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INTRODUCTION TO SPATE IRRIGATION

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Abstract

Spate irrigation is a type of water management that is unique to arid and semi-arid regions. Spate irrigation is a type of water management that makes use of water from "spates", - short duration floods, and lasting for a few hours or a few days. Flood water from mountain catchments is diverted from river beds and spread gently over large area of agricultural land. After the land is inundated crops are sometimes sown immediately. Often the moisture is stored in the soil profile and used later. The spate irrigation system support low economic value farming system, usually cereals, oilseeds, pulses, also cotton and even vegetables. The area under this type of irrigation is more than 2.5 million hectares worldwide. It is found in West Asia, the Middle East, North Africa and the Horn of Africa and more sporadically in other parts of Africa, South America and Central Asia. The largest area under spate irrigation is in Pakistan (1402000 ha). Spate irrigation systems are among the most fascinating and complex resource management systems. Knowledge of spate irrigation systems is extremely limited.

1. Introduction

Spate irrigation is an ancient form of water harvesting and managing unpredictable and sometimes destructive flash floods for crop and livestock production.

Spate irrigation is a system used for wetting land prior to planting. Use is made of seasonal rivers; producing flash floods in the highland areas are diverted by structures to irrigate fields in the lowlands of the country. The diverted runoff with its sediment is conveyed into the earthen canals, and finally collected in the fields that are surrounded by earthen small bunds. Seeds are grown in these fields and crops are produced using the residual moisture.

Spate irrigation has a number of peculiar land use requirements and therefore the classical land suitability systems are not applicable. For example, an adequate number of floods and good water holding capacity of the soils are some of the basic land use requirements for Spate Irrigation System (SIS) to function in a sustainable way. Hence, a study has to be taken to design a land suitability system for spate irrigation schemes.

In developing a spate irrigation system, it is important to understand the entire hydrology of the system – the base flow, subsurface flow, groundwater and obviously also the pattern of spate floods. Hence, hydrological investigations have to be carried out before the design of spate irrigation system

In all irrigation schemes, especially Spate Irrigation, farmers should be consulted and involved, using their indigenous knowledge, in the planning, design and execution of the rehabilitation and improvement works.

Strengthening of farmer's Water Users Association (WUA) has to be carried out to assure responsibility for operation and maintenance (O & M) works of Spate Irrigation System.

Therefore villagers' participation is very important in Spate Irrigation system.

The most comprehensive information on how much spate irrigation there is come from FAO.

Country/Region	Year of irrigation data	Spate irrigation (ha) (1)	Total irrigation (ha) (2)	% of total irrigated area covered by spate irrigation
Algeria	1992	110000	555500	19.8
Eritrea	1993	15630	28124	55.6
Kazakhstan. Rep	1993	1104600	3556400	31.1
Mongolia	1993	27000	84300	32.0
Morocco	1989	165000	1258200	13.1
Pakistan	1990	1402448	15729448	8.9
Somalia	1984	150000	200000	75.0
Sudan	1995	46200	1946200	2.4
Tunisia	1991	30000	385000	7.8
Yemen Rep.	1994	98320	481520	20.4

2. Spate Hydrology and Sedimentation.

2.1 Spate Hydrology

Spates are relatively short duration floods which are caused by heavy rain on the catchments and are characterized by a rapid increase in the flow, a short peak and then a less rapid decline. The total duration of a spate can range between a few hours and a few days.

Therefore, it is very difficult to determine the volumes of water that will be diverted to the fields and hence the potential cropped areas. In most schemes, the long-term data needed, to design diversion structures and canals, will rarely be available.

For new schemes, it is necessary to make an estimate with respect to the likely variation between years. When data are not available, this can be achieved by assuming that the annual runoff volumes are approximately proportional to the number of floods that occur and using farmers' estimates of flood numbers.

In some rivers or streams, flood flows are supplemented by spring fed base flows. Use of this is also considered in the design of spate irrigation schemes.

The magnitude of the flood discharges with different return periods is needed to design diversion weir and canal structures. Several methods can be used. But their feasibility is often conditional and they can only be effective under certain specific cases. The following methods could be used for the design.

- "Rational" methods based on "design" rainfall intensity, a time of concentration derived from catchments parameters, and a runoff coefficient that depends on catchments conditions.
- Regional flood frequency relationships are widely used for flood estimation in un-gauged catchments.

- Slope area method is to estimate the size of the largest historical flood that has occurred. Field surveys have to be carried out combined with local farmers and their information can provide a reasonably reliable estimate of the flood water level.
- Empirical methods can also be applied to estimate this from catchments properties.

Usually long-term rainfall data are available at the project site or nearly by area. Therefore rainfall – runoff formulas are very useful in calculation of design floods.

Different methods of flood discharge calculations should be carried out for "design" discharge.

From the above calculations, flood discharges were compared and based on experiences and sound judgment, "design" discharge, has to be taken for further structural designs.

2.2 Sedimentation

Sedimentation is as important as water management. Rivers in spate lift and deposit huge quantities of sediment. As a result there is constant change in bed levels in both the river system and the distribution network. The impact of these processes differs between the various systems. It depends on the amount and composition of the sediment load that a river carries, which depends on the rainfall pattern and the characteristics of the catchments area; its geology, morphology and vegetation cover. Farmers are usually able to identify the origin of a flood by the type of sediment that is transported by it.

The degree of deposition of silt and scour also depends on the local topography and the type of material. In spate irrigated area with low gradients, as are found on the plains, a river is always in danger of choking itself with its own silt deposits and finding another way. Moreover, in the fine sandy deposits of the plains, the scouring of the riverbed is a larger danger than it is in the armoured river bed of the highland. As a result, the lowland flood irrigation systems are particularly dynamic.

In most spate irrigation systems, only the largest floods are allowed to flow beyond the irrigated area. Smaller floods are either diverted to the fields, or seep into the river bed. Coarser sediments settle in the river channels and irrigation canals and finer sediments are deposited on the fields. Farmers welcome sedimentation as a source of fertility. The sediment load, particularly during the larger floods, can cause major operation and maintenance problems for spate irrigation systems. Total load sediment concentrations rising to an exceeding 10 percent by weight can occur in floods in some rivers. Sediments concentration up to 5 percent by weight in floods is common.

The extraction of sand and gravel from river beds will also disturb the overall morphological balance. Sediment being carried into the area where extraction has occurred will get deposited and the flow will tend to erode the bed further downstream in order to regain the stable sediment load.

3. Water Diversion and Control Structures.

3.1 Diversion Weir

There is no single approach to the design of improved spate systems. Specific requirements vary widely between and in some cases within schemes. In spate irrigation system, the objective is to divert the maximum possible amount of water to the fields during the very limited spate flood.

Intakes and canals thus have a very much larger discharge capacity per unit area served than would be the case in perennial schemes. Discharge capacities have to be selected taking account of the distribution of flows within the annual hydrograph, the duration of and discharge variations during flood events, as well as crop water requirements.

The standard equation is used to determine the head over the weir crest. Potential scour is usually calculated using the Lacey Formula which is simple. Bligh or Lane's weighted creep theory is used to determine the length of the structure and the depth of cut-offs. The creep length should be greater than the maximum head difference multiply by the creep coefficient.

Stilling basins are provided downstream from weirs to dissipate energy and to reduce the scouring affect of high velocity flows. The cost of overall weir appurtenant structures and associated energy dissipation arrangements increase with specific discharge and height over the weir. **The general recommendation is to avoid high specific discharges and large head drops.** But it has to adopt sufficient head to achieve effective sluicing and to maintain command over the area to be irrigated.

Intake in spate systems has to divert flood flows, delivering water to canals at a sufficiently high level to ensure command over the irrigated fields. Canal need to convey large volumes of water to the fields in the short periods when flows occur. The timing, duration and maximum discharges of spate flows are unpredictable.

Gated intakes provide a capability to regulate the flow into the canal. The gates should be as wide as possible, considering the intake requirements, and preferably by manual operation. In general, vertical lift gates wider than 2 meter are not suitable for manual operation especially in spate systems. In spate intake, the width of the head regulator opening is usually kept approximately the same as downstream canal.

Scour or under sluice should be provided to remove deposited coarse sediments in river bed above the weir. Sluices can usually only the operated for the short periods when the river flows exceed the canal discharge.

3.2 Canals and Water Control Structures

Usually canal bed slopes are steeper than then conventional "regime" canals. High slopes provide the high velocities needed to convey very high sediment loads. Although quite-high flow velocities are generated, canals do not seen to suffer from widespread scour problems, probably because high discharges occur only over short time periods. During flood peaks canals are rapidly silted up and need frequent desilting to maintain discharge capacities.

Water control structures are usually provided as per conventional irrigation systems. All structures have to be designed for the maximum canal discharge.

In spate irrigation systems, the objective is to divert the maximum possible amount of water to the fields during the very limited spade flood duration period. Therefore intake head regulators and canals have very much larger discharge capacities with wide bed width and steep slopes compared to conventional canals. This rule is out of the use of most conventional canal design procedures.

Spate canal networks can give better control and overcome some of the disadvantages of the field-to-field water distribution system. Water User Association (WUA) or Water Users Groups (WUG) should be formed, if not existed. Detail discussions with concerned authorities and all water user groups is needed for water management and distribution procedures.

4. Spate irrigation in Myanmar

The following projects were under investigation and construction by Ministry of Agriculture and Irrigation, Water Resources Utilization Department (WRUD).

In Monywa Township, In Ye- Butalin Pump Irrigation Projects, a diversion weir will be constructed in Thade Chaung to irrigate about (2000) acres of land.

Topographic survey and design works were carried out for implementation during the year 2011 and 2012.

In Shwe Hlan Bo Region Greening Porject, spate irrigation system was planned and design works were completed. The Project will consists of construction of a diversion weir on Natyekan stream with Left and Right side Head Regulators. Left canal will irrigate (1200) acres of land and right canal will irrigate (500) acres of land with total irrigable area of (1700) acres.

No Rainfall station or discharged observation station are installed in project area. Therefore for weir design, 20 years daily rainfall data of Kyaukse and Singaing were analyzed. 100 years frequency rainfall is calculated and used for design flood calculation. Design calculations are adopted mostly based on spate irrigation system criteria. Based on design flood, length of weir is adopted as 80 ft and specific discharge of 87.5 ft^3/sec. For unsilting of deposited course sediments above the weir, silt excluders on both side of the head regulator were provided.

Irrigation canals are designed based on spate irrigation system and required structures are also included. Local available construction materials are used as far as possible for economy of the project.

In Myanmar, small scale village irrigation works were implemented for community development activities that address their basic social and food security needs in a participatory, sustainable and transparent manner. More than 20 diversion weirs with canal system as Spate Irrigation were carried out under the Integrated Community Development Project (ICDP) funded by the United Nations Development Programme (UNDP).

The works were implemented with Project Inputs and Villagers Participations. Water Users Group (WUG) were formed and implementation, operation and maintenance works were carried out together with WUG members. In Shan State and Dry Zone areas of central Myanmar, implementations were carried out since the year 2004 to 2007.

For village spate irrigation systems two types of weirs are shown in attached drawings. Retaining wall type is mostly used for medium size weirs and breast wall type is used for small scale weirs. Specific discharges, which is discharge over the weir per foot length, are usually adopted between 30 c.f.s./ ft to 40 c.f.s/ ft, so that serious downstream scour may not occured. Drawings and photographs for the implemented system are attached.

As an example, in Pindaya Township of Shan State, a retaining wall type namely Nyaung Kauk weir was constructed in 2005 and irrigating about 700 acres of paddy land as shown in photograph. In irrigation canals, (3) numbers of mini Hydropower were installed and supplying electricity to nearby villages.

In Pinlaung township, as an another example, breast wall type, namely U Htee Diversion weir was constructed in the year 2005. It can irrigate more than 200 acres and (2) numbers of mini Hydro Power were installed and supplying electricity to the nearby villages.

Conclusions

There are many potential areas in Myanmar to develop Spate Irrigation System in arid and semi-arid regions of States and Divisions. In dry zone areas, possible site should be investigated and feasibility studies should be carried-out. Spate irrigation system is economy compared to the other method of irrigation. Local available construction materials could be mostly used and local skill labours could also be used for implementation of the works.

In many semi-arid areas, spate irrigation is the most cost-effective way to retain and store water for improvements in soil and water management.

Acknowledgement

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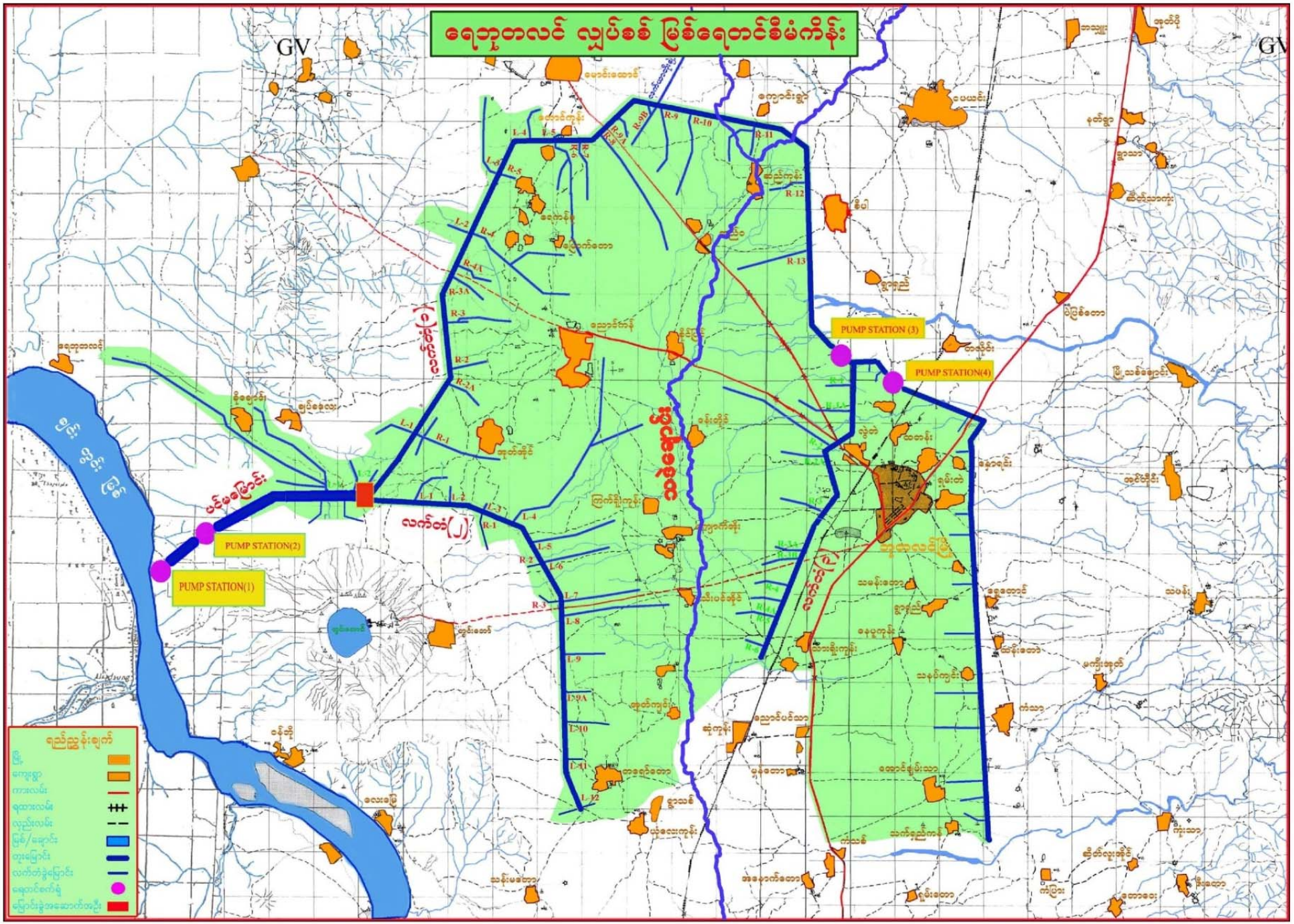
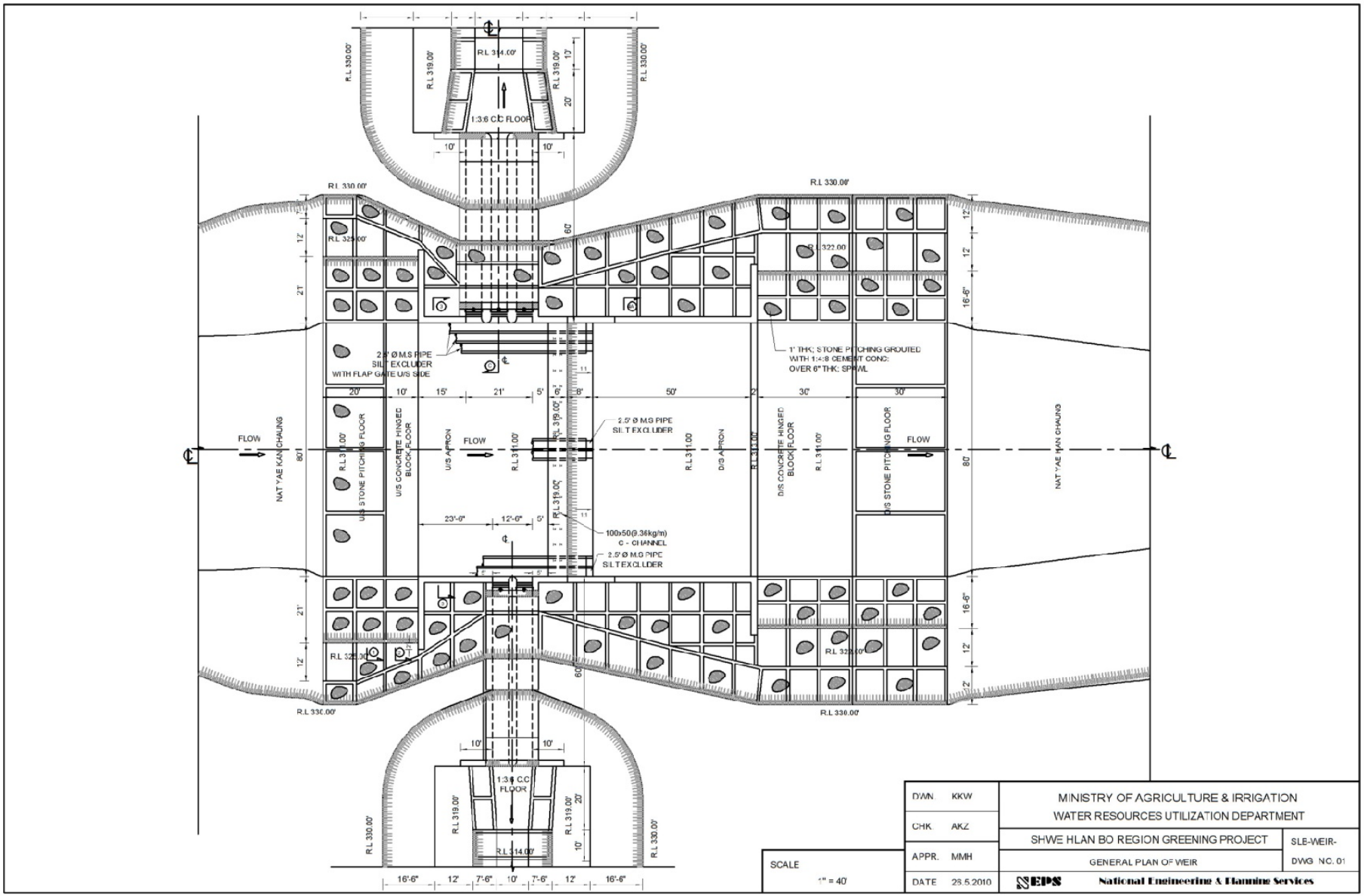
Location Map of Proposed and Completed Spate Irrigation System

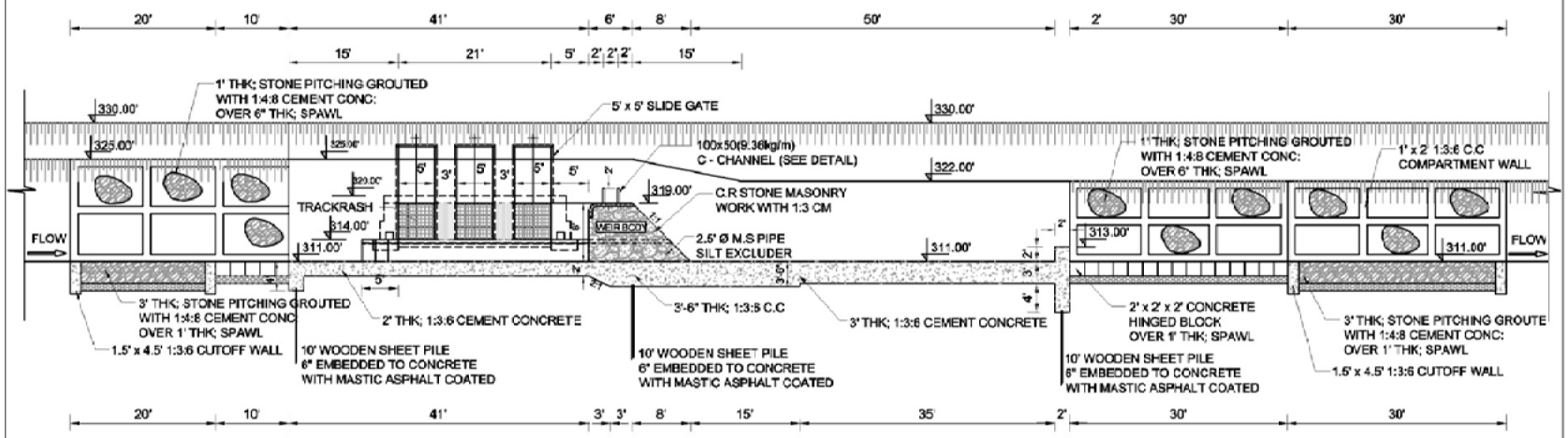

ရေဘူတလင် လျှပ်စစ် မြစ်ရေတင်စီမံကိန်း
GV
GV
PUMP STATION (3)
PUMP STATION(4)
PUMP STATION(2)
PUMP STATION(1)
ပင်မမြောင်း
လက်တံ(၂)
လက်တံ(၁)
ရည်ညွှန်းချက်



DWN. KKW	MINISTRY OF AGRICULTURE & IRRIGATION WATER RESOURCES UTILIZATION DEPARTMENT	
CHK. AKZ	SHWE HLAN BO REGION GREENING PROJECT	SLE-WEIR-
APPR. MMH	GENERAL PLAN OF WEIR	DWG NO. 01
DATE 28.5.2010	EPS National Engineering & Planning Services	

SCALE
1" = 40'

LONGITUDINAL SECTION OF WEIR



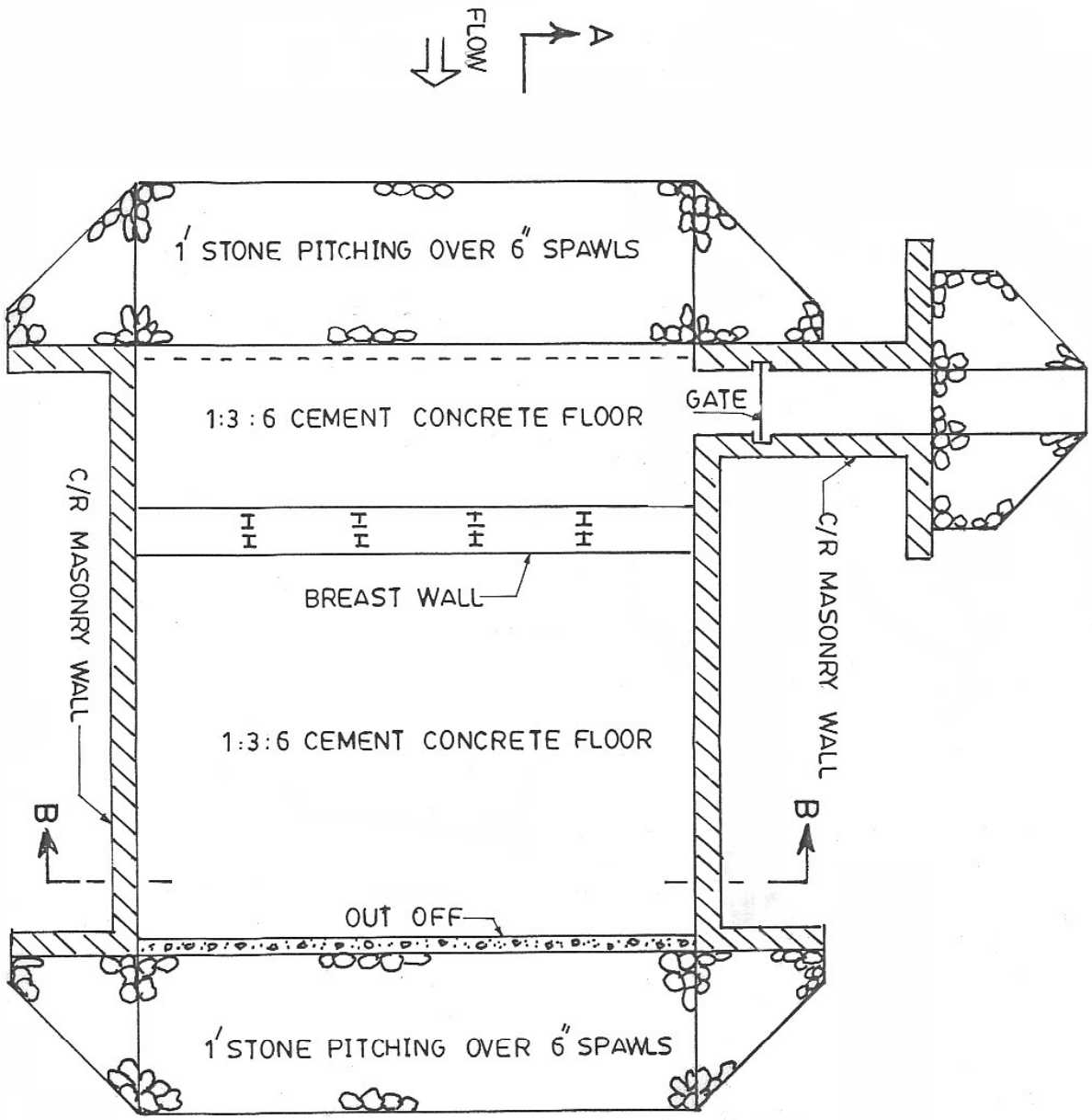
SECTION A - A

PROFILE OF LEFT SIDE

SCALE 1" = 16'

SCALE 1" = 20'	DWN. KKW	MINISTRY OF AGRICULTURE & IRRIGATION WATER RESOURCES UTILIZATION DEPARTMENT
	CHK. AKZ	SHWE HLAN BC REGION GREENING PROJECT / SLB-WEIR-
	APPR. MMH	SECTION A-A (PROFILE) / DWG NO 04
	DATE 26.6.2010	EPS National Engineering & Planning Services

TYPICAL PLAN OF DIVERSION WEIR & HEAD REGULATOR
RETAINING WALL TYPE

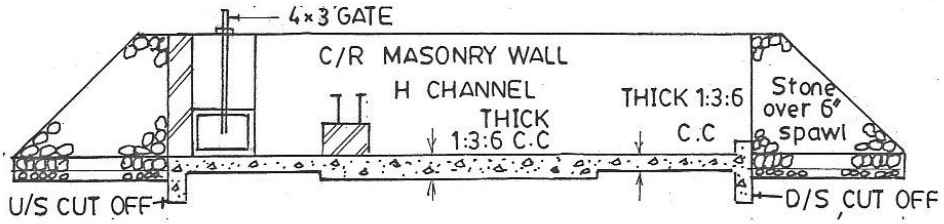


PLAN

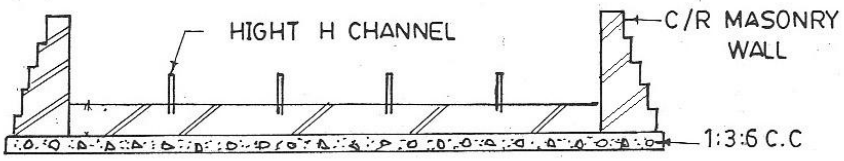
THE INTEGRATED COMMUNITY DEVELOPMENT PROJECT MYA /01/001

U MAUNG MAUNG HTAY
CONSULTANT MYA /01 /001
IRRIGATION & WATER HARVESTING

TYPICAL CROSS SECTION OF DIVERSION WEIR & HEAD REGULATOR
RETAINING WALL TYPE

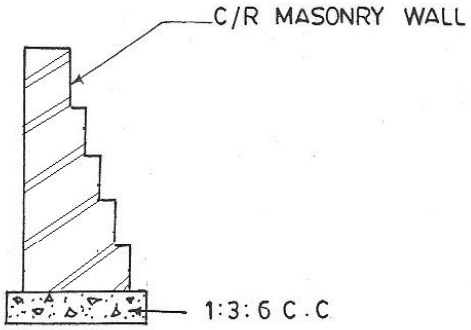


CROSS SECTION A.A



CROSS SECTION B-B

SCALE~1" = 10'



RETAINING WALL DETAIL

SCALE~1" = 5'

THE INTEGRATED COMMUNITY DEVELOPMENT PROJECT MYA/01/001
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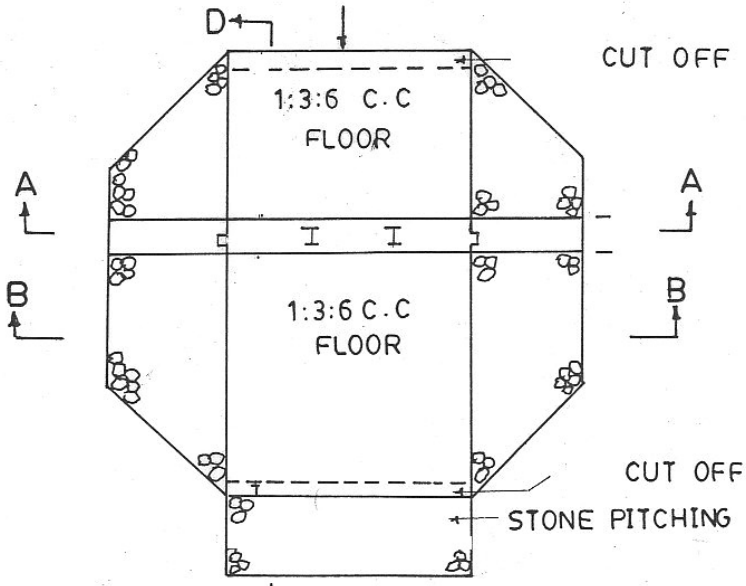
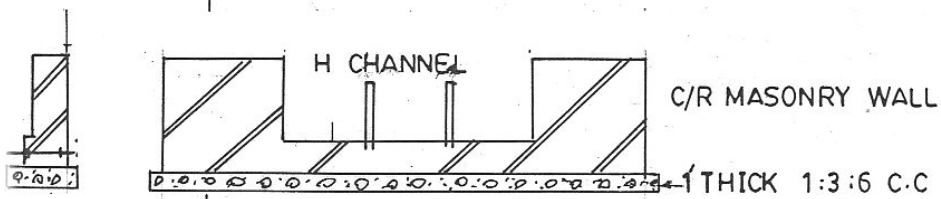
TYPICAL PLAN & CROSS SECTION OF DIVERSION WEIR
BREAST WALL TYPE

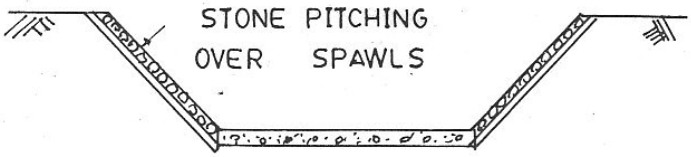


PLAN

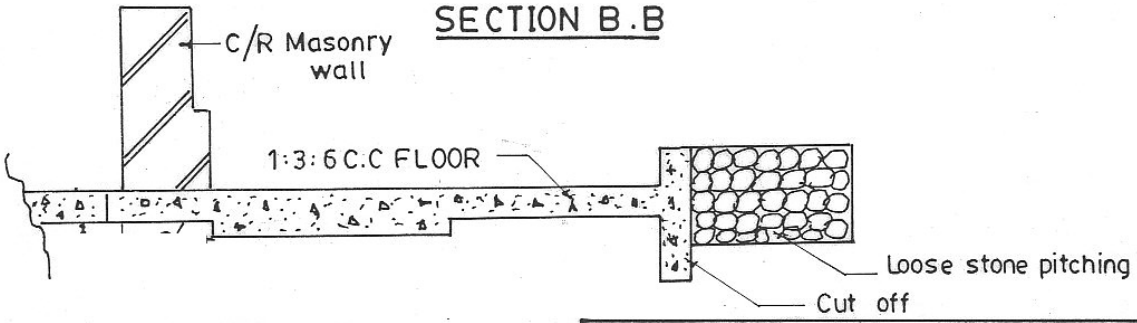


SECTION C.C

SECTION A.A



SECTION B.B



SECTION D.D

THE INTEGRATED COMMUNITY DEVELOPMENT PROJECT MYA/01/001

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IRRIGATION & WATER HARVESTING

Shwe Hlan Bo Region Greening Project

Site Investigation With Villagers and Project Staff

Part of Spate Irrigation Structure and Canal

Photographs of Monitoring Construction Works of Community Based Irrigation and Water Harvesting Activities

Shan Zone – Pindaya Township

Nyaung Kauk Diversion Weir during construction, nearly completed.

Nyaung Kauk Weir after construction completed, June 2005.

Photographs of Monitoring Construction Works of Community Based Irrigation and Water Harvesting Activities

Shan Zone – Pinlaung Township

U Htee Diversion Weir during Construction.

U Htee Diversion Weir after completed in June 2005.