THE KINGDOM OF THAILAND

DETAILED DESIGN SURVEY REPORT
ON
THE MODEL INFRASTRUCTURE WORKS
FOR
THE DAIRY FARMING DEVELOPMENT PROJECT
IN
THE CENTRAL REGION OF THE KINGDOM OF THAILAND

FEBRUARY 1995

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Japan International Cooperation Agency (JICA), in accordance with the Record of Discussion (R/D) etc. held together with the implementing agencies of the Kingdom of Thailand, has been carrying out technical cooperation for The Dairy Farming Development Project in the Central Region of the Kingdom of Thailand, which is designed to improve conventional dairy farming technology in the Central Region of Thailand and thus contribute to increased production of domestic fresh milk in an attempt to keep step with greater demand levels for milk and dairy products in the said country. The technical cooperation is being implemented in the shape of a 5-year plan which was started on August 1, 1993. As part of this technical cooperation, it was decided to construct some of the facilities, which are necessary for the implementation of the said Project, into Model Infrastructure Works.

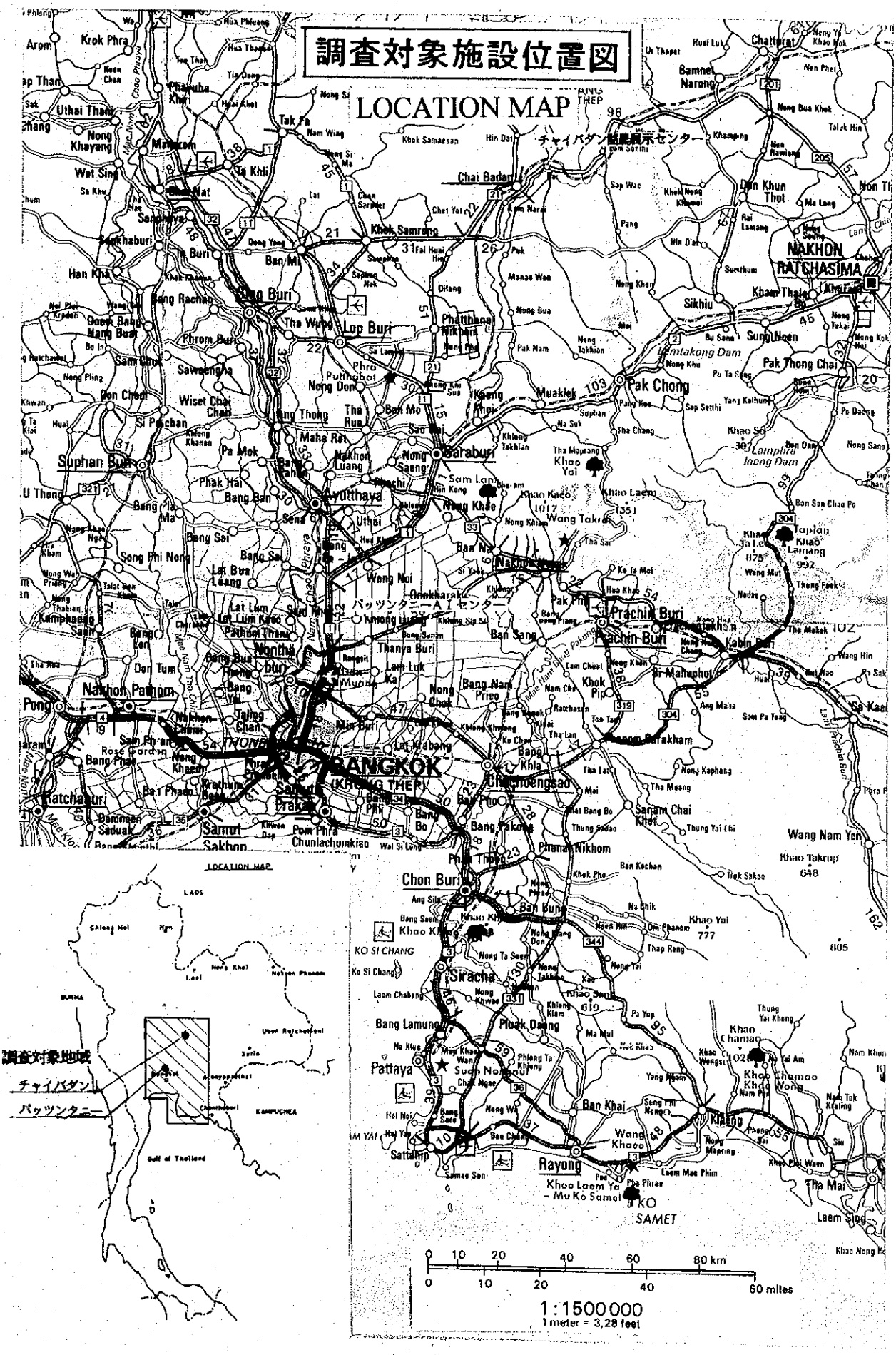
In order to carry out the detailed design for the subject facilities, JICA dispatched a Detailed Design Survey Team headed by Mr. Kazuhiko OIKAWA, the Deputy Director of the JICA Agricultural Development Cooperation Department Planning Division. The Survey Team was in Thailand from November 6 through December 15, 1994 and in that time it conducted the necessary field survey for the Model Infrastructure Works.

This Report is a compilation of the results obtained from the field survey and the subsequent design activities carried out in Japan, and it is hoped that it will serve as a guideline for the implementation of the scheduled Model Infrastructure Works.

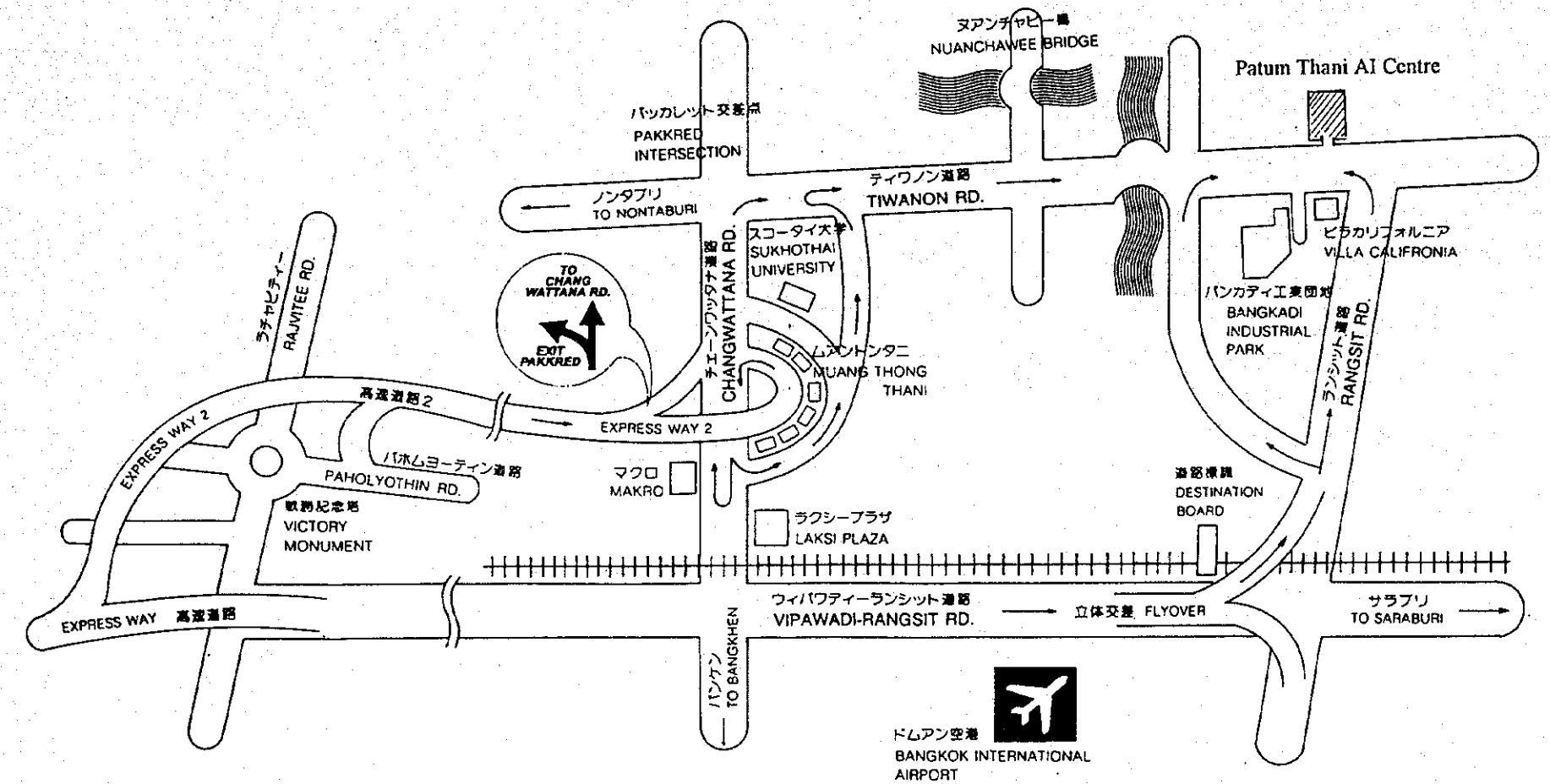
Finally, I would like to express my sincere appreciation to those concerned on both the Japan and Thailand sides for their support and cooperation in the implementation of the Detailed Design Survey.

February, 1995

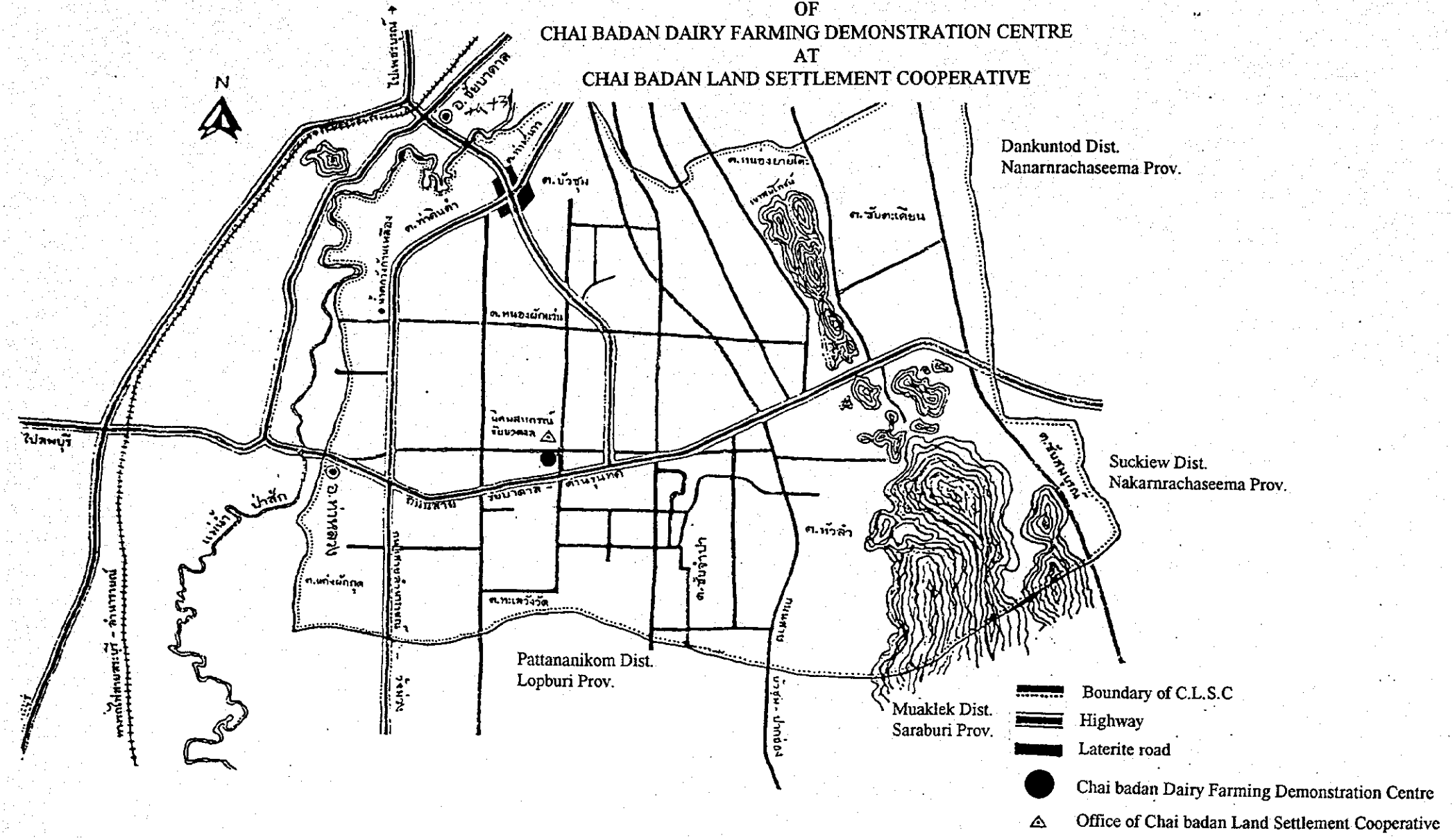
Michiyo ARIKAWA
Director,
Agricultural Development Cooperation Department,
Japan International Cooperation Agency


調査対象施設位置図
LOCATION MAP
チャイバダン観測展示センター
ドンムアン空港
バッツンタニーAIセンター
BANGKOK
(KRUNG THEP)
NAKHON RATCHASIMA
Lamtakong Dam
Lamphra loeng Dam
Khao Laem Ya - Mu Ko Samet
KO SAMET
KO SI CHANG
0 10 20 40 60 80 km
0 10 20 40 60 miles
1:1500000
1 meter = 3.28 feet
LOCATION MAP
LAOS
KAMPUCHEA
Gulf of Thailand
調査対象地域
チャイバダン
バッツンタニー

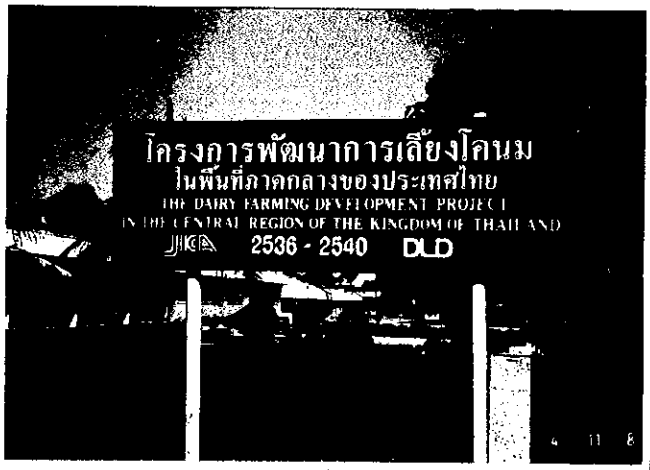
LOCATION MAP
OF
PATHUM THANI AI CENTRE



LOCATION MAP
OF
CHAI BADAN DAIRY FARMING DEMONSTRATION CENTRE
AT
CHAI BADAN LAND SETTLEMENT COOPERATIVE



パッツンタニーＡＩセンター
PATHUM THANI AI CENTRE



センター入口に設けられたプロジェクトのサインボード
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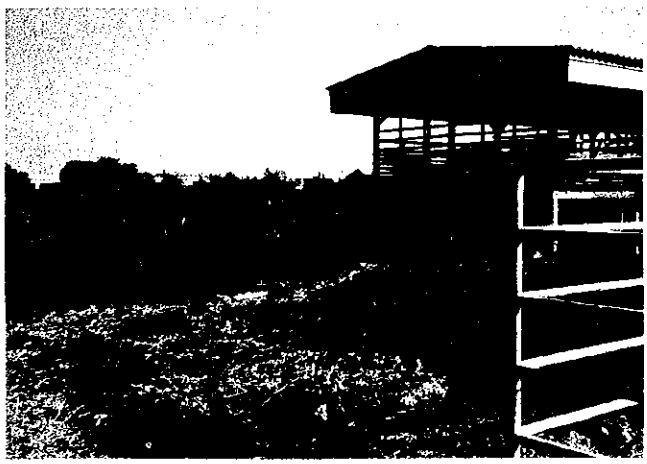

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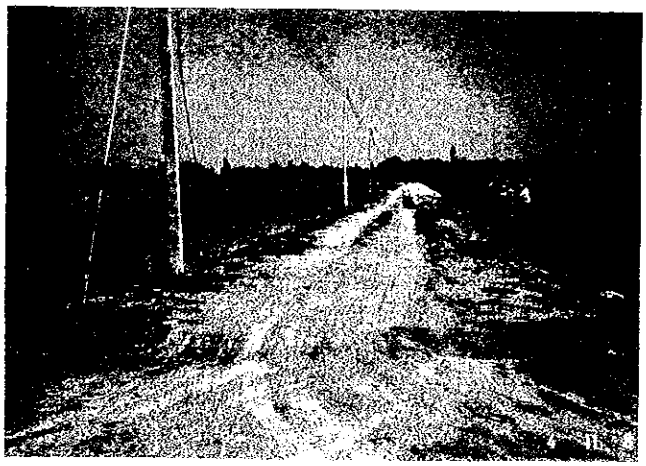
メインゲート（県道）越しに見る幹線道路
ENTRANCE AND MAIN ROAD



幹線道路から見る既設支線・Ｒ２－Ｒｄ．
EXISTING LATERAL ROAD R2

既設支線・Ｌ１－Ｒｄ．越しに見る蓄潦施設用ため池建設予定場所の現況
LAND FOR PROPOSED FARM POND AND LATERAL ROAD L1

MAJOR WORKS TO BE DONE IN THE MODEL INFRASTRUCTURE WORKS

Work Item	Quantity
< Pathum Thani AI Centre >	
1. Water Supply Facilities	
1) Deep Well	1 place
2) Elevated Water Tank	1 No.
3) Water Supply Pipe	116 m
2. Paddock	1 place
3. Manure Deposit Shed	1 No.
4. Road	
1) Approach to Milking Cow Shed	70 m
2) Approach to Semen Collecting Building	44 m
3) Approach to Manure Deposit Shed	148 m
< Chai Badan Dairy Farming Demonstration Centre >	
1. Irrigation Facilities	
1) Deep Well	1 place
2) Farm Pond	1 place
3) Water Distribution Facilities	
Pump for Irrigation	1 unit
Pipe Line (Sprinkler Irrigation System)	690 m
2. Road	
1) Approaches to Major Buildings	180 m (6 nos.)
2) Main Road	294 m
3) Lateral Road Junctions	15 m

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CHAPTER 1 DISPATCH OF THE SURVEY TEAM

1.1 Background and Purpose of the Dispatch

The Government of the Kingdom of Thailand has raised as goals, within the guidelines concerning the promotion of agriculture and cooperative associations of its Seventh National Socioeconomic Development Plan (1992-1996), the overall development of agriculture, which is a key industry in Thailand, the correction of income differentials that exist between industries and regions, and the conservation and development of natural resources. In specific terms, it is aiming to achieve a minimum annual growth rate of 3.4% in the agricultural sector. Agricultural production policy is laying the emphasis on the encouragement of a shift from single crop business, based around the traditional products of corn and rice etc., to the production of more diverse produce such as fruit, livestock and fisheries, more suited to market demand and local resources, in order to promote multiple business.

Concerning the livestock sector in particular, the Government of Thailand is aiming to raise the domestic fresh milk sufficiency rate to 80% by 1997 and promote dairy farming through the implementation of measures designed to increase the number of dairy cattle, improve cattle quality, improve dairy farming technology and expand the financing system etc. As a result of these efforts, it is expected that the number of milking cows in Thailand will rise to 571,000 by 1996 from 278,000 in 1992, and that production of fresh milk will double in volume from 257,000 tons to 500,000 tons over the same period. This will enable the dairy farming industry in Thailand to respond to recent increases in the demand for milk and dairy products.

However despite these efforts, productivity levels of fresh milk remain low and production costs are still high due to technological problems in the areas of reproduction, hygiene and feeding management, insufficient training to farmers and agricultural cooperative and government employees, and also less developed organization of the system for fresh milk collection and transportation. In order to overcome these problem areas, the Government of Thailand is currently implementing dairy farming stimulative measures based on the development and diffusion of dairy farming technology, market development and fresh milk

processing in designated districts located all over the country. In order to promote the smooth implementation of these policies and hasten the achievement of policy targets, the Government of Thailand, in November 1991, requested the Government of Japan's technical cooperation with the implementation of the Dairy Farming Development Project. In response to this request, the Government of Japan instructed JICA to dispatch to Thailand a Preliminary Survey Team in February 1992 and following that, a long term Preliminary Survey Mission from October to December of the same year. The survey mission considered the feasibility of implementation of Technical Cooperation Program, selected potential Project sites, clarified cooperation contents and achievement targets for a five-year period and compiled a temporary framework for effective Project implementation. As a result of this, an Implementation Survey Team was sent to Thailand in March 1993 to sign the Record of Discussion (R/D) and Temporary Schedule for Implementation (TSI), and the 5-year Technical Cooperation Program concerning The Dairy Farming Development Project in the Central Region of the Kingdom of Thailand was commenced on August 1, 1993.

The objectives of Technical Cooperation Program are to improve conventional dairy farming technology in the Central Region of Thailand and carry out training and demonstration of the improved technology. The main areas of cooperation for the Project can be summarized as follows:

1) Improvement of conventional dairy farming technology (artificial insemination, animal reproduction and health, feeding management, and forage crops).
2) Training and demonstration of the improved technology to government officers, technical staff of dairy cooperatives and key farmers.

The Thailand side is implementing construction of training facilities, offices, some cattle sheds and grassland necessary to Project activities, however due to financial constraints, it is unable to provide infrastructure facilities such as farm roads, water supply facilities, paddocks and irrigation facilities. In response to this situation, in order to promote and raise the effectiveness of Project Technical Cooperation, it was decided that the aforementioned related facilities would be provided through Model Infrastructure Works by the Japan side. The Detailed Design Survey Team was sent to Thailand in order to carry out the necessary design for these works.

1.2 Survey Team Members

Name	Assignment	Dispatched Period	Organization/Position
Kazuhiko OIKAWA	Team Leader	FM: 6.11.1994 TO: 13.11.1994	Deputy Director, Planning Div., Agricultural Development Cooperation Dept., JICA
Tsuneo AMANO	Irrigation Facilities	FM: 6.11.1994 TO : 15.12.1994	Overseas Dept., Japan Engineering Consultants Co. Ltd.
Toshiaki SHIMAUCHI	Farm Road	FM: 6.11.1994 TO :15.12.1994	Overseas Dept., Japan Engineering Consultants Co. Ltd.

1.3 Survey Details and Schedule

The Survey Team first made a reconnaissance the two Project sites, discussed the facilities to be constructed, location and scale of the facilities, and their priority rankings with officials from the Thailand implementing agencies and JICA experts, and then confirmed the result of discussions. As the result of the discussions, further detailed site survey were conducted and the necessary date and information were collected. The results of the site survey and the basic plan made through a series of discussions with officials concerned were compiled into a Field Report. The basic policy and the basic plan were brought back to Japan by the Team for the detailed design to be subsequently conducted.

The schedule of the field survey conducted by the Team is as shown in Table 1.3.1.

Table 1.3.1 Schedule for the Field Survey

Date/Day	Place	Schedule
Nov. 06/Sun	-	Arrived at Bangkok(BKK) from Japan
07/Mon	BKK	Courtesy call on DTEC, CPD, JICA & Embassy of Japan, Move to Chai Badan(C.B.)
08/Tue	C.B.	Field reconnaissance at C.B. Demonstration Centre, Meeting with JICA experts and CPD, Move to BKK
09/Wed	BKK	Field reconnaissance and discussion at Pathum Thani AI Centre
10/Thu	BKK	Collecting information from similar projects, Preparation of survey
11/Fri	BKK	Joint meeting among DLD, CPD, JICA experts and the survey team, Issuance of Team Leader's letter
12/Sat	BKK	Internal Meeting
13/Sun	BKK	Team leader left for Japan, Preparation of the field survey
14/Mon	BKK	Reconnaissance survey, Alignment of farm road, Site clearance, Water quality test and Data collection at AI Centre
15/Tue	BKK	Survey at AI Centre
16/Wed	BKK	- ditto -
17/Thu	BKK	- ditto -
18/Fri	BKK	Survey at AI Centre, Collection of data and information at CPD
19/Sat	BKK	Computation of the survey
20/Sun	BKK	Computation, plotting and drafting
21/Mon	BKK	Preparation of soil test and survey for C.B. Demonstration Centre, Discussion with JICA expert, Move to C.B.
22/Tue	C.B.	Survey at C.B. Demonstration Centre
23/Wed	C.B.	- ditto -
24/Thu	C.B.	- ditto -
25/Fri	C.B.	- ditto - , Soil sampling, Collecting deep well data

Nov. 26/Sat	C.B.	Survey at C.B. Demonstration Centre, Making irrigation plan
27/Sun	C.B.	Computation of the survey, Making irrigation plan
28/Mon	C.B.	Survey at C.B. Demonstration Centre
29/Tue	C.B.	Data collection, Move to BKK,
	BKK	Discussion with JICA experts at AI Centre
30/Wed	BKK	Computation, plotting and drafting at CPD
Dec. 01/Thu	BKK	Preliminary design of roads and irrigation facilities at CPD, Discussion with JICA experts at AI Centre
02/Fri	BKK	Preliminary design of roads and making detailed layout plan for paddock and manure deposit shed
03/Sat	BKK	Preliminary design
04/Sun	BKK	Preliminary design
05/Mon	BKK	Preliminary design, Data collection
06/Tue	BKK	- ditto -
07/Wed	BKK	Complemental survey at AI Centre, Discussion with JICA experts, Data collection
08/Thu	BKK	Preliminary design
09/Fri	BKK	- ditto - , Data collection
10/Sat	BKK	- ditto -
11/Sun	BKK	Preparation of Field Report
12/Mon	BKK	Preparation of Field Report
13/Tue	BKK	Meeting with JICA experts, Report to CPD
14/Wed	BKK	Report to DLD and JICA
15/Thu	-	Leave for Japan

1.4 Visited Agencies and Concerned Persons

(1) Department of Technical and Economic Cooperation (DTEC)

Mr. Wichai Choowisetsuk	Japan Sub-Division
Mr. Michimasa Numata	Aid Coordinator/JICA Expert

(2) Department of Livestock Development (DLD)

Mr. Yant Sukwongs	Director of Pathum Thani AI Research Centre
Dr. Parishat Sakhato	Acting Director of A-I Div.

Ms. Kalaya Kengrikkum	Veterinarian 7
Ms. Jreerat Sanpote	Animal Scientist 6
Mr. Viboon Yiengvisavakul	Veterinarian 7
Ms. Mukda Ratanapaskorn	Veterinarian 7
Ms. Rapiphan Uavechanichkul	Veterinarian 7
Mr. Vichai Chanatinart	Chief of Frozen Semen Production Sec., Pathum Thani AI Centre

(3) Cooperatives Promotion Department (CPD)

Mr. Vichien Tongsima	Director of Agricultural Co-op. Div.
Ms. Boonna Tiragool	Senior Officer, Dairy Co-op. Promotion Sec., Agricultural Co-op. Div.
Ms. Kanitta Promsamak	Co-op. Technician
Ms. Piyarat Faiuppara	Co-op. Technician
Mr. Kriangkrai Krutthai	Co-op. Technician
Ms. Rachaneewan Pratomthong	Chief of Special Project Sec., Planning Div.
Mr. Wichen Tanthammaroj	Senior Policy and Plan Analysis
Mr. Charas Woodieha	Senior Officer
Mr. Kanokpol Phothong	Civil Engineer
Mr. Komol Sur-sa-ngiam	Mechanical Engineer
Mr. Somnuek Phongphuth	Civil Engineer

(4) Embassy of Japan (EOJ)

Mr. Ryuji Shimojo	First Secretary

(5) JICA Thailand Office

Mr. Shinichiro Omote	Resident Representative
Mr. Naoto Hattori	Asst. Resident Representative

(6) JICA Expert/LWCC Project

Mr. Yasuhiko Mishima	Team Leader
Mr. Yoshinori Takahashi	Coordinator

(7) JICA Expert/IEC Project

Mr. Kiyoshi Horii	Team Leader
Mr. Masafumi Taguchi	Coordinator/Irrigation Engineer

(8) Colombo Plan JICA Expert

Mr. Kosho Daigo	Planning Div., Land Development Dept.
Mr. Mitsuo Sayama	Geotechnical Div., Royal Irrigation Dept.

(9) JICA Expert/DFD Project

Mr. Kazuo Kanaya	Team Leader
Mr. Yosihiro Shimizu	Coordinator
Mr. Seijun Kikuchi	Forage Corp., Grassland Management
Mr. Teruo Sato	Animal Reproduction and Health
Mr. Atsushi Suzuki	Animal Feeding and Management
Mr. Haruaki Uetsuki	Breeding Livestock

CHAPTER 2 PRESENT CONDITION AND BASIC PLAN

2.1 Pathum Thani AI Center

2.1.1 Outline

The Pathum Thani AI Center is located in the Bang ka Dee Sub-district, Muang District in the southern part of Pathum Thani City in Pathum Thani Province, which is to the immediate north of Bangkok. It is roughly 35 km from the center of Bangkok and can be reached by car in around one hour by taking Highway 2 and driving along the Tiwanon Road for about 6 km at which point the Center can be found on the left side. The Center was established in 1976 and it contains an A/I (artificial insemination) main building, E/T (embryo transfer) building, semen processing building, research building, training building, hay storages, dormitory, officer's houses, worker's houses, garages, sheds and pasture (roughly 8 ha) etc. within a site area of some 16 ha (see Fig. 2.1.1).

At the time of the Center's establishment, the surrounding marshlands had yet to undergo any major development. In recent years however, this land has been dramatically transformed into a new residential and industrial area. Facing the Center is a high income residential estate (the California Village where one JICA expert is currently living), and next to that is a large scale modern industrial estate (the Bang ka Dee Industrial Park).

The Pathum Thani AI Center acts as the central facility among the other AI centers located in nine administrative areas within Thailand, and it is directly run by the AI Division of the Department of Livestock Development (DLD). As well as being a production and supply base of frozen semen, the Center is also responsible for carrying out various research work into AI, the determination of diseases in livestock reproduction, offspring examinations and training and education of AI and ET techniques.

The Team for the Technical Cooperation Program has been granted part of the Center's facilities to use as an office and a laboratory, and has started its activities. Moreover, some of the Project facilities (milking cow shed and hay storage for 30 cows) have been newly

built and other facilities such as a training building and dormitory are scheduled for construction under the national budget of Thailand.

As well as the above mentioned facilities, establishment of water supply facilities (deep well, elevated water tank and water supply pipes) for the new milking cow shed, construction of a new paddock and a manure deposit shed for the 30 cows, and construction and improvement of the farm road to the pasture and approach roads to the main facilities are all urgently required for the Project. However, because financial constraints make the construction and improvement of all these facilities by the Thailand side alone extremely difficult, it has been decided to implement the works with grant aid (to cover the cost of the model infrastructure works) provided by the Government of Japan.

As well as the problems caused by the delay in construction and rehabilitation of the above mentioned facilities, the AI Center is also faced with constant shortages of electric power and drinking water, and also the threat of flooding in the rainy season due to the fact that it is located on low ground. The annual inundation of the Center's pasture is a particularly serious problem.

In its discussions with the JICA experts and Project officials from the Thailand side, the Detailed Design Survey Team confirmed the facilities to be made the subject of the model infrastructure works and also clarified the order of priority for each facility to be constructed. Those results, which provided the guidelines for the Detailed Design Survey implementation, are summarized in Table 2.1.1.

Table 2.1.1 Priority Order of the Facilities to be constructed in the Model Infrastructure Works at Pathum Thani AI Center

Priority	Facilities and Work Content
1	- Water supply facilities (deep well, elevated water tank and water supply pipes) for the new milking cow shed (for 30 cows) and the paddock.
1	- Paddock (partially concrete paved and roofed).
1	- Approach to milking cow shed (L1): paved, 4 m paving width.
2	- Approach to bull shed of semen processing building (R4): paved, 2.5 m paving width.
3	- Manure deposit shed.
3	- Approach to manure deposit shed (R9): laterite, 5 m wide.
4	- Approach to hay storage (R10): laterite, 5 m wide.
5	- Farm road to pasture: laterite, 5 m wide..

The water supply facilities, the approach to the milking cow shed and paddock, and the approach to the hay storage and manure deposit shed are predominantly needed for the Project activities of animal feeding and management, feeding, general management of milking cows, suckling, weaning and raising of calves, and milk quality control and improved technology trial experiment and demonstration. The approach to the bull shed of semen processing building will contribute to improvement of the frozen semen production process and also semen collecting and processing. The farm road will be predominantly used to aid forage crop and pasture management activities, although the section of it leading up to the manure deposit shed will also be used as the approach to the hay storage and as a connection between these two and other neighboring facilities.

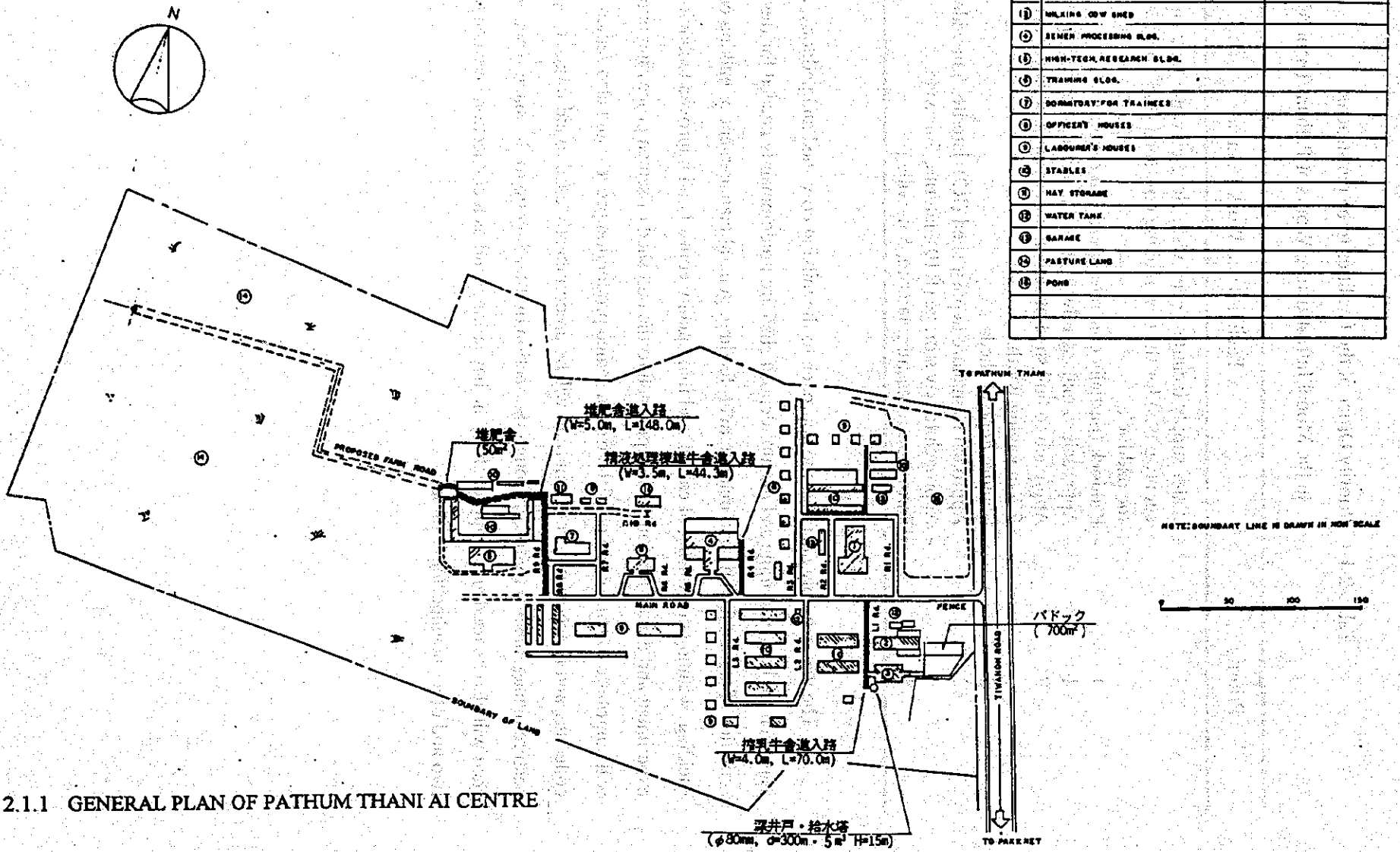


Fig. 2.1.1 GENERAL PLAN OF PATHUM THANI AI CENTRE

2.1.2 Roads

On the eastern edge of the center is a gate which faces the public Tiwanon Road from which a straight paved road of some 300 m runs westward. This road acts as the main arterial road within the Center site. A number of minor roads branch off from the main road on both sides (north and south) and it is these branch roads which connect the Center's various facilities (offices, research buildings, training building, dormitory and cow sheds etc.).

The site survey found that the main road and branch roads within the site consist of a standard specification of asphalt low cost pavement (4 m wide). The branch roads leading to older facilities such as the offices, cow sheds, officer's houses and worker's houses are paved according to this specification, however the approaches leading to more remote areas and recently constructed facilities are unpaved. These unpaved roads are covered with a layer of gravel or sandy soil, however because this layer is not thick enough, the said roads turn into mud tracks during the rainy season, creating problems in terms of cattle movement and tractor work. This problem could be solved by simply laying additional gravel or sand, however as is the case with the newly constructed hay storage (to store hay for the 30 milking cows scheduled to enter the new cow shed), although the facility building is complete, access by vehicle is impossible due to the fact that no approach has been provided, which makes actual use of the facility extremely difficult. The order of priority for those facilities subject to the Model Infrastructure Works in the Center was shown in Table 2.1.1.

Actual site survey work confirmed that a sum of roughly 620 m of road required is in need of construction and improvement. The results of the survey are shown in Table 2.1.2.

Incidentally, each road within the Center complex is to be given a name in the Detailed Design Survey for the sake of convenience (see Fig 2.1.1). The road names decided upon are as follows:

Arterial road : MAIN ROAD,
Branch roads : L1, L2, L3, R1, R2, R3, R4, R5, R6, R7, R8, R9, R10 Rd.
Farm Road : FARM ROAD.

Table 2.1.2 Lengths of Roads in the Pathum Thani AI Center

Unit: m

Road Name	Priority	Surveyed Length	Work Length Pavement	Laterite	Remarks
Main Road	*	313.2	0	0	
L1 Rd.	(1)	63.2	70.0	0	Paved width: 4m
R4 Rd.	(2)	46.3	44.3	0	Paved width: 2.5m
Approach to manure shed	(3)	150.0	0	148.0	Width: 5m
R9 Rd. (Farm road)	(5)	272.8	0	273.9	Width: 5m
R10 Rd.	(4)	97.4	0	81.0	Width: 5m
Total		939.9	114.3	502.9	

(Note) ET building: Embryo Transfer Building

The following sections proceed to describe the present condition of each road and the improvement and construction plan devised for each.

(1) Approach to the New Milking Cow Shed (L1 Rd.)

The main purpose of this road will be to allow access to the new milking cow shed, however as well as this, it will also be used for coming and going to the deep well and elevated water tank to be built as part of the Model Infrastructure Works, and also to enable access to the existing ET laboratory lying next to the new cow shed, and the existing cow sheds located on the other side of the road.

This road has lost its top layer of low cost pavement asphalt pavement due to erosion leaving the sub-grade crushed stone exposed, however the road itself was not found to be suffering from deflection.

Paving work on the road shall thus consist of a refill of course base material (crushed stone), and over this a layer of hot mixed asphalt surface course shall be provided (manual

spreading and rolled compaction). Concerning the section from the new cow shed entrance to those areas beyond, the road bed shall be partially replaced due to its weakness.

(2) Approach to the Bull Shed of Semen Processing Building (R4 Rd.)

Because this approach turns into a mud track during the rainy season, bulls being taken to the semen processing building for semen collection become covered in mud and this adversely affects hygiene control in the semen collection process. Because the Center is aiming to make qualitative improvements to its AI technology, this is a problem which cannot be ignored if related activities are going to be advanced. For this reason, improvement of this approach has been given a high priority ranking.

Because the road bed of the approach is weak, this shall be partially replaced and following that, one layer of hot mixed asphalt surface course is to be laid. The surface work shall be the same as that mentioned in (1).

The paving methods that can be considered in both (1) and (2) are either the hot mixed asphalt method or the asphalt penetration macadam method, however for the following reasons, the hot mixed asphalt method is planned for adoption in the surface work.

1. The service life of hot mixed asphalt method laid pavement is much longer than that of pavement laid with the asphalt penetration macadam method and it is also more resistant to heavy rain. This reduces the need for maintenance and repair work after road completion.
2. Due to the proximity of the site to the capital Bangkok, procurement of the necessary pavement materials is easy.
3. The planned pavement area is small at 400 sq.m, which means that the difference in construction costs between the two methods will not exert great influence on the total construction cost.

(3) Approach to the Manure Deposit Shed (R9 Rd.)

Due to the fact that manure from the manure shed is used on the pasture, it was decided to locate the shed at the north-western edge of the facilities complex closest to the pasture area. For this reason, utilization of part of the farm road as the approach came to be settled. As a result, as mentioned previously, it has been decided to use the section of the farm road leading to the pasture as the approach to the manure shed (see Fig. 2.1.1).

Only a minor part of the approach to the manure shed starting from the begging point is firmly laid with gravel and sandy soil, however almost all of the remaining section lies upon extremely weak foundation. When the Survey Team visited the Center in November, it was the dry season and the foundation of the approach was so dry that team members observed areas of cracking. However, the hard soil is barely 20 cm thick, and based upon the results of a ground bearing capacity test using a cone-penetrometer, it is surmised that below that lies humus soil and clay containing a high moisture ratio.

Considering the extreme weakness of this ground, it is considered that rather than making the situation worse by treating the surface of the foundation, it would be more effective to limit the surface treatment to manual stripping and then lay good quality soil and after allowing that to settle, work the road into its final form. Consequently, this section of road is to undergo banking with good quality material (which needs to be brought in from outside because such material cannot be obtained within the Center complex). Regarding the firm section near the beginning point, levelling material shall be supplemented and surface finishing shall be carried out.

(4) Approach to the New Hay Storage (R10 Rd.)

There is currently no approach to the new hay storage, making access by vehicle impossible. Construction of such an approach is required as soon as possible in order to facilitate feeding management for the milking cows.

This approach shall branch right (southward) from the farm road at a point just before the existing hay storage and lead to the new hay storage and bull shed. The foundation for this road is also very weak and so as with the approach to the manure deposit shed, execution shall avoid disturbing the foundation and involve banking with good quality material.

(5) Farm Road to the Pasture

The Center possesses some 8 ha of pasture land to the rear (west) of the facilities complex, however there is no prepared farm road leading to it and because this land was originally a marsh, it becomes inundated and inaccessible during the rainy season. This means that proper field management cannot be implemented and that sufficient pasturing results cannot be achieved. Assuming that one of the AI Center's objectives is to make the pasture accessible all year round and to cultivate enough pasture to feed its cattle based upon proper field management, preparation of the farm road to the pasture is indispensable.

This road is the section of road leading from the manure deposit shed to the pasture, however because the ground in the pasture is around 1 m lower than in the facilities complex, it is very weak. However, track marks within the pasture, formed by tractors during the dry season form a route which would prove to be excellent functionally as a farm road and so this route has been selected for the proposed farm road. Because the foundation is extremely weak, as the case with the approach to the manure deposit shed and the approach to the new hay storage, disturbance of the foundation is to be avoided as much as possible and execution shall consist of banking with good quality soil. Moreover, execution with bulldozers and soil compactors is to be considered and the good quality material is to laid at a spreading depth of at least some 50 cm.

2.1.3 Water Supply Facilities

The existing water supply facilities within the AI Center consist of a pond and a deep well (ϕ150 mm, 276 m deep) which act as water sources, and a pipeline system that includes an elevated water tank (H = 15 m, V = 50 m3). The deep well is normally used to provide the Center's water, however during the dry season when demand increases and the well's pump

head falls, water is also pumped from the pond and used jointly with the well water. Despite this, the use of a large quantity of water at one time to clean the cattle and cow sheds etc. during the dry season often leads to suspension of the water supply. Added to the absolute shortages of water, there are also problems regarding the quality of water. In particular, water from the pond is bacteria ridden. The Center is planning to provide water for experiments and employee living purposes from the public water mains, however this has yet to materialize.

Bearing the above mentioned situation in mind, it was judged that it would be impossible to provide water for the 30 new milking cows from existing facilities, and so construction of a new deep well has been planned. Incidentally, tests carried out on water from the existing deep well showed it to have an electric conductivity of 700 μ/cm, confirming it as being high in salt concentration.

According to the date collected and information gathered from interviews with various people in the area, it was found that the new large scale industrial park located next to the Center obtains its water from deep wells dug to a depth of 300 m or more and that geologically speaking, alternating stratum of clay and sand continue for a depth of 300 m from the surface. A survey of water taken from one of those wells showed it to have an electric conductivity of 300 μ/cm and be of better quality than the water taken from the Center's well.

In consideration of economic and execution viability factors, the proposed water supply facilities (deep well and elevated water tank) shall be constructed on land adjoining the new milking cow shed to the south-west. The drilling depth of the deep well has been roughly set at 300 m in view of the situation regarding the Center's existing well and surrounding wells.

The new elevated water tank is to be the conventional champagne glass-type, which is advantageous in terms of execution, maintenance and appearance, and is widely used throughout Thailand. Tank capacity shall be determined based upon consideration of the electricity situation at the Center (frequent power cuts) as well as the usual deciding factors. Regarding the height of the elevated tank, it is to be set in relation to that of the existing

elevated water tank in consideration of the possibility that it may be connected to the existing pipeline system in the future.

The destinations of the new water supply are to be the new milking cow shed and paddock, however diversion to the existing RC water tank provided on the ground shall also be made possible in the hope of improving the quality of water used in research experiments currently taking place.

2.1.4 Related Facilities

(1) Paddock

The existing cow sheds are provided with adjacent paddocks to allow the animals to exercise. The new milking cow shed (for 30 cows) does not as yet have a paddock, although land for this has been secured in an adjoining area (on the public road side).

The proposed paddock is be partially paved and partially unpaved, and partly covered by a simple roof. A drainage conduit is to be provided for hygiene purposes and the fence surrounding the paddock shall be made of the same material (GSP) as that used for the cow shed fence. Feeding and drinking facilities are to be provided in the paddock.

(2) Manure Deposit Shed

The AI Center currently possesses no manure deposit shed. Manure from the cow sheds is indiscriminately disposed of around the complex, which can hardly be described as a desirable situation in terms of general hygiene. The establishment of a manure deposit shed has thus been planned under the Project for the above reason and for the purpose of carrying out trial experiment and demonstration of feeding and management of the new milking cows. In consideration of the nature of the manure deposit shed and convenience of use, it is to be located on the boundary of the research facilities site and pasture, facing the planned farm road. Its size shall be sufficient to handle the manure produced by the 30 milking cows and it shall be of rectangular shape with large frontage.

The walls shall be concrete and the roof slate. There will be a gap between the roof and walls, however long eaves shall be provided in order to prevent rain from blowing in. Manure shall be carried in and out of the shed by tractor-pulled trailer and a concrete floor shall be provided to the front of the shed to allow dumping of manure. Care shall also be taken to ensure that there is enough turning room for tractor and trailer.

2.2 Chai Badan Dairy Farming Demonstration Center

2.2.1 Outline

The Chai Badan Dairy Farming Demonstration Center (herein referred to as the Dairy Farming Demonstration Center) is located in Tha-Luang District, Lopburi Province some 200 km to the north of Bangkok. It is currently under construction on the site of the Chai Badan Land Settlement Cooperative Unit. The nearest town is Lamnarai located around 20 km north of the Dairy Farming Demonstration Center.

The land here is situated some 15 km from the left bank (eastern side) of the Pasak River and is a hilly region at an altitude of around 130 m and with a gradient of about 1/500. The annual average rainfall of 1,070 mm (1985-1994) is less than that of Bangkok and 40% of this rainfall is concentrated over the months of August and September.

The Chai Badan Land Settlement Cooperative Unit is a new dairy farming area. The land area per farm is relatively large at 50 rai (about 8 ha) and the farmers use their pasture for grazing and cutting forage crops such as fresh hay and grain-sorghum, which is fed to the livestock. Although the reclamation of new pasture is taking place here, little knowledge of pasture cultivation means that cultivation techniques are limited to the simple scattering of manure and that farmers only use the natural growing pasture for grazing and cutting purposes. Although interest in forage crops is increasing as can be seen with the appearance of farmers who keep pasture non-harvested for the dry season and who use sorghum as fodder, the basic trend of harvesting all pasture for use as feeding hay shows that cultivation and adjustment technology is sparse. Moreover, in the paddy areas of the Central Region of Thailand, field areas are small and pasture is insufficient, which means that the utilization of farm and food processing industry by-products is absolutely vital in order to establish a fodder production and supply system suited to the needs of the area.

For this reason, the Dairy Farming Demonstration Center is carrying out improvements into mainly forage crop production, storage and utilization technology, and also developing

technologies for the storage and utilization of farm by-products, which are an important source of fodder.

The land of the Dairy Farming Demonstration Center is managed by the CPD Land Settlement Cooperative Division. It covers an area of some 25 ha and is adjacent to the Tha-Luang Dairy Cooperative Office. The CPD Land Settlement Cooperative Office is also nearby. This land was previously covered by eucalyptus forest, which is the raw material for charcoal, however the CPD is currently reclaiming this land by cutting down the trees in order to create land for pasture and facilities. As well as this, local contractors are carrying out building works and electric works in the land. This contracted work is ordered not by the CPD but by the Province due to the fact that it is included as an item in the national budget.

The facilities currently scheduled for construction at the Dairy Farming Demonstration Center are a milking cow shed for 10 cows, a shed for addition of milking cows, a research laboratory, a hay storage, a research building, an agricultural machinery store, offices, a lecture hall, officer's houses, worker's houses, pasture irrigation facilities and in-site roads etc. (see Fig. 2.2.1).

Of the above facilities, financial restraints on the Thailand side mean that it is unable to execute the work on the irrigation facilities (deep well, farm pond and pipeline), the paving of existing roads and the construction of new roads. It has thus been scheduled to implement this work with grant aid (to cover the cost of model infrastructure works) provided by the Government of Japan.

As in the case of the AI Center, the Detailed Design Survey Team held discussions with the JICA experts and those concerned with the Project on the Thailand side in order to confirm which facilities would be made eligible for model infrastructure works and to clarify the order of priority for each works area. The agreed contents, according to which the Detailed Design Survey was executed, are shown in Table 2.2.1. For the sake of convenience, the subject roads within the Dairy Farming Development Center have been given the following simple names (see Fig. 2.2.1) as the case with the roads of the AI Center:

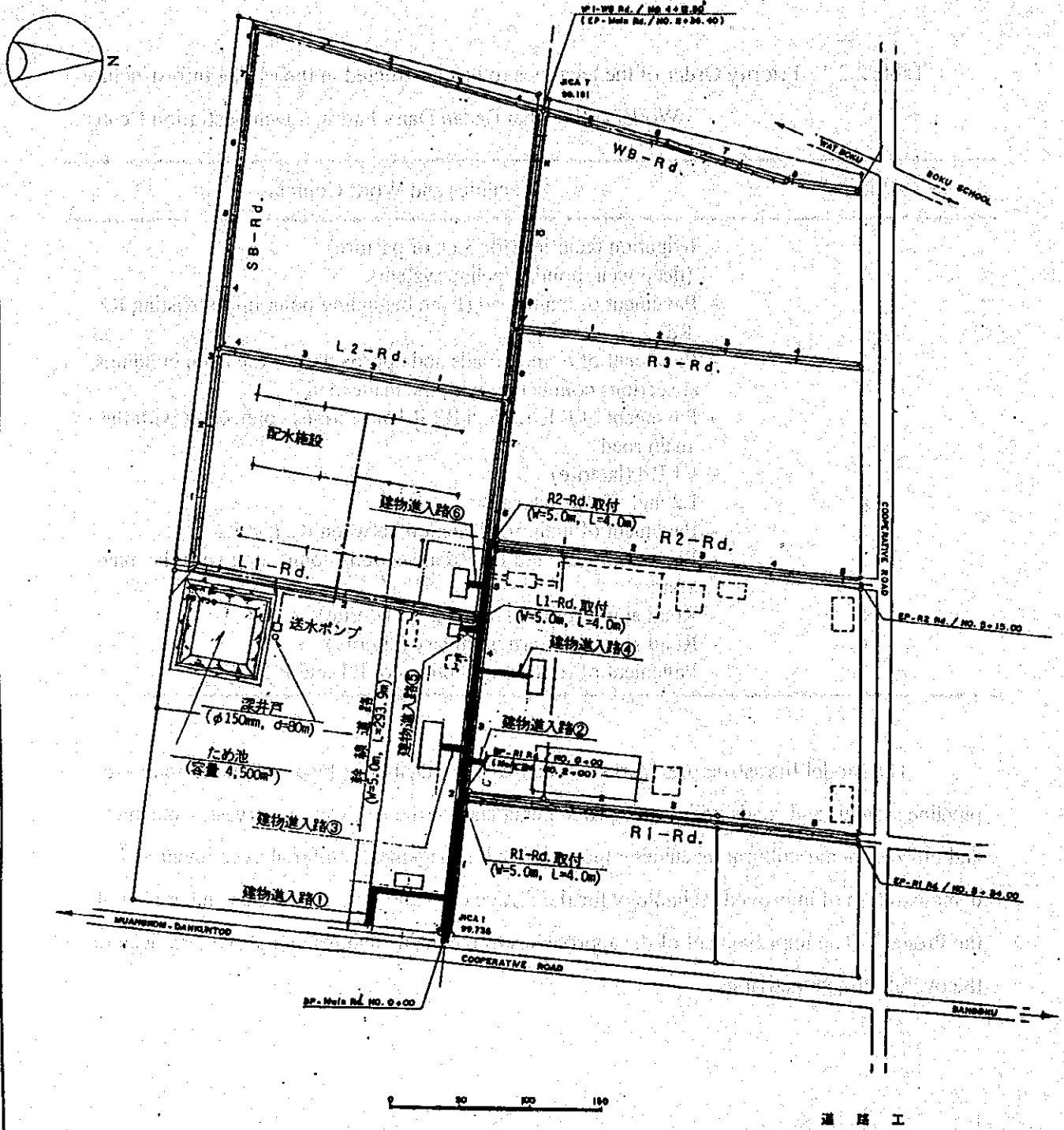
Arterial road : MAIN ROAD,

Branch roads : L1, L2, R1, R2, R3, SB, WB Rd.

Table 2.2.1 Priority Order of the Facilities to be constructed in the Model Infrastructure Works at the Chai Badan Dairy Farming Demonstration Center

Priority	Facilities and Work Content
1	- Irrigation facilities (for 3 ha of pasture) (deep well, pond, pipeline system)
2	- Pavement of main road (from beginning point up to existing R2 Rd)
2	- Pavement of branch roads and approaches to the main buildings, at sections connecting with the main road
2	- Pavement of R1, L1 and R2 Rd at sections connecting with the main road
3	- L1 Rd (laterite)
4	- L2 and R2 Rd(laterite)
5	- Pavement of main road section between R2 and L2
5	- Pavement o L2 and R3 Rd at sections connecting with the main road
6	- Road along southern boundary (laterite)
6	- Road along western boundary (laterite)
7	- Pavement of remaining sections of R1 and R2 Rd

The Model Infrastructure Works on the irrigation facilities (deep well, farm pond and pipeline system) and roads will mainly prove beneficial for the cultivation, harvest, adjustment and utilization, agricultural machinery operation and management, and trial experiment and demonstration of improved technology for the forage crop and grassland management area of the Project. The improvement of the approaches to the main facilities will prove beneficial to the overall Project activities.



道 路 工

番号	建物名称	道路延長	備 考
	幹線道路	293.9	ｱｽﾌｧﾙﾄ舗装 W= 5.0m
	支線道路取付	15.0	ｱｽﾌｧﾙﾄ舗装 W= 4.0m
①	事務所棟	90.0	ｱｽﾌｧﾙﾄ舗装 W= 4.0m
②	搾乳牛舎	11.0	〃
③	研修棟	16.0	〃
④	乾草収納庫	36.0	〃
⑤	専門家宿舎	15.0	〃
⑥	農器具倉庫	12.0	〃
小計		180.0	
計		468.9	

Fig. 2.2.1 GENERAL PLAN OF CHAI BADAN DAIRY FARMING DEMONSTRATION CENTRE

2.2.2 Roads

As can be seen from Figure 2.2.1, a 6 m wide road from the main entrance of the Dairy Farming Demonstration Center facing the provincial road runs straight from east to west for roughly 600 m almost through the middle of the Center. This road acts as the Center's arterial road. The main road has existing 3 branch roads, one is running south (left) and two are running north (right). These roads are partly laid with laterite, however they are all unpaved gravel roads. There is one more 3 m wide gravel road in the forage crop test cultivation fields which is located on the right of the entrance of the Centre, however this has not been made a subject for the Model Infrastructure Works. These are the only roads that exist within the complex and all other proposed roads are those which are to be newly constructed.

Land reclamation of the field on the northern side of the main road had already been completed and pasture was being cultivated under the guidance of the JICA experts at the field, while on the southern side block was under reclaiming work at the end of November 1994.

Surveying of the Project roads found that a total length of some 2,680 m was in need of improvement and new construction. The breakdown of the survey results are shown in Table 2.2.2.

Table 2.2.2 Lengths of Roads in Chai Badan Dairy Farming Demonstration Center

Unit: m

Road Name	Priority	Surveyed Length	Work Length Pavement	Laterite	Remarks
Main Road	(1)	586.4	446.6	0	Paved width: 5m
Facilities approaches	(1)	188.7	180.0	0	Paved width: 4m
R1 Rd.	(6)	284.7	282.9	0	Paved width: 4m
L1 Rd.	(3)	210.2	5.0	205.2	Laterite, total width: 5 m
R2 Rd.	(6)	265.0	263.6	0	Paved width: 4m
L2 Rd.	(3)	210.5	5.0	205.5	Laterite, total width: 5 m
R3 Rd.	(3)	248.0	5.0	240.5	Laterite, total width: 5 m
SB Rd.	(5)	384.5	0	384.5	Laterite, total width: 5 m
WB Rd.	(5)	447.5	0	449.4	Laterite, total width: 5 m
Total		2,825.5	1,188.1	1,485.1	

The following sections describe the basic plan for the detailed design of each of the roads within the Dairy Farming Demonstration Center.

(1) Main Road and Existing Branch Roads

Discussions with officials from the Thailand side revealed that the main road and branch roads R1 and R2 are scheduled for raising with laterite (50 cm on average) under the national budget for 1994/95. The planned road works are thus to be executed upon the assumption that this will take place. Pavement thickness shall be decided based upon the results of laboratory CBR tests on the banking material (laterite) to be used in the raising work.

(2) Other Branch Roads

Excluding the existing branch road L1, all the others (L2, R3, SB and WB) are to be newly constructed through laterite banking. Ground conditions may differ slightly according to section, however there are no major differences and each road shall be planned under equal conditions. Surveying of the existing L1 Rd revealed that its foundation is some 20 cm higher than that of the other branch roads and it was judged that the ground bearing capacity should

also be comparatively higher. The design for this road shall thus differ from the other road plans in terms of banking thickness.

2.2.3 Irrigation Facilities

Because the Dairy Farming Demonstration Center is still under construction, it does not yet have any irrigation facilities. Moreover, there is no farmland equipped with irrigation facilities in the surrounding area either.

An important requirement of the Detailed Design Survey is the design of irrigation facilities for a 3 ha field (pasture) to be used in order to contribute to trial experiments and demonstration of forage crop cultivation management in the Chai Badan Dairy Farming Demonstration Center, which is a major Project activity.

The first issue to consider concerning irrigation facilities is the source water, however the Center and surrounding area do not possess any surface water resources that could be utilized for irrigation purposes. Rainfall during the rainy season in this area amounts to around 1,000 mm, which means that the digging of ponds to save this rainfall for irrigation use during the dry season is a possibility. However, considering the facts that rainfall during the rainy season often doesn't reach 1,000 mm and that the Project activities need to be executed within a limited time, it is felt that the utilization of ground water as a water source, as has already been planned for the Project, is a more viable alternative.

There are a number of deep wells around the Center that are drawing on ground water, so it is judged that it would be possible to obtain water in this way. However, there are no large size wells and judging from the information gathered, there is a major concern that although some water can be obtained, it may not prove to be enough for irrigation purposes.

It is therefore necessary to add a pond to the Center's irrigation system in order to make up any differences that may arise between obtained well water and the irrigation water requirement. In order to prevent extreme water seepage loss during the dry season, the hopes

of Project officials are to be met by fully lining the pond in the same way as at the farm pond provided by Japanese aid in the Phraphuthabat Field Crop Experiment Station which is not far from the Dairy Farming Demonstration Center.

The next design issue that has to be settled is the type of irrigation system to be selected. Irrigation systems are basically separated into spray irrigation, surface irrigation and below surface irrigation. Following the decision of irrigation system, the type of irrigation needs to be chosen. Irrigation type can be selected from either the sprinkler method, the surface method, trickle irrigation or the below surface method. Selection of the optimum type for the fields in question requires careful consideration of field conditions, soil conditions, types of crops to be cultivated, labor conditions and economic viability.

As was mentioned earlier, the main objective of the Project facilities is demonstration of forage crop and grassland management, and so the sprinkler method that has already been planned by the JICA forage crop experts and CPD officials, who are leading the demonstration activities, is to be the type adopted for the purposes of the detailed design survey. The sprinkler system shall consist of a pumping unit, an underground main pipe unit and lateral pipe unit and portable rotary rain gun type sprinklers.

The irrigation facilities (system) to be constructed in the Model Infrastructure Works can thus be summarized in the following manner:

Deep well with submergible pump →Farm pond →Water distribution pump →
Pipeline → Sprinklers.

CHAPTER 3 DETAILED DESIGN

Since the Model Infrastructure Works should be implemented within the limit of the budget, it is uncertain that all proposed facilities can be constructed in the Works without cost estimate for the construction works. In this survey, therefore, it was decided that detailed design of all proposed facilities would be carried out and after that selection of facilities to be constructed in the Woks would be done in accordance with the priority given and the construction costs estimated in the detailed design.

3.1 Facilities in Pathum Thani AI Center

(1) Approaches to the Milking Cow Shed and Bull Shed of Semen Processing Building

It is desired that work on the approach to the new milking cow shed (L1 Rd.) and that to the bull shed of semen processing building (R4 Rd.) be given top priority among the road works in the AI Center. These two roads are interrelated in terms of the Project activities and shall be asphalt paved.

Because the foundation of part of the L1 road and all of the R4 road is weak, after improving the road bed with laterite filling (procured from outside), these sections are to be laid with a sub-base course (15 cm thick) by crusher-run and a road base course (10 cm) of graded crushed stone, to which a layer (4 cm) of hot mixed asphalt surface course shall be added.

As for the section of L1 road where the foundation is in good condition (about 50 m between the main road and the new milking cow shed), a layer (10 cm) of supplementary graded crushed stone shall be applied and after this has been levelled, surface layer work shall be carried out. Whether sub-grade improvement is done or not, satisfactory compassion shall be carried out to ensure that deflection of base course surfaces does not occur.

The paved widths for L1 and R4 shall be 4 m and 2.5 m respectively.

(2) Other Approach Roads and Farm Road

The approach to the manure deposit shed (R9 Rd.), that to the hay storage (R10 Rd.) and the farm road leading to the pasture are all new roads to be constructed through laterite banking. Although there are some minor differences in ground conditions in the planned sections, it was judged that these are not large enough to necessitate separate execution contents, and so all three roads shall be planned and designed under equal conditions.

Prior to the laterite road banking, an average of 5 to 10 cm of surface soil shall be removed from the planned ground, and roadbed surface levelling and compassion shall be carried out in order to remove any harmful objects such as plant roots, organic materials and concrete lumps and remove surface irregularities and so form a flat and even roadbed surface. Following this, the surface shall be spread with a thick laterite layer (30 cm or more), which will then be compacted to the designated level of compassion, to leave a road of, on average, 50 cm thickness. Roadbed levelling and compassion is usually carried out by motor grader and tire roller etc., however it is felt that wheeled machinery will not be suited to the ground conditions on site and that it would be more effective to carry out levelling and compassion by bulldozer until a certain degree of trafficability can be attained.

The width of each of these roads shall be a constant 5 m.

3.1.2 Water Supply Facilities

(1) Water Supply Requirement

The water supply requirement includes that for drinking, washing and disinfectant of the 30 milking cows and suckling cows, spray for the cooling, allowance for spilled water from water cups and water set aside for fire prevention. The amount of drinking water for cows depends on cow size, level of activity, amount of food, milking volume and climatic conditions such as temperature, humidity and wind. The water requirement of cows in the Midwest of America is 133-170 liters per head per day for milking cows and 23-38 liters per head per day for suckling cows, although an additional 75 liters per head per day is needed if

milk cooling water is used. Bearing in mind the Thai climate, it is estimated that 300 liters per head per day for milking cows and 50 liters per head per day for suckling cows is required, and assuming that there are 10 suckling cows, the following water supply volume estimates can be arrived at:

Mean water requirement = 9.5 m3/day,

Peak-use water requirement (mean requirement x 1.3) = 12.35 m3/day.

As was stated earlier however, the existing water supply facilities at the Center are not sufficient, and it is also necessary to consider supply of water for use in emergency cases other than the above situations. The peak-use water requirement has thus been set at 15 m3/day.

(2) Deep Well and Submersible Pump

Based upon consideration of the existing deep well (276 m deep) on the site and data and information on nearby wells, the drilling depth for the new deep well has been set at 300 m. In consideration of the current electricity situation and management conditions at the AI Center, assuming a pump operation time of 6 hours per day, design pump discharge of the pump works out to 0.042 m3/minute.

Assuming a well water level drawdown of GL -70 m based on that of the existing well (50-60 m) and information on nearby wells, a discharge level (elevated water tank) of GL + 18 m and a pipe head loss + discharge head loss + allowance of 12 m, the total pump head works out to 100 m. Based upon these figures, the specifications for the planned deep well and submersible pump are as follows:

Well drilling diameter	: 200 mm (8")
Well diameter	: 100 mm (4")
Pump discharge diameter	: 32 mm (1.25")
Motor output	: 2.2 kW.

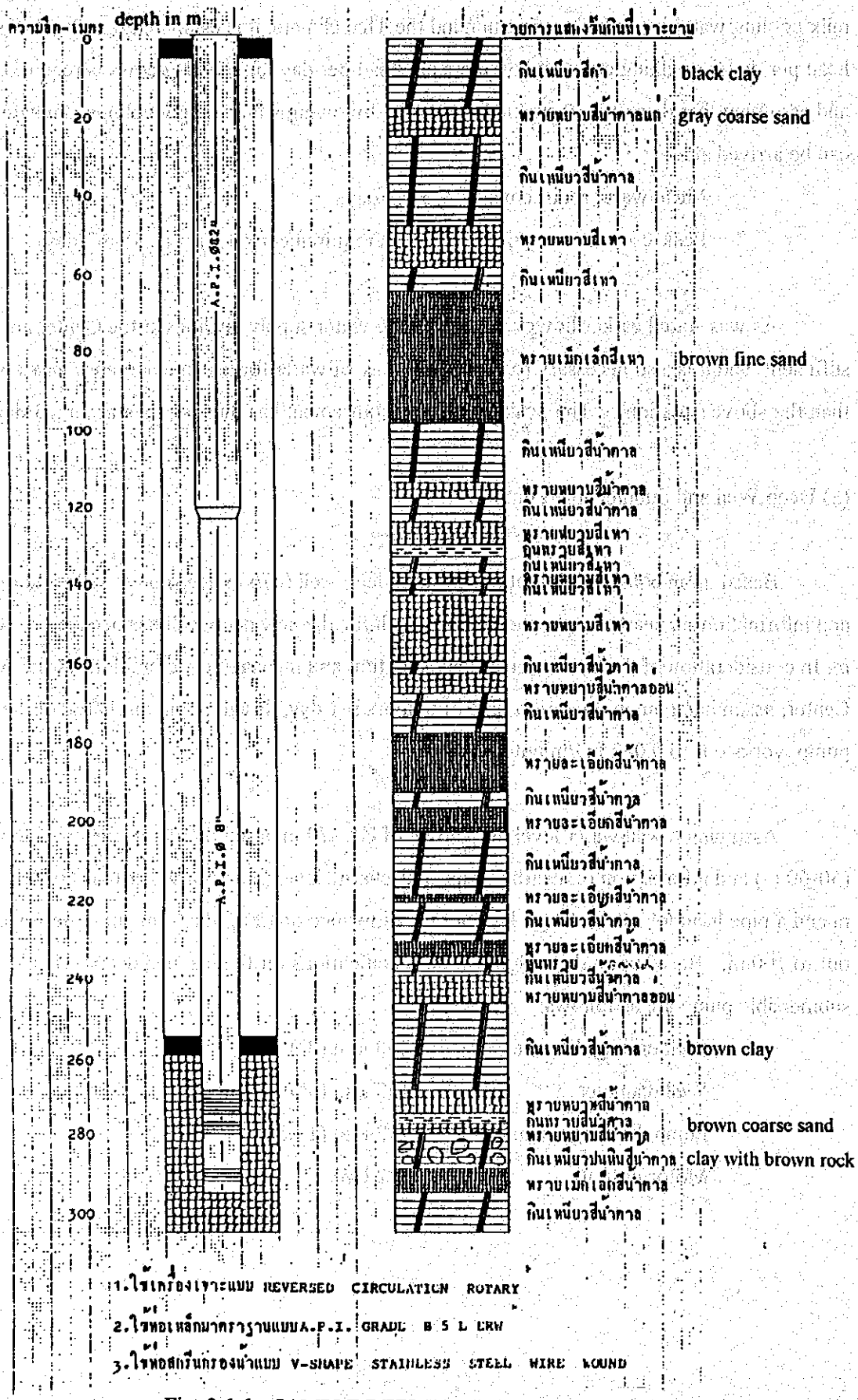


Fig. 3.1.1 SAMPLE DEEP WELL AT BANGKADI

3.1.3 Related Facilities

(1) Paddock

The paddock for the 30 new milking cows is necessary for the health management of the cows and to allow cleaning of the cow shed. The paddock is to be built on land (currently unused) on the eastern side of the cow shed and a concrete passage shall link the paddock to the shed.

The paddock area shall be 700 sq.m as proposed by the JICA experts, and of that, 400 sq.m on the new cow shed side (south side) shall be concrete paved with the remaining 300 sq.m on the north side being unpaved (dirt). Appropriate paddock size is generally said to be 30-50 sq.m per cow and according to standard design by the Ministry of Agriculture, Forestry and Fisheries of Japan, an unpaved paddock should be at least 30 sq.m per cow and a paved paddock should be at least 10 sq.m per cow. Going by these figures, the planned paddock can be said to be appropriate size. The shape of the paddock is to be pentagonal so as to match the existing shape of the site.

The concrete paving shall be 10 cm thick with a 1/50 gradient running towards gutters at the sides. The concrete paving shall be laid in separate 4 m squares in order to prevent cracking, and it shall be trace of rake finished to prevent slipping.

Part of the concrete paved section (cow shed side) shall be covered with a slate roof and a water trough and feeding manger shall be provided. In order to facilitate good drainage off the unpaved section, it shall be given a 1/25 gradient running from the center (boundary line with the pavement) to the outside, however because the existing soil is cohesive soil, the ground is to be firmly compacted and then laid with a 15 cm layer of sandy soil.

The paddock shall be surrounded by a steel pipe fencing and drainage conduits shall be provided beyond the fencing. Out side of the fence, trees shall be planted in order to create some natural shade for the cows.

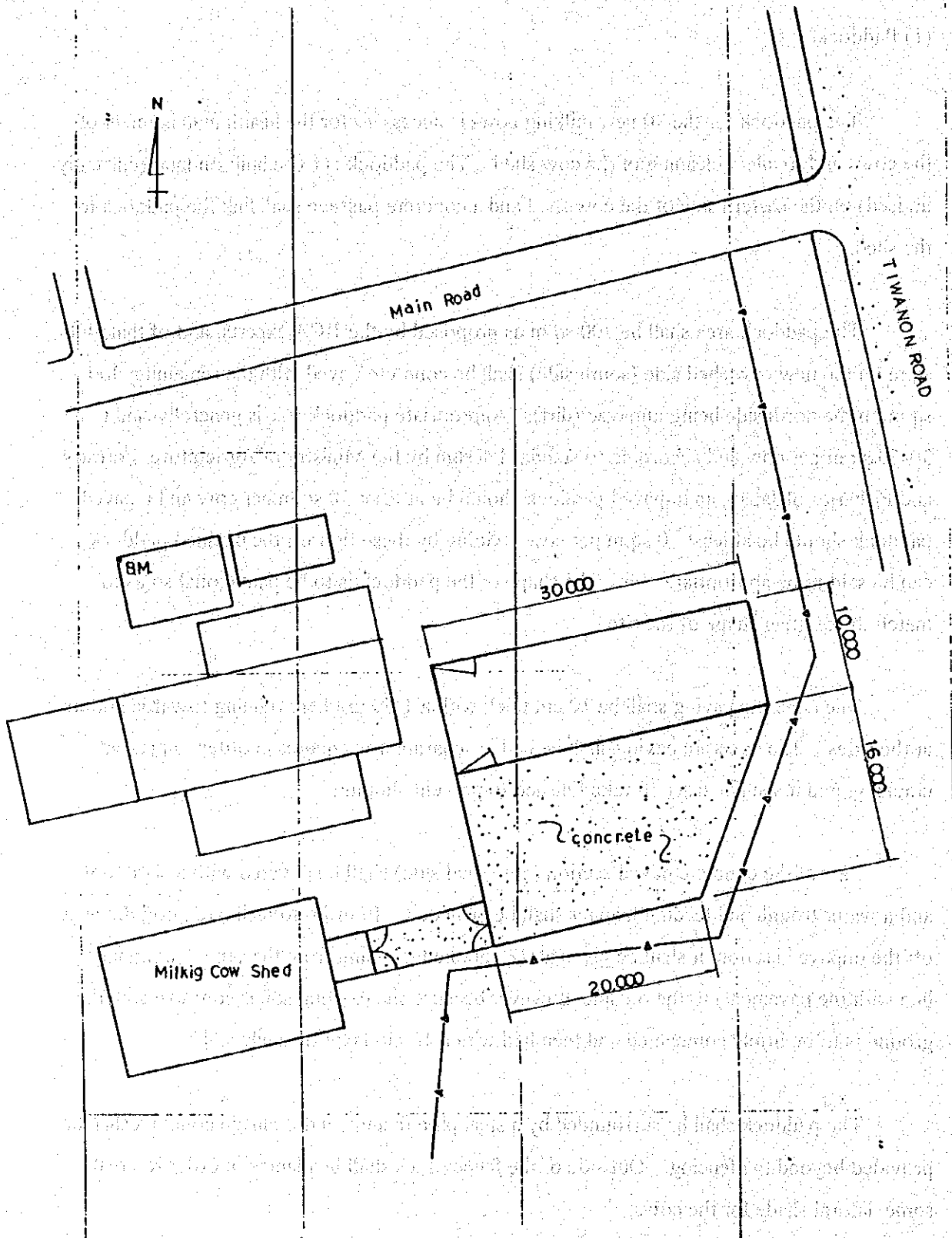


Fig. 3.1.2 GENERAL PLAN OF PADDOCK SCALE : 1/500

(2) Manure Deposit Shed

The manure deposit shed is to be constructed in order to allow excreta from the cattle to be temporarily accumulated and stored for maturing until it is fully manured and can be returned to the land as fertilizer. The size of the manure deposit shed is dependant upon the number of cattle, the feeding management method and quantities of straw bedding and fodder provided to the cows etc., as well as the size of the cultivated area and cultivation methods.

Assuming there are 30 milking cows each producing 30 kg of manure per head per day 56 liters per head per day) and a manure storage period of 4 months (120 days), the total volume of collected manure works out to 160.8 cu.m (considered volume decreasing of 20%). If the manure is piled to a height of 3 m, the required floor space of the manure deposit shed will be 53 sq.m.

The floor area of 50 sq.m (5 m x 10 m) and height of 5 m proposed by the JICA experts is seen to be appropriate in view of the fact that not much straw bedding is used. The scale of the manure deposit shed shall thus be set at 5 m x 10 m x height 5 m.

In consideration of the fact that work will be performed using tractor, the shed's lengthwise direction is to be its frontage, with the loading entry and exit fully open. Walls shall be made of concrete in view of the possibility of corrosion due to the organic nature of the manure, and they shall be 3 m high. There shall be an open gap between the walls and roof, however long eaves shall be provided in order to prevent rain from blowing in.

The floor shall be concrete block pitching and it shall have a 1/50 gradient running towards the back of the shed in order to allow juices to run off. A 10 cm thick concrete apron is to be provided at the front of the shed to allow easier unloading and removal of manure, and this is to be given a 1/50 slope running to the outside in order to prevent the inflow of surface water to the shed.

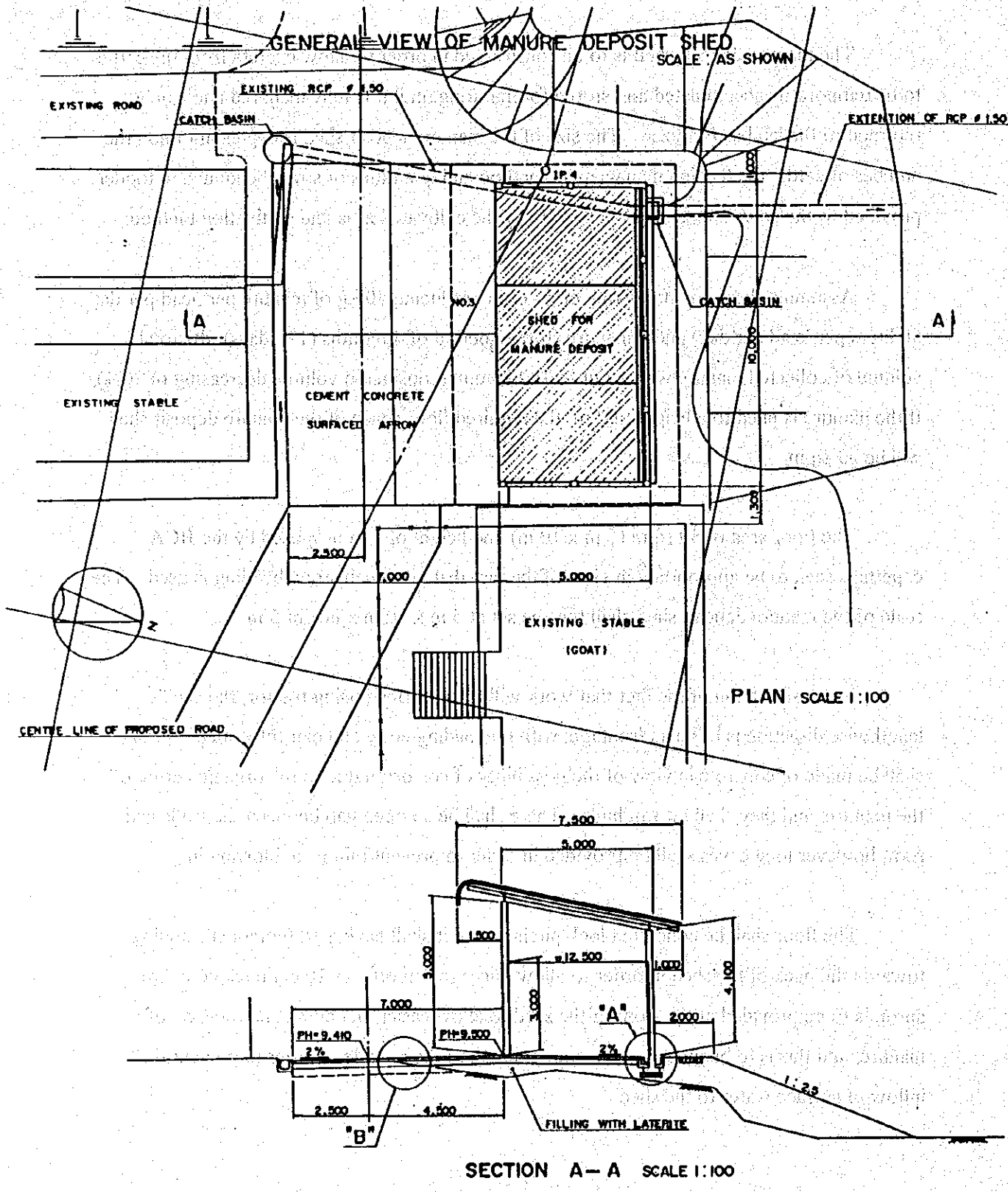


Fig. 3.1.3 GENERAL PLAN OF MANURE DEPOSIT SHED

3.2 Facilities in Chai Badan Dairy Farming Demonstration Center

3.2.1 Roads

(1) Paving of the Main Road and Facility Approaches

As was mentioned in Chapter 2, the main road is scheduled to undergo raising with a 50 cm layer of laterite under the Thailand national budget for this year (1994-95). The thickness of the pavement is therefore dependent upon the bearing power of the laterite to be used in the raising work. For that reason, samples of banking material were taken from two areas of the quarry scheduled to be used to provide the laterite for the raising work, and these were put through an indoor CBR test, a compacting test and other geological tests. The results of the tests revealed the laterite taken from area A of the quarry to have a CBR value of 5.54% and the laterite from area B of the quarry to have a CBR value of 3.97%. Based upon these differing results, the design CBR for the main road was set at 4.

According to the Manual for Low Cost Asphalt Pavement (Japan Road Association), a 20 cm thick sub-base course of crushed stone should be laid in cases where the design CBR is 4. Thus, the composition of pavement layers for the main road has been set as shown in Fig. 3.2.1. The same composition shall also be adopted for the facility approaches and the branch roads.

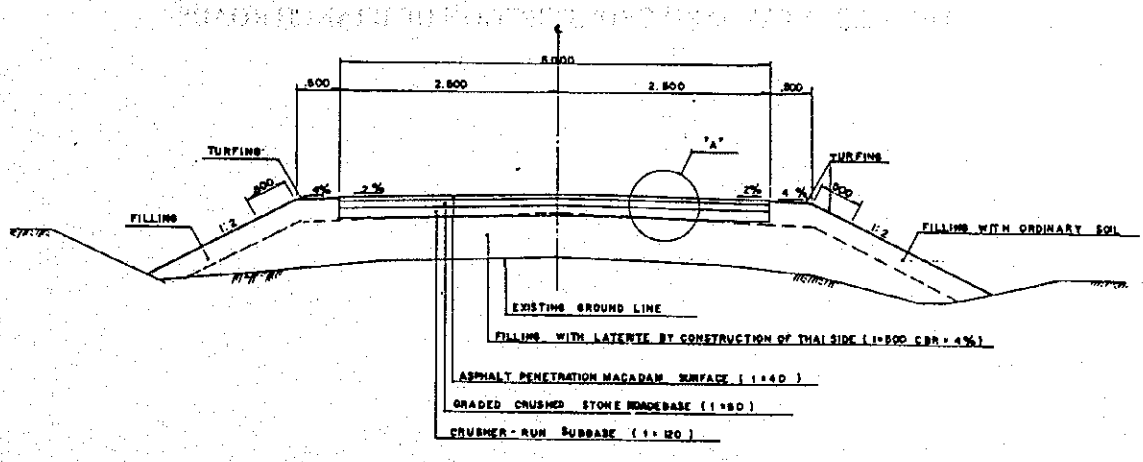


Fig. 3.2.1 STANDARD CROSS SECTION OF PROPOSED PAVED ROAD

(2) Branch Roads

Regarding the existing L1 branch road, the existing foundation (in this case, the present road surface) shall be cleared of harmful objects, levelled and compacted. Over that, laterite shall be spread evenly and compacted to the designated compassion so that a laterite road of 20 cm average thickness is formed.

As for the other branch roads to be newly constructed, the existing foundations shall be cleared of harmful objects, levelled and compacted, and then undergo the same laterite road laying method as for L1 road to form roads of 30 cm average thickness, finished to the designated shape. Fig. 3.2.2 shows a standard section taken from a laterite road.

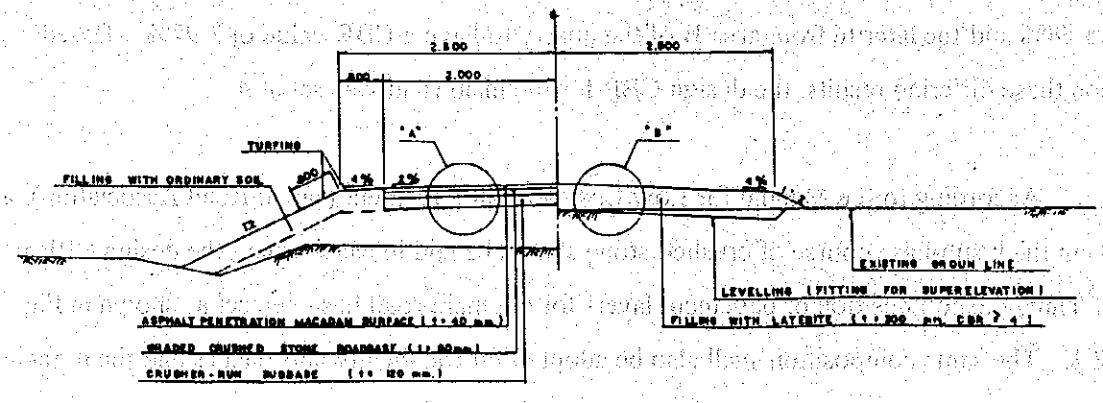


Fig. 3.2.2 STANDARD CROSS SECTION OF BRANCH ROADS

3.2.2 Irrigation Facilities

(1) Irrigation Water Requirement

Design Conditions

Irrigation area	: 3 ha
Crops to be irrigated	: pasture
Irrigation method	: sprinkler
Daily operation hours	: 6 hr (field working time 7.5 hr 1.5 hr for sprinkler movement etc.)
Peak-use daily demand for the crop	: 7 mm/day (pasture feeding)
Water application efficiency	: 85% (sprinkler irrigation)
Conveyance efficiency	: 95% (pipeline)
Irrigation efficiency	: 80% (application efficiency x conveyance efficiency)
TRAM	: 21 mm (the midpoint for sandy soil and humus)

Irrigation water requirements calculated on the basis of the above conditions are as follows:

Peak-use Daily Net Water requirement

(Peak-use daily demand for the crop x Ha to be irrigated)

= 210 m3/day

Peak-use Daily Gross Water Requirement

(Peak-use daily net water requirement) /(Irrigation efficiency)

= 260 m3/day

Irrigation Interval

(Total readily available moisture-TRAM-)

/ (Peak-use daily demand for the crop)

= 3 days

Net Amount of Each Irrigation

(Peak-use daily demand for the crop) x (Irrigation interval)

= 21 mm/irrigation

Amount of Each Irrigation at Field

(Net amount of each irrigation) / (Water application efficiency)

= 25 mm/irrigation

Gross Amount of Each Irrigation

(Net amount of each irrigation) / (Irrigation efficiency)

= 27 mm/ irrigation

(2) Pipeline and Sprinkler Arrangement

The irrigation field is to be divided into 6 sprinkler blocks in consideration of several conditions, such as to minimize labor required for the operation, to make operation simple, to minimize waste land, and to minimize disturbing reap of grass as well as the issues of irrigation interval, the location of the water source and shape of the field.

The pipeline shall take a fish bone form having an underground mainline and three underground laterals each branching off left and right. Each lateral pipe shall have two riser pipes so that the interval between laterals and the interval between sprinklers shall be roughly 50 m (see Fig. 3.2.3).

(3) Sprinkler Capacity

Sprinkler capacity (q) (l/in) = E1 x D0 x D1/60 x T,

where:

E1 : amount of each irrigation at field = 25 mm/irrigation,

D0 : interval between sprinklers = 50 m,

D1 : interval between laterals = 50 m, and

T : Hours per irrigation = 3 hr (assuming sprinkler transfer twice a day).

Thus: q = 347 l/min.

Of those sprinklers on the market, the specifications of that selected from the maker's catalogue which satisfies the above conditions and conforms to specified pressure requirements is as follows:

Nozzle diameter : 15.2 mm
Pressure : 5.6 kg/sq.cm
Sprinkle capacity : 355.8 l/in
Radius : 39 m
(somewhere between 1.4-1.7 times the sprinkler and sprinkler pipe interval is desirable)
Irrigation intensity : 8.5 mm/hr

As to the question of the actual number of sprinklers to be installed, judging from the above block divisions, the irrigation interval and the number of transfers per day, one set of 2 sprinklers is thought to be sufficient.

(4) Pipeline and Distribution Pump

Irrigation system capacity Q = 166.7 x A x E1/F x T,
where:

A : number of ha to be irrigated = 3 ha,
E1 : amount of each irrigation at field = 25 mm/irrigation,
F : irrigation interval = 3 days
T : irrigation hours per day = 6 hr.

Thus, Q = 695 l/min.

However, when the above sprinklers are used, the actual amount of sprinkling becomes as follows:

356 l/in x 2 sprinklers = 712 l/min.

Furthermore, assuming a conveyance loss of 5%, the irrigation system capacity (Q) shall be 750 l/in (0.0125 m3/sec).

a) Pipeline

The pipeline is to consist of galvanized steel piping (GSP) in view of the fact that it needs to be laid underground, heavy loads such as the weight of tractors will be placed on it, and the pipe diameter is to be less than 100 mm. Regarding pipe diameters, trial calculations based upon the conditions that an economical flow is generally 1-3 m/sec and that the difference in pressure at the sprinkler closest to the pump and at that farthest from the pump is held to within 20% resulted in a mainline diameter of ϕ100 mm and a lateral pipe diameter of ϕ80 mm.

Hydraulic characteristic of the pipeline and friction losses calculated using the Hazen & Williams formula are as follows:

Mainline (ϕ 100 mm)

Quantity	: 0.0125 m3/sec	
Velocity	: 1.435 m/sex	
Velocity head	: 0.171 m	
Friction loss	: 0.0370 m/m	

Laterals (ϕ 80 mm)

Quantity	: 0.0125 m3/sec	0.00625 m3/sec
Velocity	: 2.444 m/sex	1.222 m/sec
Velocity head	: 0.305 m	0.076 m
Friction loss	: 0.125 m/m	0.0375 m/m

Head losses in the pipeline

from pump to farthest sprinkler	: 14.3 m
from pump to nearest sprinkler	: 8.6 m
difference pressure	: 0.57 kg/cm2

b) Distribution Pump

Pump total head

Assume that the actual water head is 2.0 m, required total head of the distribution pump should be 73 m, because that sprinkler pressure is 56.0 m and pipeline loss is 14.3 m.

Capacity of power unit (electric motor)

Required power (kW) = $0.163QH(1+\alpha)/\eta p \eta t$

where,

Q	: discharge	0.750 m3/in
H	: total head	73 m
ηp	: pump efficiency	0.55
ηt	: transmission efficiency	1.0 (direct connection)
α	: allowance	0.2 (for motor)

Thus, Required power should be 19.5 kW.

Selection from the maker's catalogue of the pump which is satisfied with the above requirements gives a pump with the following specifications:

Discharge	: 750 l/in
Total head	: 73 m
Type	: Single type volute pump
Suction diameter	: 80 mm
Discharge diameter	: 65 mm
Motor output	: 22 kW (50 HZ)

(5) Deep Well

a) Design Pump Discharge

Assuming a loss of 10% at the pond, the peak-use daily source water requirement will be about 300 m3/day, because the peak-use daily gross water requirement is 260 m3/day.

If daily pump operation hour is 20 hours per day, the peak pump discharge will be 250 l/min.

b) Submersible Pump

Based upon collected data and information collected through interviews, assuming a well water drawdown of 25.0 m, an additional GL +2.0 m to the planned discharge

level and a head loss and velocity head of 3.0 m in the discharge pipe, the total pump head becomes 30 m.

Selection from the maker's catalogue of the submersible pump which matches these figures closest of all gives a pump with the following specifications:

Discharge	: 250 l/in
Suction diameter	: 50 mm
Number of stages	: 5 stages
Motor output	: 2.2 kW.

c) Deep Well

According to gathered information and data, it seems that the ground around the area of the proposed deep well construction site consists of a 3 m layer of limestone boulders (Paleozoic Era) starting from about 1 m below the surface. Underneath that, a layer of white laterite continues for over 10 m, followed by a clay strata of some 15 m, and then hard volcanic rock (Tertiary Period) which is cracked and contains vehicles. In the event of well excavation, water layers that can be expected to carry water veins can apparently be found at depths of 18-22 m, 38-42 m and 60-70 m. Many of the wells that have been bored nearby are small scale types, reaching a depth of 30-40 m and possessing a water yield of 100 l/in or less. Dry wells have also been recorded in the area.

Bearing the above factors in mind, the design specifications for the planned deep well have been set as follows:

Drilling diameter	: 300 mm
Drilling depth	: 80 m
Well diameter	: 150 mm
Water yield	: 250 l/min.

(6) Farm Pond

As was previously mentioned, the purpose of the pond is to store and regulate water in order to make up differences that arise between the irrigation water requirement and the yield from water resources.

If the deep well water source is able to provide 250 l/in of water as planned, the size of the pond should be ample if it is able to hold enough water to make up the difference between this and the distribution pump discharge of 750 l/in for a few days. However, as was stated in the previous section, drilling of a well with a yield of 250 l/in is seen to be difficult, and therefore it will be necessary, as the overall plan for the irrigation system, to provide the pond with enough capacity to make up larger differences. The pond size is thus to be decided based upon the assumption that the deep well can only produce 70% (180 l/in) of the planned 250 l/in, or 216 m3/day.

Here, by using the dry season mean water requirement (6 mm/day) instead of the peak-use water requirement (7 mm/day), the source water requirement works out to 250 m3/day. This results in a water source shortage of 34 m3/day.

However, a look at the climatic statistics for this area over the past 10 years shows that hardly any rain at all falls in the 4 months between November and February. The pond shall therefore be able to hold a minimum amount of water equivalent to four months of the deep well source water shortage. The pond shall thus be designed to hold the following volume of water:

34 m3/day x 30 days x 4 months x 1.1 (allowance) = 4,500 m3.

The shape of the pond is illustrated in Fig. 3.2.4.

As was stated in Section 2.2.3, the pond shall be fully lined with flexible thin sheet to prevented seepage loss. A flexible PVC membrane liner (1.2 mm thick), which is readily available locally, shall be used for this purpose. The pond shall be surrounded by a net fence for safety reasons.

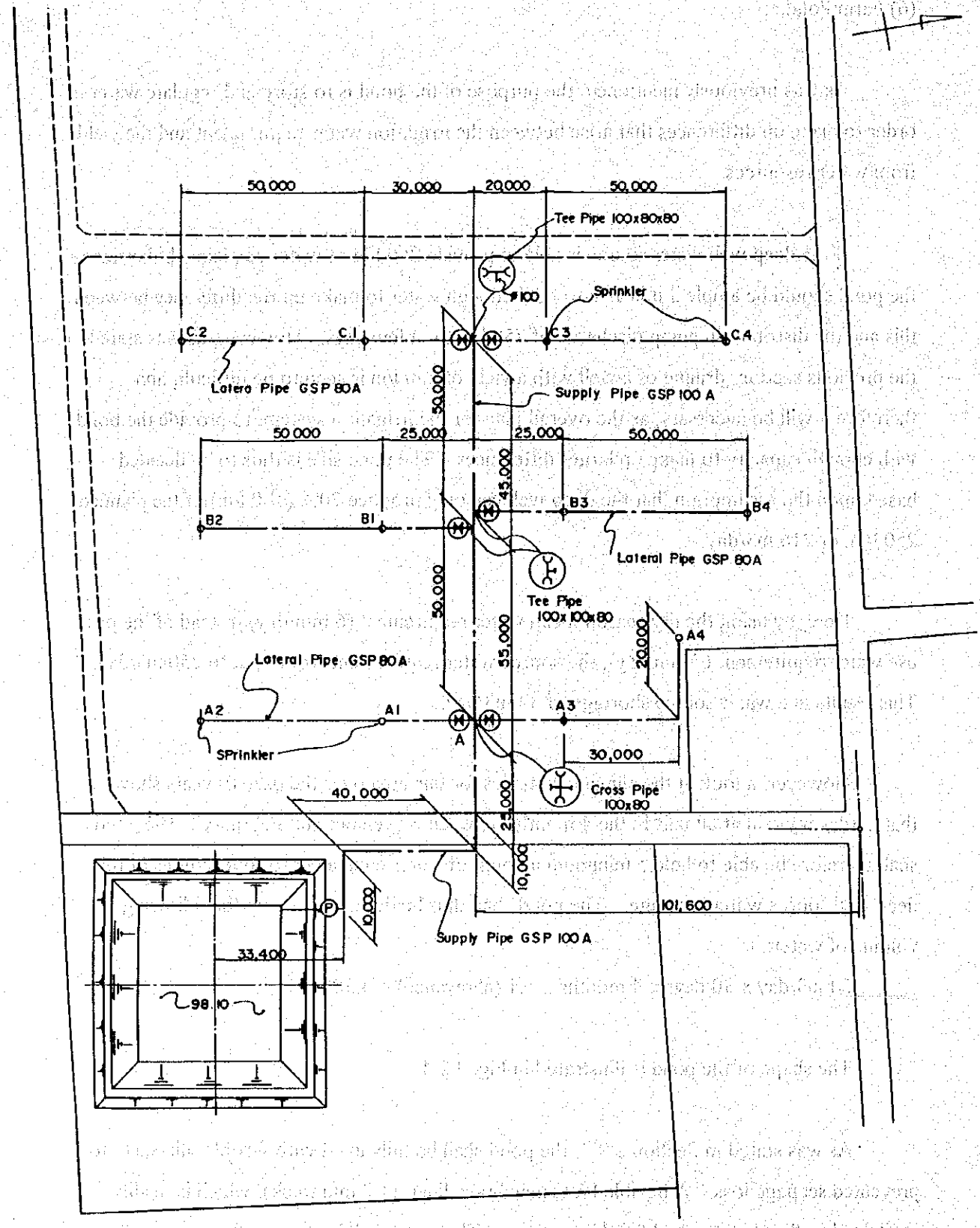


Fig. 3.2.3 LAYOUT PLAN OF DISTRIBUTION FACILITIES

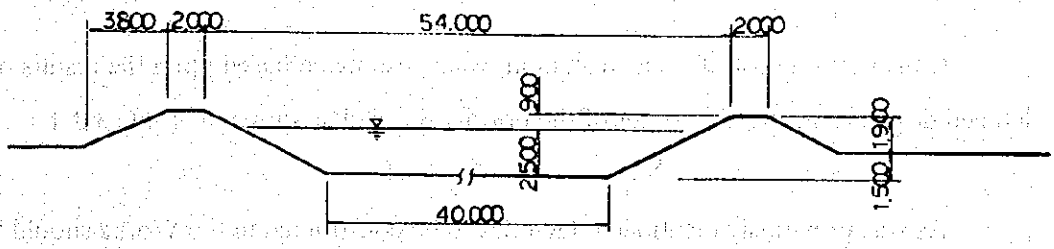


Fig. 3.2.4 CROSS SECTION OF FARM POND

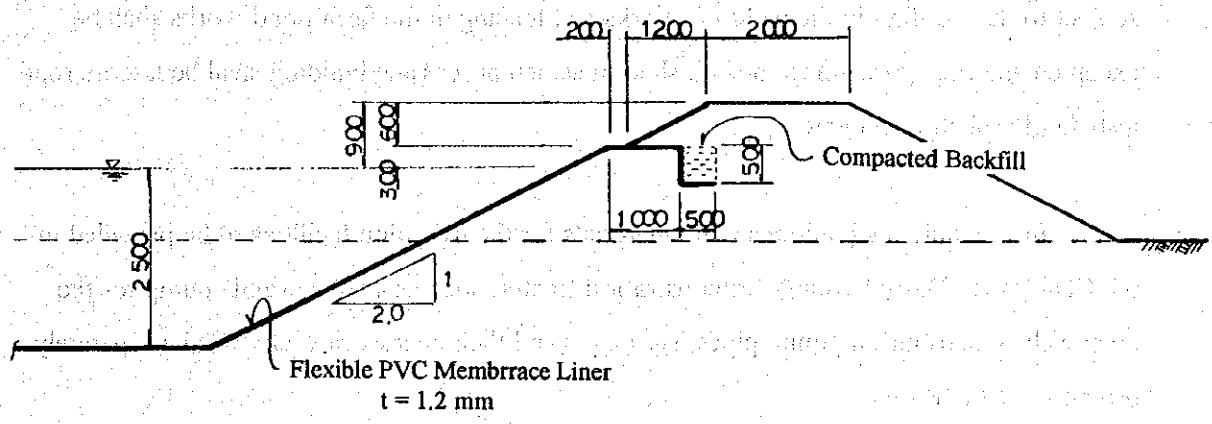


Fig. 3.2.5 LINING DETAILS