PN-ABS-669

THE INITIAL DEVELOPMENT OF SMALL-SCALE IRRIGATION MANAGEMENT PROJECT (SSIMP) EXPERIMENTAL GROUNDWATER IRRIGATION SYSTEMS IN NTT

FINAL REPORT

Martin Wright

PSC Consultant

(May 1987 - Feb.1989)

USAID

Kupang, May, 1989.

FOREWORD

This report describes the initial development of the Small-Scale Irrigation Management Project (SSIMP) experimental groundwater irrigation systems in the Province of Nusa Tenggara Timur (NTT).

The program is being implemented by the Public Works Groundwater Development Agency hereafter referred to as P2AT.

The report discusses the factors affecting the choice of systems considered appropriate for development in the region. A description of the sites developed to date is given including an explanation of factors causing delays in implementation of the project, comparisons of capital costs for the experimental systems and other important aspects of the development process.

The ultimate objective of the experimental program is to provide recommendations of irrigation technologies and management systems appropriate for the further expansion of grouindwater irrigation within the project area. However, due to the delays in project implementation such recommendations cannot be provided at this stage.

TABLE OF CONTENTS

DEVELOPMENT OF SSIMP EXPERIMENTAL SYSTEMS IN NTT

1. INTRODUCTION

The potential for groundwater irrigation development in the Oesao-Pariti plain was first recognised during the 'Timor Island Water Resource Development Study' (Ref.1) implemented by Crippen International with CIDA funding.

Between 1982 and 1986, P2AT implemented a drilling program in the plain which produced five productive wells with depths of 50 to 65 meters and yields of between 9 to 15 liters per second. Between 1985 and 1987, P2AT constructed irrigation distribution systems at four of these productive well sites.

SSIMP involvement in the development of groundwater irrigation in NTT began in 1985 when a USAID consultant implemented a detailed socio-economic survey to monitor the development of the first P2AT demonstration plot at Pukdale I. (Ref.2 to 6)

One of the lessons learned from this study was that the farmers in the area responded positively to the opportunity to increase their incomes but that the costs of deep tubewells and distribution systems as developed at this first site were too high to be self-sustaining or farmer replicable.

A major component of the SSIMP groundwater development program in NTT therefore involves the construction of experimental systems to investigate alternative, simple, low-cost technologies more appropriate to local conditions. Apart from the technical aspects of system design, the experimental sites will also provide the opportunity to experiment with alternative management techniques for operation and maintainance of irrigation systems.

The ultimate objective of this activity is to provide recommendations of appropriate technologies for distribution, and management systems to support the further development and expansion of groundwater irrigation in the project area.

2. CHOICE OF APPROPRIATE IRRIGATION SYSTEMS

In this section the factors that determine the type of irrigation systems considered appropriate for development within the project area are discussed.

The discussion starts with the choice of application system, i.e. how the water is actually applied to the crop. The next section covers the conveyance system i.e. how the water is carried from the pump to the point of application. The following two sections deal with the choice of pumping equipment and the water source itself and the final section considers equity issues which may also affect the type of system chosen for further development.

2.1. Application system:

In March, 1987 the SSIMP engineering consultant, Bill Menninger prepared a report comparing three alternative irrigation application techniques including sprinkle, trickle and surface (furrow) systems. (Ref. 7)

The main advantages of sprinkle irrigation are high application efficiency, low labour requirement, and the ability to irrigate sloping and undulating topography. The disadvantages stated in the report include high capital costs, the need for good quality water, the need to avoid windy and excessively dry areas and that field shapes other than rectangular are inconvenient.

Trickle irrigation offers similar advantages but disadvantages include high capital costs, low distribution uniformity, clogging, salt accumulation and the sensitivity of the crop to even short periods of interrupted irrigation.

The advantages of the furrow system were stated as minimal capital investment, simplicity of operation and low energy costs. Disadvantages include high labour requirement, lower efficiencies (compared with sprinkle or trickle), soils may be affected by waterlogging and salinity and that fields need to be well graded.

When these three systems are considered in the context of the project area in NTT, although the first two systems are said to give high application efficiencies with low labour requirements, the level of technology involved in operating and maintaining the systems at these high levels of efficiency is likely to be beyond the capabilities of most farmers in the project area and, in terms of SSIMP objectives and the labour situation in NTT, the low labour requirement is to be considered of far less importance than the very high capital costs of these systems. As climatic conditions in Oesao-Pariti during the dry season could well be described as 'windy and excessively dry', this condition would also suggest that the sprinkle system is inappropriate for the project area.. Therefore, it would seem that of the three alternatives, the furrow application system provides the most appropriate technology.

In fact, furrow irrigation is just one of a number of 'surface' application techniques: others including basin and border-strip systems. As most of the land in the project area likely to be developed for irrigation has been planted to lowland rice in the rainy season with the formation of small, level, bunded plots, the basin and border strip type systems are probably the most appropriate for the initial stages of development.

2.2. <u>Conveyance system</u>:

The significant differences in both capital cost and level of technology between the surface application technique and those of sprinkle and trickle indicate quite clearly that surface systems are the most appropriate for development under SSIMP in NTT.

The choice of technology for <u>conveying</u> the water from the well to the point of application is not so straightforward.

The technical alternatives for conveyance systems fall into three main categories:

a) Unlined, open channels

b) Lined, open channels

c) Buried pipes

Some of the important factors affecting the choice of system are described below.

<u>Buried pipe vs. open channels</u>

Buried pipe systems are likely to be more expensive to construct than open channels but offer a number of advantages and may be the only feasible choice in certain situations:

- Open channels can only be used where the land slopes gently downwards away from the well allowing for gravitional flow whereas with pressurised pipe systems, water can be carried up slopes and over undulating land.

- Where land is considered of high value, right-of-way for land taken up by open channels may result in organisational problems whereas a buried pipe system only requires a very small area for turnout structures.

- Once the location of turnouts is determined the layout of buried pipes can be arranged to supply the turnouts taking the shortest possible routes whereas open channels may need to follow field boundaries to avoid right-of-way issues.

- Obstructions such as roads and drainage ditches can be easily overcome in buried pipe systems whereas open channels would require special structures.

- As there are virtually no conveyance losses in piped systems the design discharge can be provided equitably at all turnouts.

- Properly constructed buried pipe systems can last for up to forty years and require very little maintenance.

- Once the basic design work has been completed construction of buried pipe systems is very simple and quick. Properly constructed open channels are more time consuming and require accurate leveling in the field.

The disadvantages of piped systems, apart from higher initial cost, include :

- A higher pumping head requirement to overcome pipe friction.

- For simplicity of design and to avoid the need for expensive regulating devices, systems should be designed for discharge at only one turnout at a time.

<u>Lined vs. unlined open channels</u>

In situations where open channel systems can be used the factors affecting the decision of whether to line the channels include:

- The magnitude of conveyance losses from an unlined open channel will be dependent on soil texture and structure. If the soil is of a stable, fine-textured nature, seepage losses may not be exceptionally high although intermittent usage during long dry periods may lead to deep-cracking.

- Another problem associated with the seepage from unlined channels is that adjacent cropped land may become waterlogged.

- Design slopes for unlined channels need to be steep enough to overcome friction and achieve even flow but not so steep as to cause erosion of the channel.

- To operate efficiently, unlined channels require regular maintenance to clear weed growth.

Thus, if soil type and site conditions are suitable and labour can be organised to maintain the channels, unlined open channels can be used to construct a low-cost, viable conveyance system.

The choice of conveyance system obviously requires careful consideration of many socio-economic and technical issues and therefore it is considered that sound recommendations can only be made on the basis of detailed evaluation of experimental systems.

2.3. Pumping equipment

The choice of pumping equipment for use on SSIMP experimental sites has so far been restricted to surface-mounted centrifugal pumps coupled to small (5.0-7.5 Hp) diesel engines. At this stage, the use of submersible or turbine pumps is not being recommended due to the relatively high cost and the lack of local skills and facilities for servicing such equipment within the project area.

2.4. Water sources

The alternative water sources considered appropriate for development under SSIMP include shallow, hand-dug wells, shallow and intermediate depth tubewells and springs.

Where aquifer conditions allow, priority is given to shallow, hand-dug wells and shallow tubewells due to the relatively low cost of construction and maintenance. The development of springs is also given high priority but to date no suitable springs have been identified within the project area.

In some situations, the nature of the aquifer will obviously necessitate the drilling of deeper tubewells. In these cases, the very high cost of constructing and maintaining such wells will require a higher degree of public sector support to maintain the wells in efficient working order.

2.5. Equity issues affecting choice of system

Although, the SSIMP program to carry out a detailed hydrogeological assessment of the project area has been delayed due to administrative problems, the existing data indicate a complex, irregular aquifer system. The observed effect of this situation is that two wells, within close proximity to eachother may possess significantly different discharge characteristics and potential for irrigation.

To illustrate this situation and emphasise its significance for groundwater irrigation development policy consider the following, simplified example:

GIVEN: A 100 hectare parcel of land evenly divided between 200 farmers.

CASE I: (See Figure 1. - page 8.) Firstly, consider a situation in which the aquifer can support up to 50 wells with equitable discharge rates of 12 liters per second.

In this situation there are a number of possible alternatives to irrigation development of the whole 100 hectare area: small, low-cost, kerosene pumps could be used to irrigate e.g. 50, two-hectare commands with only a four farmers in a group; larger diesel powered pumps with unlined channels could supply e.g. 20 five-hectare commands, including 10 farmers per group; or diesel pumps with lined channels could supply 10 hectares with 20 in each group.

The potential benefits in terms of increased production would be the same for all the farmers in the area whichever system is used, so recommendations for the most efficient and appropriate systems would be based on evaluating which system incurs the lowest operational costs (including capital costs) and/or provides the ideal size of farmer groups for organisational purposes.

CASE II: Farmers have dug wells at 50 points throughout the area.

Of these 50 wells, 40 prove to be unproductive for irrigation purposes and the other 10 exhibit discharge rates of 12 liters/second.

If the productive wells are pumped using small, low-cost, kerosene pumps irrigating 2 hectare commands, a total of only 20 hectares could be irrigated with 10 beneficiaries

If larger diesel pumps are used in conjunction with unlined channels supplying 5 hectare commands, a total of 50 hectares could be irrigated with 100 beneficiaries.

If diesel pumps are used in conjunction with lined channels supplying 10 hectare commands the whole 100 hectares could be irrigated to the benefit of all 200 farmers.

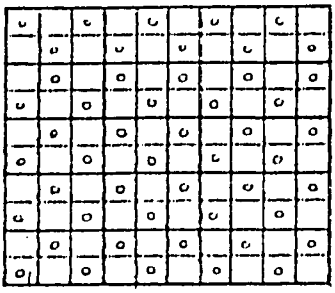
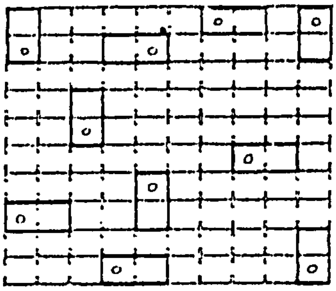
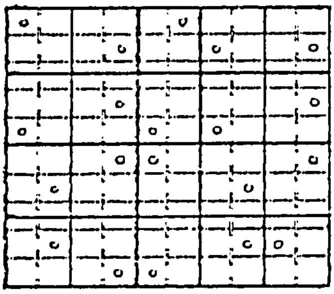
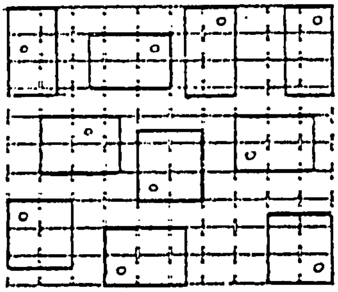
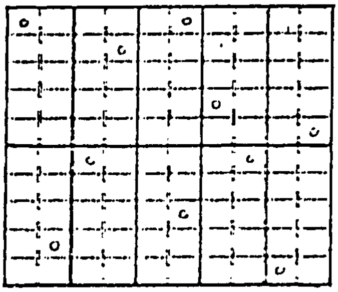
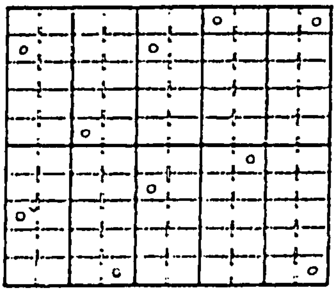
In this case, if the potential benefit of a productive well is to be equitably distributed to maximise the area of land and/or number of beneficiaries, the distribution system should be designed to minimise conveyance losses. This suggests the construction of lined channels or piped systems.

If the capital cost of constructing the conveyance system is to be borne by the beneficiaries, the economic benefits per unit area or per person may well be lower than a system of simple unlined canals serving a smaller area but the overall benefit to the community will be higher.

The situation in 'Case I' is obviously far more conducive to equitable private sector development because whichever type of system is chosen, all farmers in the area will have the same opportunity to utilise the groundwater for the purposes of irrigation. However, in a 'Case II' situation, if farmers with land close to the productive wells choose to utilise the least capital intensive system, only a small fraction of the potential total command could be serviced. Therefore, if equity is considered of major importance, a higher degree of public sector intervention would probably be required.

As stated above, the hydrogeological situation in the Oesao-Pariti area appears to be closer to a 'Case II' situation although this can only be verified by implementation of the exploration program.

Figure 1.

	CASE I = 50 wells	CASE II = 10 wells
Small kerosene pump Unlined channels Command = 2 ha/well		
TOTAL AREA IRRIGATED =	100 HA	20 HA
Diesel pump Unlined channels Command = 5 ha/well		
TOTAL AREA IRRIGATED =	100 HA	50 HA
Diesel pump Lined channels/pipes Command = 10 ha/well		
TOTAL AREA IRRIGATED =	100 HA	100 HA

3. EXPERIMENTAL SITE DEVELOPMENT TO DATE

To date, only two of the proposed nine experimental sites have been constructed and designs prepared for a third, construction awaiting the processing of a commit PIL.

3.1. Lukman Barat: (Plates 1 to 4)

Inspired by the example of the nearby P2AT Pukdale I site, a group of farmers at Lukman Barat dug a shallow (7 meter deep) well and then asked P2AT to evaluate it's potential for development. After establishing that the site conformed to selection criteria, and especially considering it's particular attraction for the purposes of demonstration, being located by the side of the main trunk road in Timor, Lukman Barat was chosen for development of an SSIMP experimental system.

The pumping test, at this site indicated a sustainable discharge of 12.6 liters per second and the design command area was established at 10 hectares.

The design consists of a diesel-powered centrifugal pump (7.5 Hp engine coupled to a 3" pump) which discharges through a flowmeter directly into a network of buried PVC pipes(150 meters of 5" and 600 meters of 4" pipe). There are ten turnout structures, at approximately 75 meter spacings, and consisting of iron pipe risers with T-joints providing outlets in two directions. Each outlet can be closed off with a threaded cap. When irrigating, any one outlet is opened and a 3 meter length of reinforced rubber hose is connected, discharging into unlined farm channels. Each outlet supplies an area of ± 0.60 hectares.

The water users' association established at this site includes 30 farmers.

3.2. Pariti II: (Plates 5 to 10)

The water source at this site is a P2AT artesian tubewell which was constructed in 1986 and is free-flowing for several months during and after the rainy season. After the well was constructed the discharge during the rainy season was used by the farmers to provide supplementary irrigation for approximately 7 hectares of ricefields but was not used for dry season cropping .

A pumping test carried out at the end of the dry season indicated a sustainable discharge of over 16 liters per second.

To avoid organisational problems, the design command was limited to 10 hectares but with the possibility of expansion at a later date.

The system was designed to allow for distribution of the artesian flow whenever possible, and switching over to pumping at times when the artesian flow proves insufficient. A 4" centrifugal pump was installed, coupled to a 7.5 Hp diesel engine.

As the well is sited at a low point of the command area, 250 meters of 6" PVC pipe is used to convey the water from the well to the highest point, at an elevation approximately 2 meters above the elevation at the well. Three, screw-capped risers at 125 meter spacings discharge into distribution boxes and then into lined channels for conveyance to turnouts further away from the pipe. The total length of lined channel is 665 meters.

The channel linings were fabricated on site and consist of one-meter lengths of pre-cast concrete, half-round sections. The formers for these sections were designed by P2AT staff and fabricated in the USAID Provincial Development Program's Sukabitetek workshop. The sections have an internal radius of 10 cm and are interlocking to maintain longitudinal stability. The channel sections are assembled on top of a consolidated earth embankment. In the original design, joints between sections were to be made using an asphalt-sand mix but due to difficulty obtaining the asphalt, cement mortar was used.

There are 28 farmers in the Pariti II water users' association.

3.3. <u>Lukman Timur:</u>

This site is situated between the P2AT Pukdale I site and Lukman Barat. As was the case with Lukman Barat, inspired by the example of Pukdale I, farmers in the Lukman Timur area had dug a number of shallow wells intended for irrigated cropping in the dry season. One of these wells has been exploited for irrigating secondary food crops and vegetables using a pump donated to the group by the Bupati of Kabupaten Kupang.

At the suggestion of the group involved, a pumping test was carried out on another, recently dug well which the group considered of greater potential. The test indicated a 'safe' discharge of 10 liters per second up to the end of the dry season.

The farmers at this site were actively involved in establishing the design layout for a 10 hectare command.

The conveyance system for this site will be an open channel, lined with pre-cast, trapezoid channel sections. The size, shape and jointing of these sections are all different to those used for the Pariti site. The channel sections will be trapezoid in section, have flat rather than interlocking ends and joints will be supported by small concrete pillars set into firm soil. The total length of channel for this site will be 825 meters.

The pumping equipment for this site will be a 3" centrifugal pump coupled to a 5.5 Hp engine. The pump will discharge into a small reservoir/stilling tank and then through a V-notch, metering device into the canal system.

Construction of the experimental systems has been by force account. P2AT staff are responsible for the procurement of equipment and materials and the actual construction work is implemented by the farmers at each site under the guidance of P2AT irrigation staff. The farmers are not paid for their labour, but mid-day meals have been provided to enable them to work a full day. At the Pariti site, after discussions with the farmers, the fabrication of the majority of channel linings was implemented by paid labourers so that the construction could be completed before the beginning of the rice-planting season.

3.4. Reasons for the delays in implementation of construction

The chronological sequence of events involved in the development of the first two sites is summarised below:

TASK	AGENCY RESPONSIBLE	TIME TAKEN
Field survey and design	P2AT - NTT	7 months (May-Nov, 1987)
Official request for PIL commit	IRRIG. II	2 months (Dec.87-Jan.88)
Issue PIL commit	USAID	1 month (February, 1988)
Request for pre-financing	P2AT - NTT	3 months (Mar-May, 1988)
Authorise release of funds and transfer to project account	DTUA, BI	1 month (June, 1988)
Inform project of transfer	Project bank	2 months (Jun-Jul, 1988)
Implement construction	P2AT - NTT	5 months (Aug-Dec, 1988)

From this table it can be seen that the whole process from the initial site investigation to the completion of construction of these two sites took a total of twenty months.

The field survey work was delayed mainly because there was no appropriate pumping equipment available at P2AT to carry out the pumping tests necessary for establishing design command area. Thus, the total time taken from initial survey work at Lukman Barat to completion of designs was seven months (May-November, 1987).

The administrative process to obtain the funding for construction from the submitting of designs and specifications by the project to Irrigation II until receipt of funds at the project took a total of nine months.

Delays in the implementation of construction were caused mainly by the project staff's lack of experience in organising construction works under force account. A committee was formed before work commenced but did not really function as hoped, leading to delays in liquidation of funds for procurement of materials, transport and per diems. The lack of coordination of of appropriate transport also caused delays as did problems of communication between project staff in the field and the main office in Kupang.

3.5. Farmer Participation.

Farmer participation in irrigation system development has been recognised as of major importance in creating sustainable systems which can ultimately be managed by farmer groups with minimal public sector support.

Farmers at all three SSIMP sites have been actively involved in all field survey activities including pumping tests, topographic surveys and plotting of land ownership boundaries. Working closely with the farmers in the early stages of site development provides P2AT staff with the opportunity to identify any previously unforeseen technical or social problems associated with the site which may influence the subsequent design work and/or manageability of the system.

Apart from often, being the only way to satisfactorily establish land ownership boundaries (see section 5.on site selection), the plotting of individual farmer's fields on the topographic map was also found to be very useful for determination of system layout, positioning of turnout structures, and for checking farmers' agreement to right-of-way for main system canals.

Once preliminary designs had been prepared, the farmers were consulted to verify their agreement with the command area boundaries, system layout and positioning of turnouts.

At all three sites, social factors affected the establishment of command area boundaries and those eventually agreed upon were quite different those that would have been determined on the basis of technical site characteristics alone.

Right-of-way issues have not significantly affected the design layouts for these three sites as the farmers consider the benefits of a year-round irrigation supply to far outweigh the associated loss of land to the main system canals.

All construction work, apart from the fabrication of channel sections at the Pariti II site has been implemented by the farmers under supervision of P2AT field staff. At both sites constructed so far, the initial excavation of trenches for the PVC pipe was divided between the farmers on the basis of area of land owned within the command area.

At Lukman Barat, the subsequent construction work was carried out on a single group 'gotong royong' basis. At Pariti II, the farmers decided to divide their group into three sub-groups of nine to ten members with only one sub-group working each day so that the other two groups could continue with other activities such as tending cattle, fencing and preparing upland fields for planting corn in the rainy season. The division of these sub-groups was based on the division of land served by each of the three main canals so that the same sub-groups could be maintained for the purposes of irrigation management when the system becomes operational.

During the process of construction, the farmers gained practical experience of assembling PVC pipes; leveling canal embankments at the correct slope; pump installation; and casting of concrete turnout structures and distribution boxes. By the time construction work was finished most farmers were capable of performing these tasks with little or no supervision. These skills should enable the farmers to maintain their systems in good working order with minimal technical assistance.

It should be noted that the initial enthusiasm and motivation of farmers during the early stages of survey and design work was put under considerable strain as a result of the long administrative delays mentioned in section 3.4.. Indeed, some farmers did not believe the project staff when informed that the construction work could begin and only started to work on the excavation of trenches after the materials had been transported to the site.

3.6. Construction costs

In Table 1 (page 26) a breakdown of the actual costs of construction for the Lukman Barat and Pariti II experimental sites and estimated cost of costruction for the Lukman Timur site are compared to the costs of constructing the four P2AT 'demplot' sites (Pukdale I, Naibonat, Pariti I and Pukdale II) under contract.

Notes on Table 1.

1. Conveyance system: includes the cost of channels and/or pipes, turnout structures, distribution boxes and metering devices. Naibonat, Pukdale I and Pariti I sites have masonary canal systems. Pukdale II has a gravity-fed galvanised pipe system.

2. Pumping equipment: costs of pumping equipment at the SSIMP sites includes the cost of installation (pipes and fittings).
Installation costs for the Pukdale I and II sites were not available.
Pumps for the Naibonat and Pariti I sites were purchased in 1988.

3. Pump Houses: The pump houses at the Naibonat, Pukdale II and Pariti I sites have brick walls and two separate compartments. The pump house at Pukdale I has palm frond walls and is divided into three compartments. SSIMP pump houses are of a much simpler construction with just enough space for pumping equipment and fuel storage.

4. Admin. transport etc: For SSIMP sites this includes the cost of P2AT staff supervision, meals for farmers, labour for fabrication of channel sections and transportation. The higher costs incurred at both the SSIMP and P2AT sites in Pariti are due to the greater distance from Kupang and difficult access during the rainy season. The high cost at the Pariti II site compared to the Lukman Barat site also reflects the greater length of time and labour required to construct the open channel system compared to the simpler and quicker construction of the buried pipe system.

Discussion of points 5 to 7 from Table 1.

Firstly, it should be noted that the cost figures for the P2AT sites are taken directly from the original contracts. The Pukdale I site was constructed in FY 85/86 and other three sites in FY 86/87. No adjustments have been made to account for inflation.

Total costs per hectare for all three SSIMP experimental sites are lower than all the P2AT contractor-built sites.

The per hectare costs for the construction of the Lukman Barat and Pariti II sites are relatively high compared to the estimated cost of the Lukman Timur site because both of these

systems include the use of high-grade PVC pipes. After gaining
experience of installing these systems, the P2AT staff feel
confident that a lower grade of PVC could be used with a cost
saving of up to 30 per cent.

Discussion of points 8 to 10 from Table 1.

The conveyance systems at all three SSIMP sites are
considerably longer than those at the P2AT sites. The SSIMP sites
were designed with longer conveyance systems to provide more
equitable delivery streams to fields within the command area as
experience with operation of the P2AT systems has shown that some
fields are too far away from the main canals and take
considerably longer to irrigate than fields closer to the main
system turnouts. Such inequity of delivery streams are bound to
cause difficulties in organisation of irrigation managemant. In a
system where farmers pay for pump operation on an hourly basis,
the relative expense of irrigating fields further away from the
main channel are likely to lead to disputes within the water
users' association. This point was raised in the monitoring
report of the Pukdale I site (Ref.5). Even if a more equitable
payment scheme could be introduced, this inequity of supply will
still lead to organisational problems in managing rotational
irrigation scheduling.

The SSIMP distribution systems have therefore been designed
so that the point of delivery into any farmers field should be no
further than 100 meters from a main system turnout structure.
This should allow for easier management and a greater likelihood
that the water users' association will be able to independently
manage sustained operation and maintenance of the system.

Having recognised this requirement for longer conveyance
systems, the final line item in Table 1., the cost per meter of
the conveyance system is probably the most significant cost
factor upon which to compare the systems.

Comparing conveyance system costs on a per meter basis, the
SSIMP systems are all significantly cheaper than the P2AT
'demplot' systems. There are however, obviously two main factors
influencing the difference in costs between the P2AT and SSIMP
systems i.e. firstly, the difference between contract costs and
construction by force account and secondly, the actual design of
the systems.

In order to make a more realistic comparison of costs for alternative designs, the bill of quantities from the original contracts for the four P2AT sites have been recalculated to exclude all labour costs and using prices contemporary to the construction of SSIMP systems. These recalculated costs for the conveyance systems are given in Table 2. (page 27) and Table 3. (page 28)

Table 2. compares the costs of the three P2AT open channel systems with the estimated costs for the Lukman Timur open channel system. As can be seen, the unit cost for the Lukman Timur system is still significantly lower at Rp.6.665/meter as compared to Rp.18.293/meter for the cheapest P2AT channel system at the Naibonat site.

In Table 3., the adjusted cost of the Pukdale II galvanised pipe system is compared to the PVC pipe sytem at Lukman Barat and the combination PVC pipe/open channel system at Pariti II. Again the difference in cost is significant with the Lukman Barat system costing Rp.19.471/meter as compared to Rp.48.751/meter for Pukdale II.

3.7. Monitoring of experimental sites

So far comparisons between sites has only been possible on the basis of designs and initial capital costs. In order to achieve the objective of providing recommendations for appropriate systems for replication in further expansion programs, the operation and maintenance of the experimental sites need to be closely monitored.

Organised operation and monitoring of the first two sites is due to commence at the beginning of the 1989 dry season.

The monitoring of experimental sites will include both technical and socio-economic aspects of system operation including:

a) Operational costs:	cost of fuel, oil and maintenance of pumping equipment.
b) Maintence requirements:	including time spent on maintaining the distribution systems as well as costs incurred.
c) Distribution efficiencies:	conveyance system water losses.
d) Agricultural production:	data to be collected at the end of each planting season.
e) Manageability:	organisational requirements for irrigation management associated with system design.

4. INSTITUTIONAL SUPPORT FOR WATER USERS' ASSOCIATIONS

Experience gained during the development of P2AT 'demplots' has indicated that the farmers in the project area are not generally used to coordinating production activities in organised groups and therefore require particularly intensive guidance in the organisational aspects of system operation during the early stages of development.

Also, as farmers in the project area have generally poor knowledge of improved agricultural practices and, apart from watering small household gardens will have had little or no experience of irrigating secondary crops in the dry season, the provision of agricultural extension and training in irrigation application techniques are also particularly important to the success of the project.

Department of agriculture extension agents have occaisionally provided advice on crop production when invited to attend water users' association meetings but have not been able to provide the sustained support required at groundwater irrigation sites, especially during the early stages of development.

Effectively, only two members of the P2AT irrigation section have been involved in: the formation of water users' associations; providing advice and guidance on irrigation management and crop production techniques; and helping farmers to obtain agricultural inputs. The regularity of site visits has also been restricted by insufficient budgetary support.

Obviously, as the number of operational sites increases it will become increasingly difficult to provide the intensity of guidance required for efficient management of systems and strengthening of water users' associations in order to eventually assume full responsibility for operation and maintenance.

In order to improve inter-sectoral coordination, a training program has been planned including field staff from P2AT, agricultural extension agents, heads of water users' associations, government community development fieldworkers and influential village figures. Training will include organisational, social and basic technical aspects of groundwater irrigation. A study tour to existing sites and seminar for officials from the relevant sectorial departments is also planned to discuss the possibilities of improving inter-sectoral coordination for the future development of groundwater irrigation in the project area.

The possibility of involving a local non-government organisation in the program to provide a network of field agents to assist in the development and operation of new sites is also being explored.

5. SITE SELECTION PROCEDURE

From experience gained during the process of development of the first three experimental sites, a logical approach to site selection has evolved which is considered to cover all the important issues as well as making most efficient use of limited time and funding.

The process is represented in the form of a flowchart in Figure 2.

1. The first step in the process is a review of existing data which may be in the form of maps (topographic, land use, administration etc), other survey reports (socio-economic, hydrogeological etc.), information from local government officials or observations in the field.

2. After reviewing existing information, a number of possible sites can be identified for further investigation. 'Sites' in this case may refer to a specific well or spring location, or an larger area of land which is considered of good potential for development even though there are no identifiable water sources. The latter situation could make the area a priority for exploration work.

3. The next step involves a field visit by P2AT staff to make a rapid assessment of the site characteristics and determine whether a more detailed and costly survey is required. This process should take only one to two days per site and involve informal interviews with farmers and local officials to establish land ownership patterns, present land use, social groupings, alternative water sources, other income generating activities as well as other general observations. A small kerosene pump would be taken to the field so that any existing, apparently productive wells could be pumped for up to two to three hours and the drawdown noted to give an early indication of well capacity before organising a complete and costly pumping test at a later stage.

If any fundamental problems are identified at this stage such as very large areas of land being owned by a few wealthy landlords or a high percentage of of land ownership by absentee landlords, the site may be designated as unsuitable for development under the project and therefore indicate no need for subsequent survey activities.

Due to the high cost of soil analysis, a general assessment of soil conditions could also be made at this early stage. A full soil analysis would only be proposed if there is evidence of an apparent soil problem i.e. from observation or information from respondents.

4. If an apparently viable water source already exists and the area is considered suitable for development, the next stage would involve a more detailed technical survey. This survey would include a 24 hour pumping test, soil sampling for textural classification (percentage of clay, sand and silt), water quality testing, and measurement of soil infiltration rates.

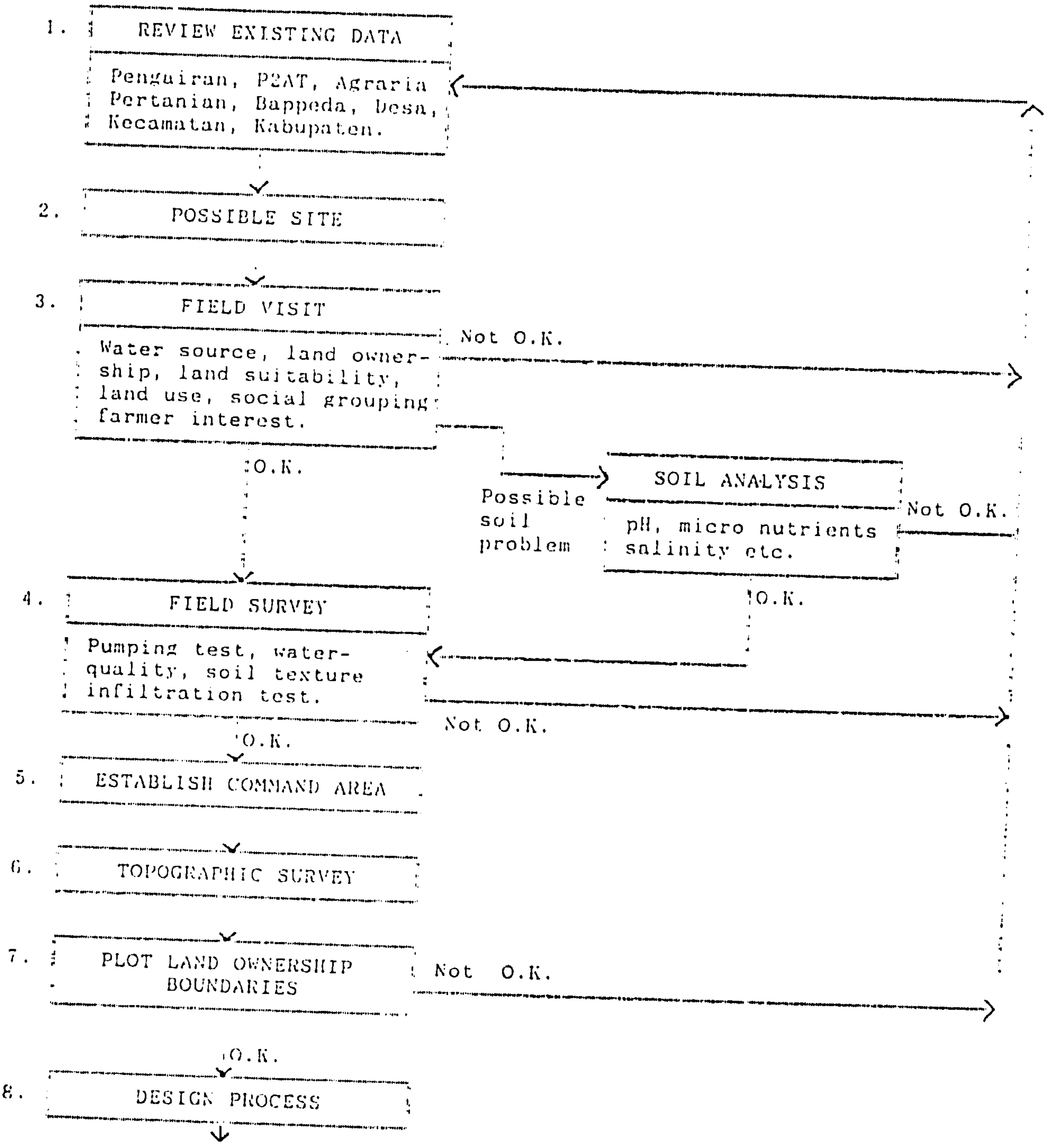
5. Analysis of the survey work carried out in step 4 will indicate whether the site is still viable for development. If suitable, the data collected also enables the potential command area to be established.

6. Once the potential command area has been established, the detailed topgraphic survey of the site can be implemented. The area covered by the topo survey should be between 50-100% larger than the estimated command area to provide flexibility for command location.

7. Experience in NTT has shown that it is very difficult to clearly establish land ownership through informal interview and, as only a very small percentage of land ownership has been officially mapped, the most accurate method is to take the detailed topographic map to the field and then invite village officials and as many local farmers as possible to walk around the fields with a tape measure and plot land ownership boundaries onto the topographic map. Plotting of land boundaries is also essential in design work to determine position of turnouts and conveyance channels.

8. At this stage,work can begin on designs.

Figure 2.


1. REVIEW EXISTING DATA
Pengairan, P2AT, Agraria
Pertanian, Bappeda, Desa,
Kecamatan, Kabupaten.
2. POSSIBLE SITE
3. FIELD VISIT
Water source, land owner-
ship, land suitability,
land use, social grouping
farmer interest.
Not O.K.
O.K.
Possible
soil
problem
SOIL ANALYSIS
pH, micro nutrients
salinity etc.
Not O.K.
O.K.
4. FIELD SURVEY
Pumping test, water-
quality, soil texture
infiltration test.
Not O.K.
O.K.
5. ESTABLISH COMMAND AREA
6. TOPOGRAPHIC SURVEY
7. PLOT LAND OWNERSHIP
BOUNDARIES
Not O.K.
O.K.
8. DESIGN PROCESS

6. CONCLUSIONS

The SSIMP experimental program in NTT is designed to identify low-cost, farmer-manageable irrigation technologies appropriate to the specific conditions of the Oesao-Pariti plains.

Strategies developed to ensure the sustainability of systems have includec the development of a site selection procedures which take account of social, as well as technical factors and the participation of farmers in the survey, design and construction stages of site development.

The technologies used in the design of initial sites include pressurised PVC pipe systems and open channels constructed with pre-cast concrete sections. The initial cost of constructing these systems has been shown to be significantly lower than those previously developed by P2AT.

Delays in project implementation have meant that only two of the nine experimental systems planned for development have been constructed and these will only become fully operational at the beginning of the 1989 dry season.

It is therefore impossible at this stage to make meaningful recommendations on the systems most appropriate for sustainable expansion of groundwater irrigation in the project area as such recommendations will dependent on monitoring the performance of the various systems in operation.

7. RECOMMENDATIONS

- Designs for the following six experimental sites should include systems using lower-grade PVC pipe than used at the first two sites; modifications to the design of pre-cast concrete channel sections; and at least one smaller site using properly constructed unlined canals for comparison with lined channel systems.

- In order to achieve the objective of providing recommendations for technologies appropriate for further expansion of groundwater irrigation within the project area, experimental sites should be closely monitored and compared with existing P2AT sites on the basis of both technical and socio-economic aspects.

- Efforts should be made at both the Provincial and Central levels to reduce the time taken for the approval and disbursement of project funds.

- Institutional support for water users' associations needs to be strengthened by improving inter-sectoral coordination at the provicial level and/or establishing a support program implemented through a non-government organisation.

- Expansion of groundwater irrigation within the project area should not commence before the completion of the geohydrological water balance study to assess the true potential of the aquifer and risks of causing environmental damage.

Table: 1.
COMPARISON OF COSTS FOR P2AT DEMPLOTS CONSTRUCTED UNDER CONTRACT AND SSIMP EXPERIMENTAL SITES CONSTRUCTED THROUGH FORCE ACCOUNT.

ITEM	P2AT DEMPLOTS CONSTRUCTION COSTS IN Rp. (Values from original contracts)				SSIMP EXPERIMENTAL SITES - FORCE A COUNT: ACTUAL COST (Rp.)		ESTIMATED COST
	PUKDALE I (85/86)	NAIBONAT (86/87)	PARITI I (86/87)	PUKDALE II (86/87)	LUKMAN BAR. (88/89)	PARITI II (88/89)	LUKMAN TIMUR
1. Conveyance system	18.313.800	18.116.500	13.170.700	18.113.750	14.603.200	10.080.250	5.498.400
2. Pump sets and installation	1.700.000	2.000.000	1.350.000	1.700.000	2.579.750	3.013.000	2.724.500
3. Pump house	3.263.750	4.695.000	5.018.850	4.965.000	850.000	350.000	930.950
4. Admin., transport etc.	500.000	2.131.000	2.274.000	978.000	845.000	3.374.000	2.500.000
5. TOTAL COST (Rp.)	23.777.550	26.942.500	21.813.550	25.756.750	18.877.950	17.817.250	11.553.350
6. COMMAND AREA (Ha.)	7	9	10	8	10	10	10
7. COST PER HECTARE (Rp./ha)	3.396.793	2.393.611	2.181.355	3.219.594	1.887.795	1.781.725	1.165.385
8. LGTH. OF CONVEYANCE SYSTEM (meters)	600	500	400	430	750	915	825
9. TYPE OF CONVEYANCE SYSTEM	Open channel	Open channel	Open channel	Galvanised pipe	PVC pipe	PVC pipe/ Open channel	Open channel
10. CONVEYANCE SYSTEM COST PER METER	30.523	36.233	32.927	42.125	19.471	11.017	6.665

Table: 2.

COMPARISON OF COSTS OF MATERIALS REQUIRED TO CONSTRUCT OPEN CHANNEL SYSTEMS AT FY 88/89 PRICES

ITEM	P2AT DEMPLOTS Cost of construction materials only at FY 88/89 prices			SSIMP - Estimated cost of materials at FY 88/89 prices
	PUKDALE I	NAIBONAT	PARITI I	LUKMAN TIMUR
1. Conveyance system (Rp.)	12.229.756	9.146.500	9.730.800	5.498.400
2. COMMAND AREA (Ha.)	7	9	10	10
3. LGTH. OF CONVEYANCE SYSTEM (meters)	600	500	400	825
4. TYPE OF CONVEYANCE SYSTEM	Open channel	Open channel	Open channel	Open channel
5. CONVEYANCE SYSTEM COST PER METER	20.383	18.293	24.327	6.665

uct

Table: 3.

COMPARISON OF COSTS OF MATERIALS REQUIRED TO CONSTRUCT PIPED CONVEYANCE SYSTEMS AT FY 88/89 PRICES

ITEM	P2AT OEMPLOT Construction materials only at FY 88/89 prices	SSIMP EXPERIMENTAL SITES Actual cost of materials at FY 88/89 prices	
	PUKDALE II	LUKMAN BARAT	PARITI II
1. Conveyance system (Rp.)	20.962.930	14.603.200	10.080.250
2. COMMAND AREA (Ha.)	8	10	10
3. LGTH.OF CONVEYANCE SYSTEM (meters)	430	750	915
4. TYPE OF CONVEYANCE SYSTEM	Galvanised pipe	PVC pipe	PVC pipe/ Open channel
5. CONVEYANCE SYSTEM COST PER METER (Rp./m)	48.751	19.471	11.017

28

Plate 1.

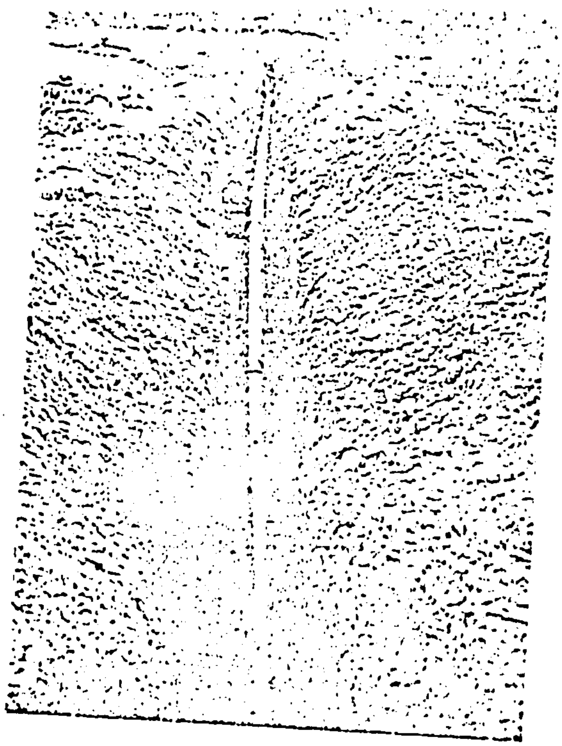


Plate 2.

LUKMAN BARAT

1. Well and pump house during construction

2. PVC pipe in trench

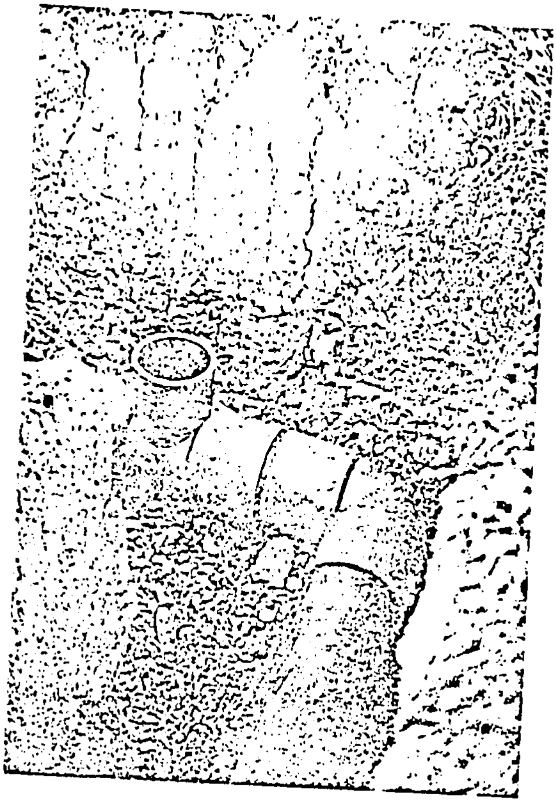
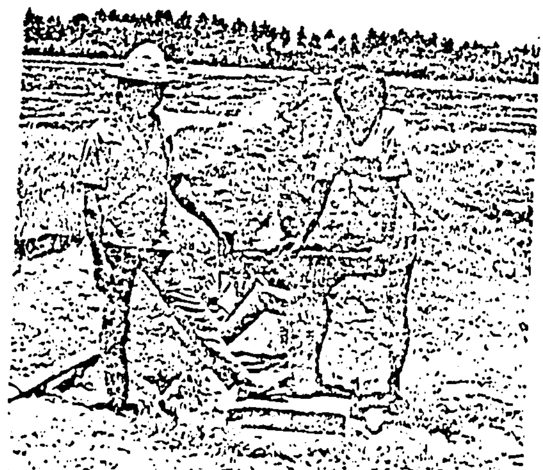


Plate 3.



LUKMAN BARAT

3. Detail of PVC pipe at benc and outlet.

4. Turnout pipes

Plate 4.

.30'

Plate 5.

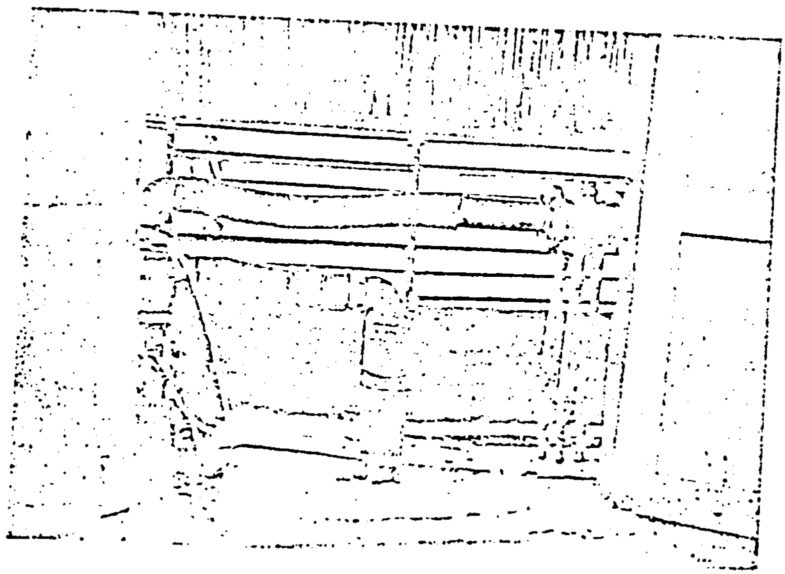


Plate 6.

PART: II

5. Meeting of water users' association during construction.
6. Well, pumping equipment and flowmeter.

Plate 7.

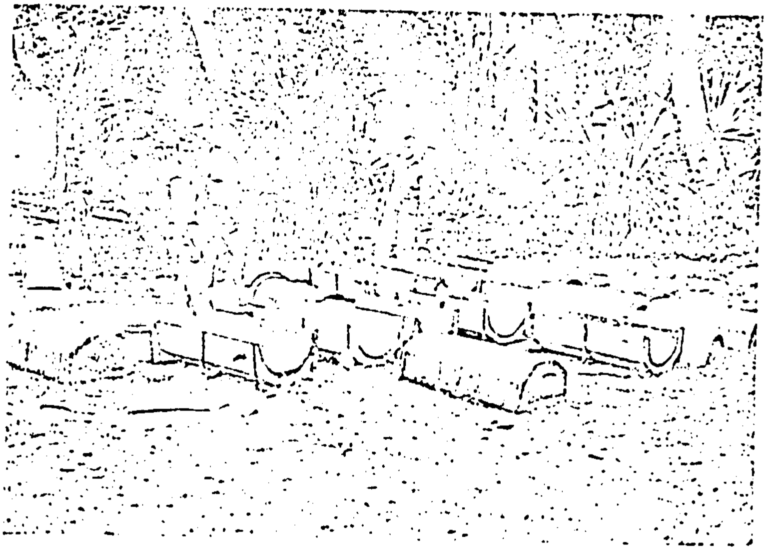


Plate 8.

PARIT II

7. Former for fabrication of channel sections.
8. Channel section fabrication on site.

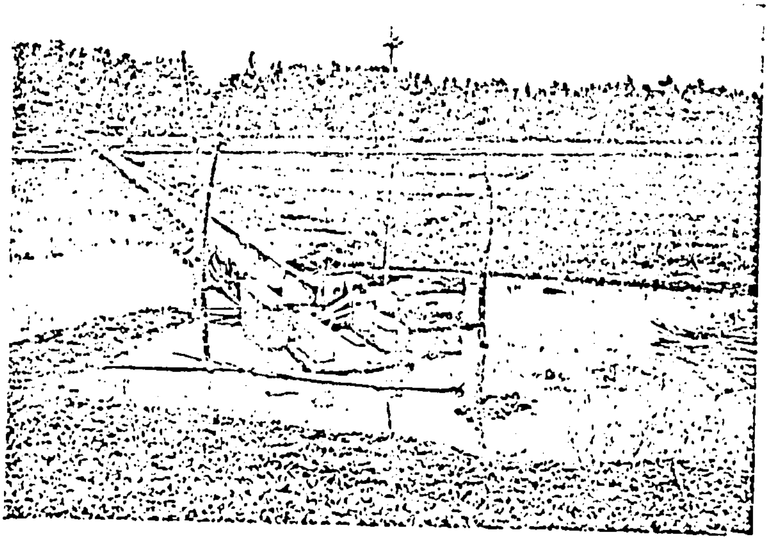
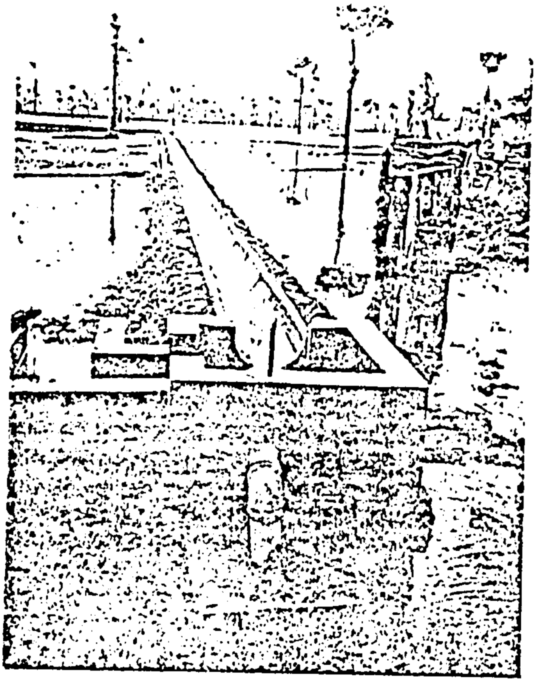


Plate 9.



PARITI II

9. Open channel in final stages of construction.

10. Outlet from PVC pipe into open channel.

Plate 10.

<u>REFERENCES</u>

1. Timor Island Water Resources Development Study
Volume 8. Groundwater
- CIDA / Crippen International Ltd. June 1980

2. Groundwater Demonstration Plot Pukdale (GDPP)
Monitoring Report No.1 - Definition of Methocology
- Suzanne E. Siskel, December 1985.

3. GDPP Monitoring Report No.2 - Results of baseline socio-economic survey of demonstration plot households.

4. GDPP Monitoring Report No.3 - Process documentation, June 1986.

5. GDPP Monitoring Report No.4 - Results of the re-survey of demonstration plot households, July 1986.

6. GDPP Monitoring Report No.5 - Final Report, July 1986.

7. Technical application methods for groundwater irrigation experimental sites at NTT.
Final Report,
William H. Menninger, March 1987.

IRRIGATION SYSTEM REQUIRING O&M