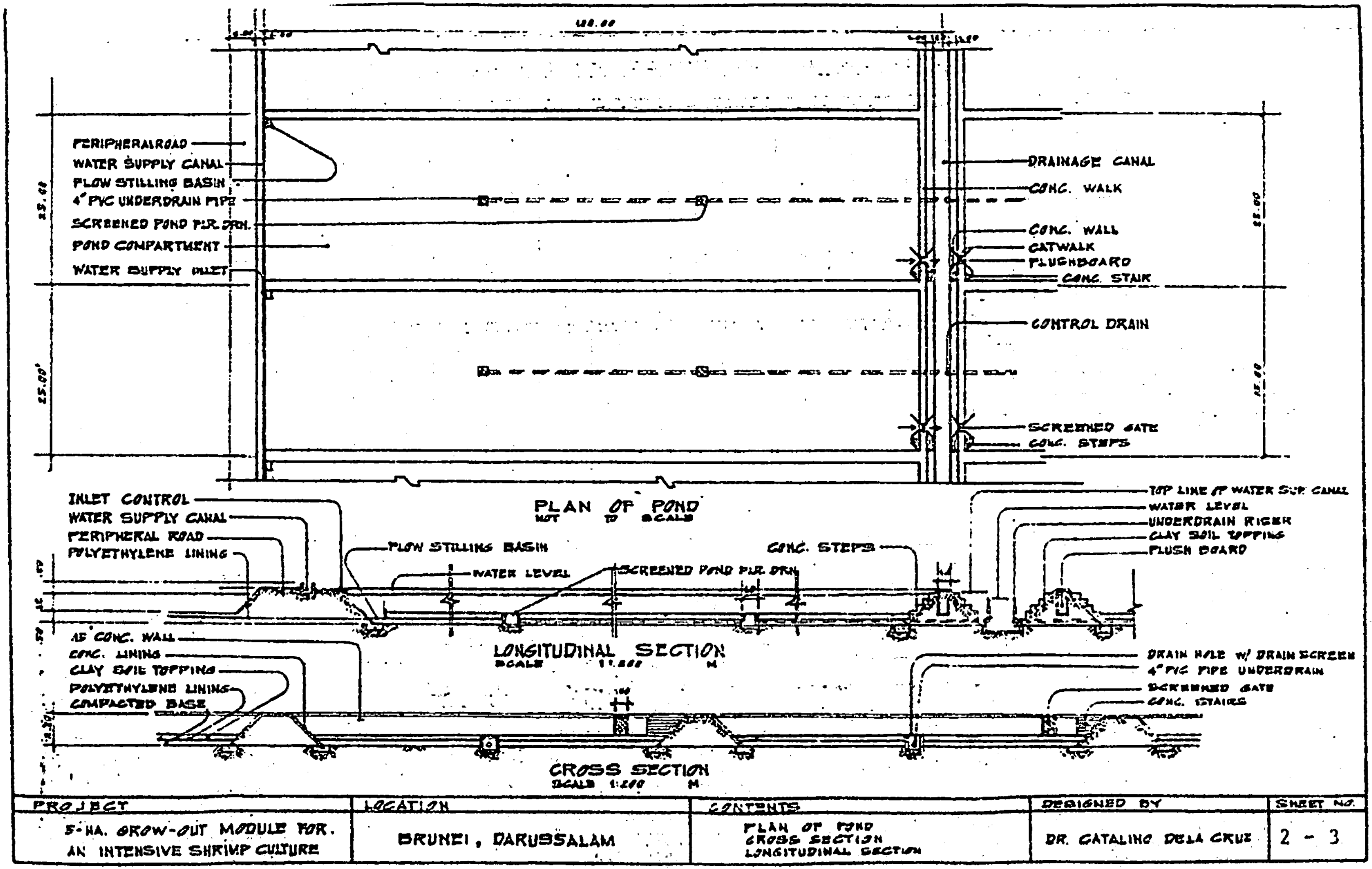


Fig. 9. Cross-section of ponds and dikes (concrete-lined earthen ponds).

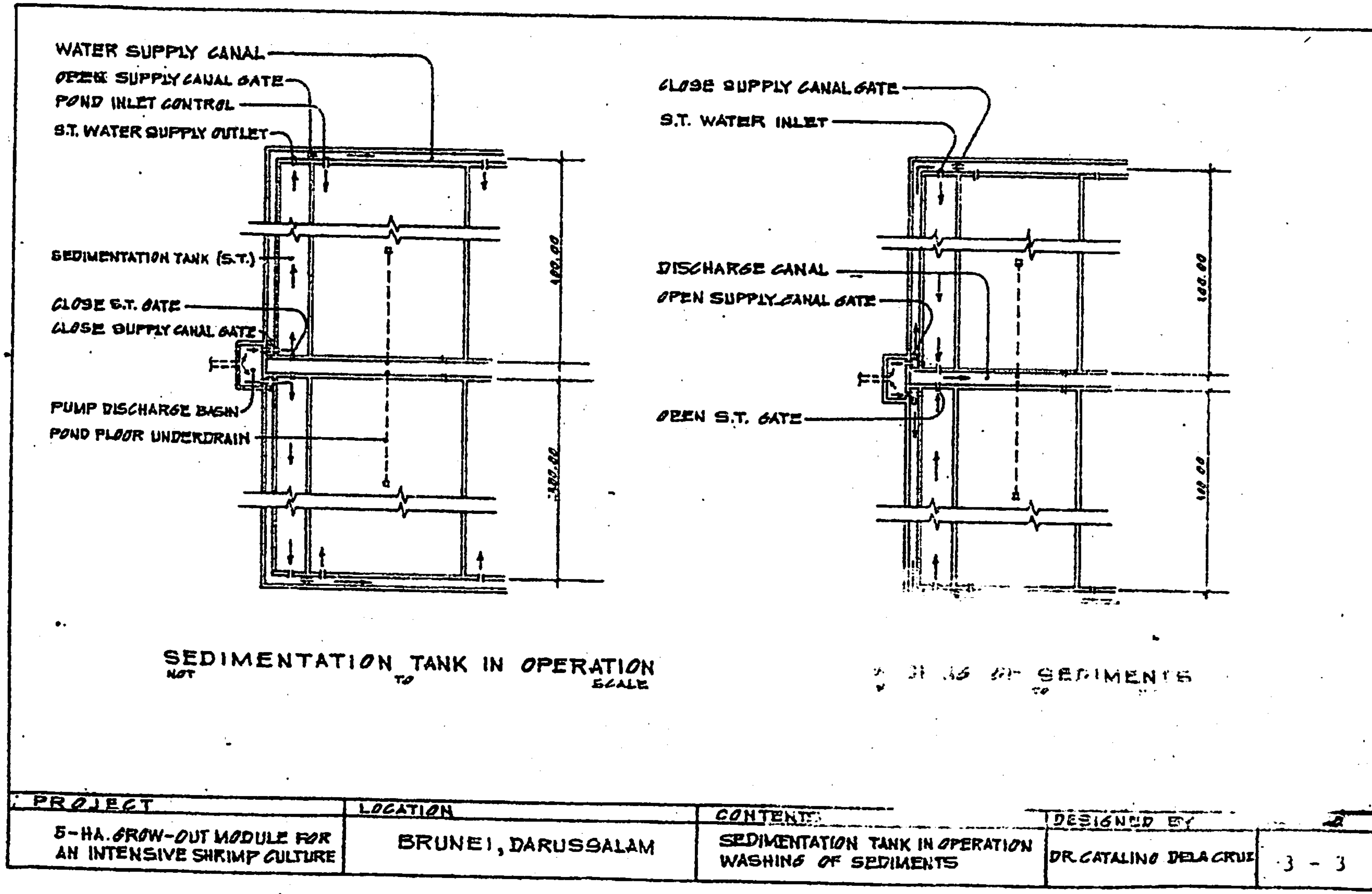


Fig. 10. Principle of operation of the sedimentation Tank
- For both concrete-lined and concrete-walled ponds

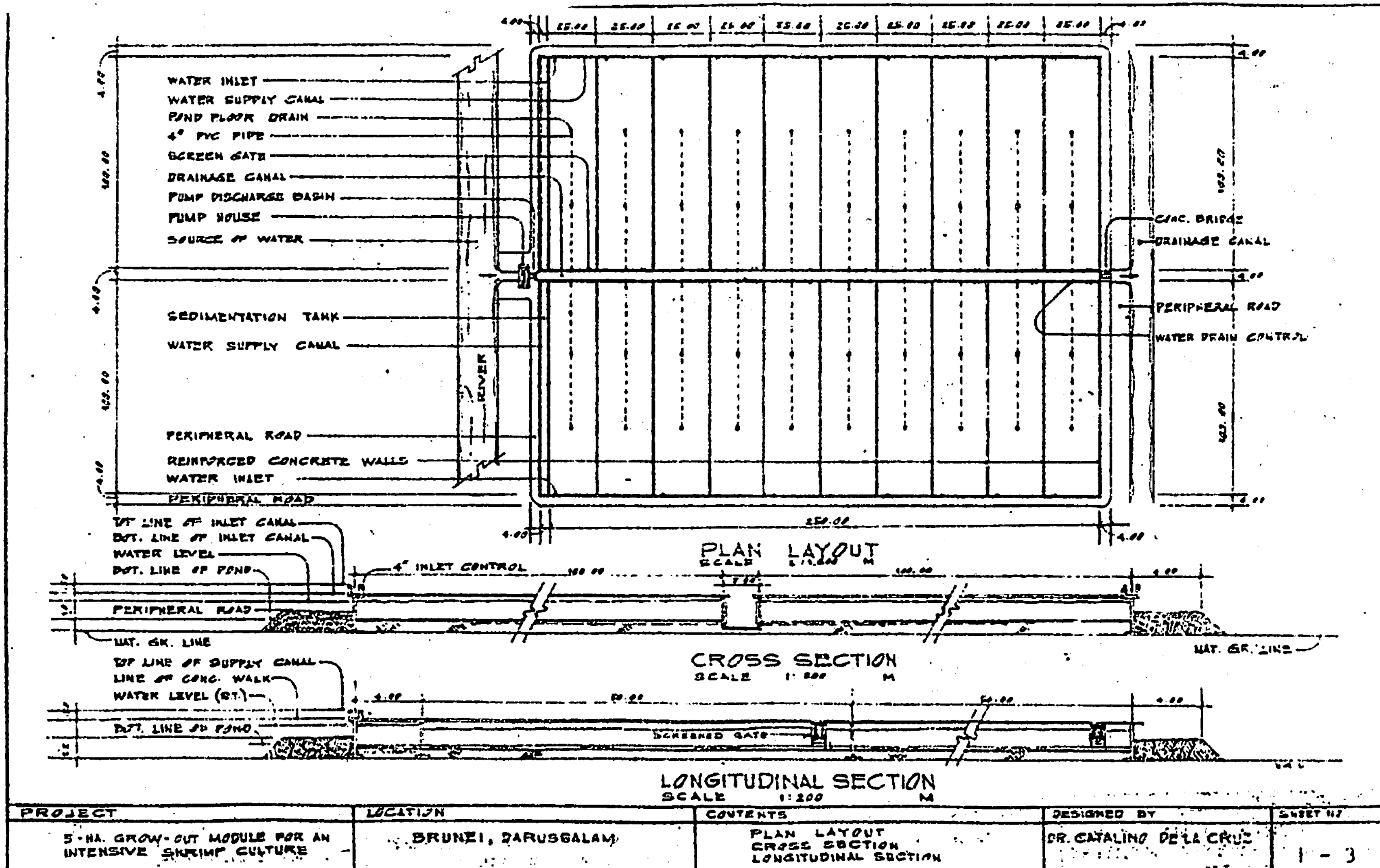


Fig. 11. Layout and cross-section of concrete-walled ponds.

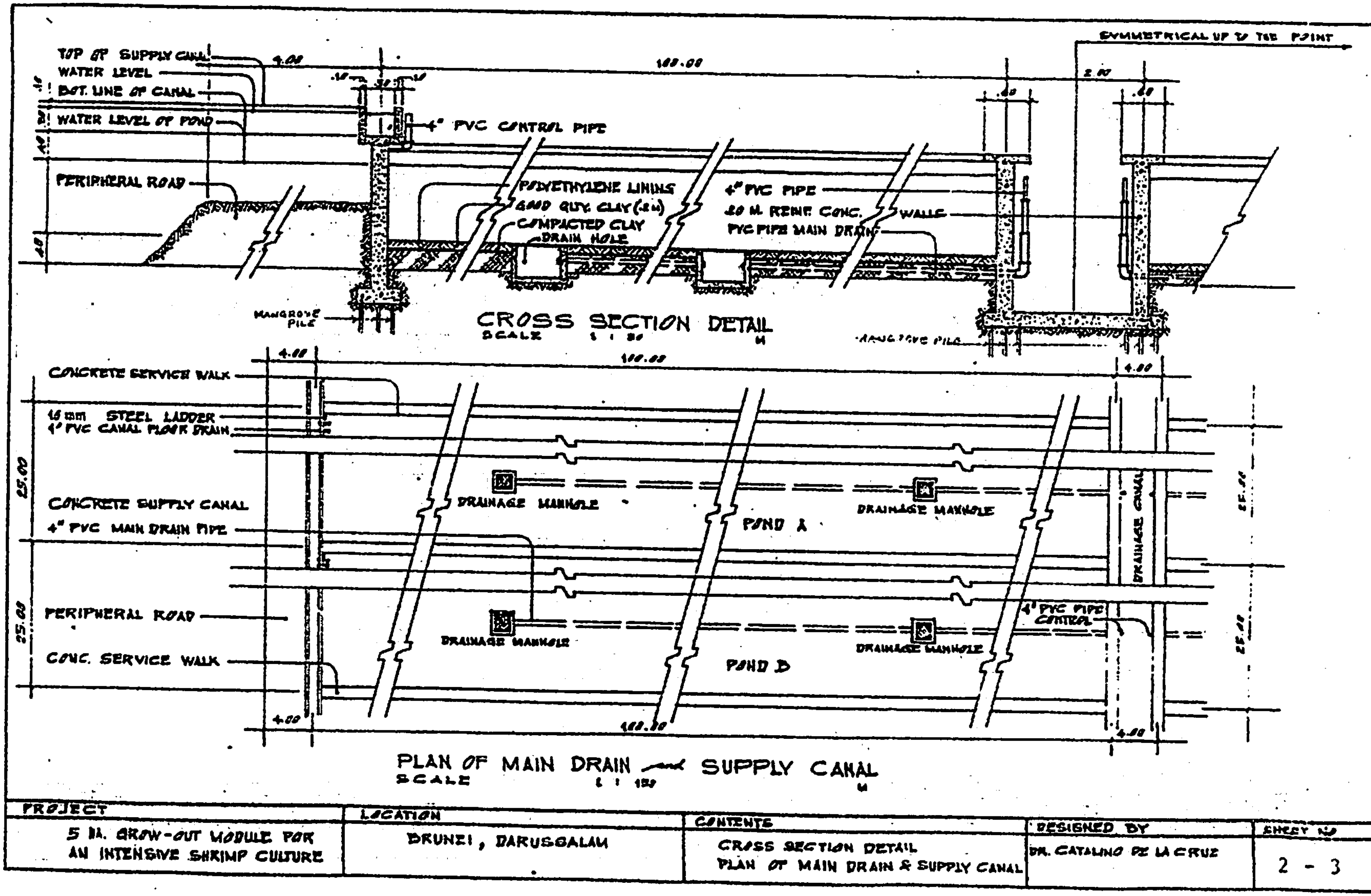
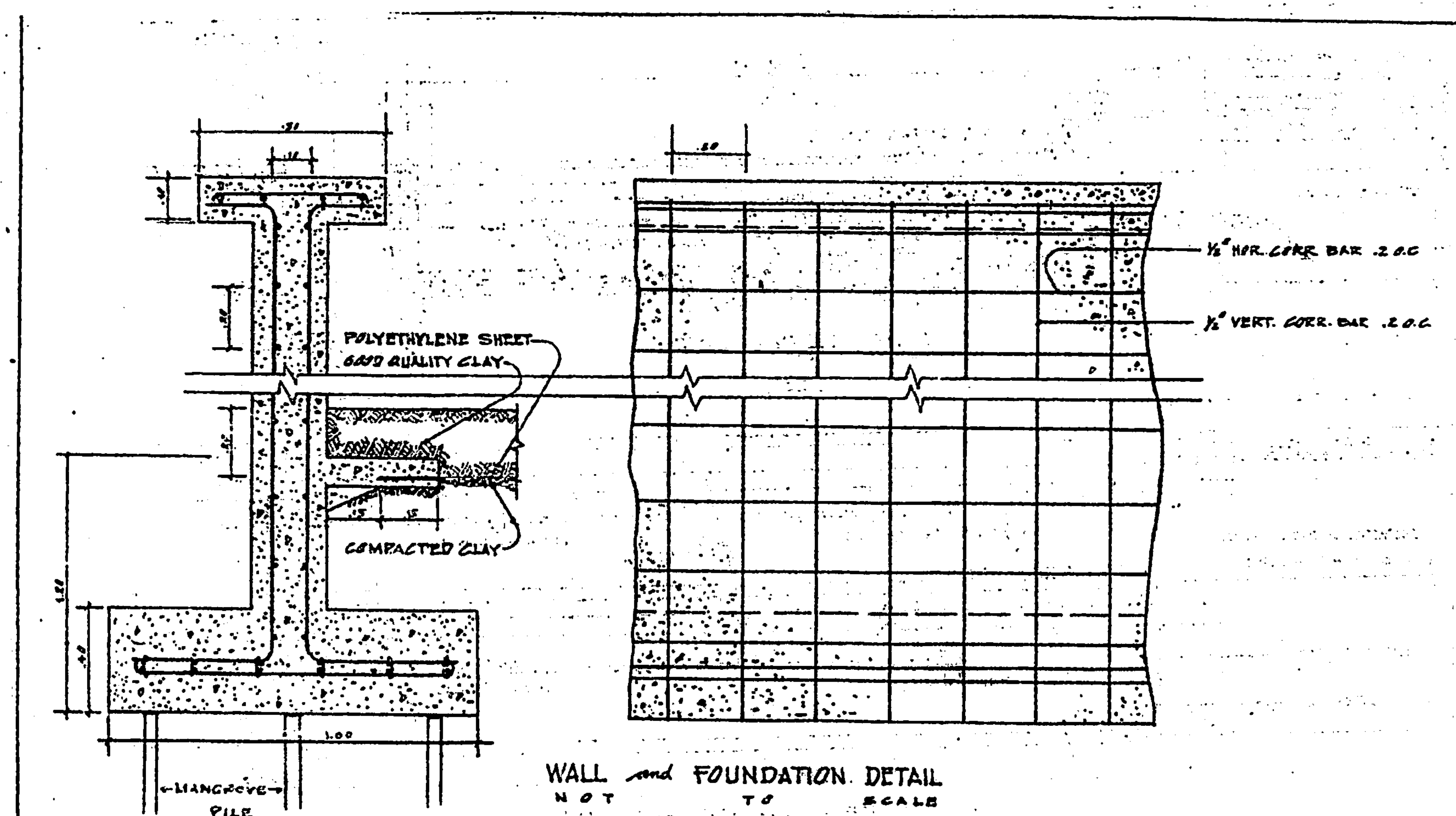


Fig. 12. Cross-section of wall pond partition, and water supply and drainage system.



PROJECT	LOCATION	CONTENT	DESIGNED BY	SHEET NO.
5-HA. GROW-OUT MODULE FOR AN INTENSIVE SHRIMP CULTURE	BRUNEI, DARUSSALAM	WALL and FOUNDATION DETAIL	DR. CATALINO DELA CRUZ	3 - 3

Fig. 13. Wall and Foundation detail.