SRKN'gineering 107 Lamaha Street North Cummingsburg Georgetown Guyana			**Project Reference:** RAID-Lots1/2/3/4 - 042017 **Document Reference:** RAID-Lots1/2/3/4 _HydraA_DM3	
Project Name:	Rural Agricultural Infrastructure Development (RAID) in Small Scale Farming Communities in Regions 4 and 5			
Title of Consultancy Services:	Consultancy Services for Engineering Designs and Supervision of Works: Rehabilitation of Drainage and Irrigation System (Earthworks, Structure and Access Dams) – Lot 1 (Ithaca), Lot 2 (Buxton), Lot 3 (Triumph) & Lot 4 (Mocha)			
Document:	Design Module 3 (DM3)	**DM Subject:**	Hydraulic Design Report	
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Submitted to:	Mr. George Jervis Ministry of Agriculture, Agriculture Sector Development Unit (ASDU).			

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1. Introduction

1.1 Background

The Government of Guyana (GOG), represented by the Ministry of Agriculture (MOA), Agriculture Sector Development Unit (ASDU) herein referred to as the "Client". The Client has engaged the Design and Supervision Services of SRKN'gineering and Associates of 107 Lamaha Street, North Cummingsburg, Georgetown, Guyana, herein referred to as the "Consultant".

The Design and Supervision Services rendered by the Consultant are aimed towards the effectuation of the "Consultancy Services for Engineering Designs and Supervision of Works: Rehabilitation of Drainage and Irrigation System (Earthworks, Structures, and Access Dams)." The Project falls under the "Rural Agricultural Infrastructure Development (RAID) in Small Scale Farming Communities in Regions 4 and 5." This Project is being executed under four lots, namely;

- Lot 1 – Ithaca
- Lot 2 – Buxton
- Lot 3 – Triumph
- Lot 4 – Mocha

The aforementioned project shall be implemented with financing made available by the Client and the CARICOM Development Fund (CDF). The Client through representation by ASDU and NDIA will administer the execution of the said projects in accordance with the requirements specified in the Contract Document more so the Terms of Reference.

1.2 Project and Related Components

Common to each Lot of the project identified above is a Design Component which is followed by a Supervision Component. The Supervision Component is geared towards the execution or implementation of the outcome presented in the Design Component. Those are systematically captured in the Hydraulic Design Report (Design Module 2).

The "Consultancy Services for Engineering Designs and Supervision of Works: Rehabilitation of Drainage and Irrigation System (Earthworks, Structures, and Access Dams) – Lot 1 (Ithaca), Lot 2 (Buxton) and Lot 3 (Triumph)", shall be managed by the Agriculture Sector Development Unit (ASDU). The designs associated with this project evolve around the development of a Main Drainage and Irrigation System, related Tertiary Units and the necessary infrastructure to support the cultivation of 900 acres of farmlands in Lot 1 and the rehabilitation of the existing systems which will facilitate the cultivation of 500 acres in Lot 2 and 600 acres in Lot 3. The Client has provided a list of potential crops of economic value for cultivation to be considered during the conceptual stages of the designs.

The contents of this report and those to follow are specific to the Design Component associated with the execution of the abovementioned projects. The designs required under the different Lots are lumped together and presented in the Hydraulic Design Report (DM2).

1.3 Problem Statements

The statements of problem tabulated below are based on the Clients hypothesis and understanding of the issues related to the projects being analyzed, as were expressed in the Terms of Reference. These will serve as the basis of the solutions formalized in addition to any other specific problems identified during the analysis.

PROJECT	Rehabilitation of D&I System – Lot 1 (Ithaca), Lot 2 (Buxton), Lot 3 (Triumph) and Lot 4 (Mocha)
No.	**Problem Synopsis**
1	Backlands of Ithaca, Buxton, Triumph, and Mocha are uncultivated, under cultivated and underdeveloped as a result of constraints associated with access
2	No existing Drainage and Irrigation (D&I) System in Lot 1
3	Dysfunctional Drainage and Irrigation (D&I) System in Lots 2, 3 and 4

Table 1 – Problem Statements

1.4 Project Deliverables

The Consultant is obligated to furnish the reports so detailed in Table 2 as is specified in the Terms of Reference for the Design phase of the project. The ultimate deliverable report shall comprise three separate components, namely:

i. R1 – Hydrologic Design Report
ii. R2 – Main System Design Report
iii. R3 – Hydraulic Design Report
iv. R4 – Supplementary Design Reports

PROJECT	Rehabilitation of D&I System – Mocha			
CLIENT	**ASDU, Ministry of Agriculture**			
	Reports Herein	**R1**	**R2**	**R3**
1	Draft Design Report		*	*
2	Final Design Report			

Table 2 – Design Deliverables

Reports 2 and 3 (R2 and R3) are presented along with the following Design Modules to be reviewed collectively. These modules will be presented as follows:

i. Design Module 1 (DM1) – Presents the Basis of Hydraulic Design
ii. Design Module 2 (DM2) – Presents Report 2 (R2) – Main System Design
iii. Design Module 3 (DM3) – Presents Report 3 (R3) – Hydraulic Design
iv. Design Module 4 (DM4) – Presents all the relevant Appendices

The amalgamation of the different reports stated above will address the Scope of Works of each project provided in the section that follows.

2. Drainage Systems Hydraulic Design

Prior to the design and improvement of the existing drainage system, an assessment was done on a global scale through manual computations and by creating hydraulic models of the respective system using HEC-RAS. The Hydraulic Assessment of the respective project areas drainage system was based on the drainage load which correspondence to a 20 years design storm event. The assessment was completed with a particular emphasis on the main drains and all related infrastructure utilized to effectuate drainage within the system.

The subchapters that follow summarize the hydraulic assessment and the premise on which the designs were proposed. Inter alia, the existing hydraulic structures within the project area were assessed against the design drainage load computed. With the exception of the focus area, the secondary and tertiary drains were not included in this analysis.

The drainage design concept presented in Design Module 2 (DM2) highlights the proposed drainage regime recommended to fulfill the drainage requirements of each project area. Additionally, DM2 tabulates the hydraulic design for the respective drains within the project areas. Chapter 5 chronicles the design features of the respective lots in totality to effectuate the smooth conveyance of the drainage load to the outfall structure(s).

Lot 1 – Ithaca

Table 3 presents the drainage load computed for the respective design levels from the project area and any other contributing area(s) to the total drainage load. Specifically the main drains hydraulic capacity were evaluated against a discharge of 13 cubic meters per second.

The existing drainage system of Ithaca is such that the drainage volume of the southern adjoining village converges at the outfall sluice located at Ithaca. Under this situation, the existing outfall sluice is inadequate to safely convey the drainage load to the Berbice River. As such the drainage system proposed concentrates on the drainage volume coming from Ithaca. This shall be achieved by isolating the drainage systems of each village.

Drainage Modulus			
Design Level	**Drainage Modulus**		**Runoff**
Tr, yrs	**m (mm/d)**	**m(in/d)**	**Q (m^3/s)**
5	108.4	4.3	9.4
10	128.9	5.1	11.2
15	141.8	5.6	12.3
20	151.4	6.0	13.1
30	165.7	6.5	14.4
50	185.0	7.3	16.1

Table 3 – Lot 1 Drainage Modulus

Nevertheless, this approach still indicated that the Ithaca outfall sluice is inadequate to convey the drainage load in a timely manner to prevent prolong inundation. As such it is recommended that a new single door sluice is constructed. This forms part of the designs proposed as is presented in Chapter 5.

Lot 2 & 3 – Buxton and Triumph

The assessment of the existing main drainage system of Lots 2 and 3, Buxton and Triumph respectively, were accomplished through the quantification of the drainage load for the appropriate project areas. The drainage load presented in Table 4 and Table 5 are a result of the drainage modulus derived from the rainfall dataset located at Enmore. The proximity of the two Lots relative to the rainfall station made this the ideal dataset to analyze.

The hydraulic requirements of the main drainage system for the two Lots were dependent on its ability to safely convey the design drainage load to the respective pump stations prior to being discharged into the Atlantic Ocean. A series of encumbrance in the form of access bridges, culverts, and bottlenecks with reduced waterway made it difficult to effectuate drainage effectively. Of greater importance, common to both Lots is the pump station utilized to lift the drainage load to an energy head that will promote gravity drainage through the outfall sluices.

Drainage Modulus			
Design Level	Drainage Modulus		Runoff
Tr, yrs	m (mm/d)	m(in/d)	Q (m^3/s)
5	131.5	5.2	12.2
10	161.7	6.4	15.0
15	181.0	7.1	16.8
20	195.6	7.7	18.1
30	217.5	8.6	20.1
50	247.5	9.7	22.9

Table 4 – Lot 2 Drainage Modulus

Drainage Modulus			
Design Level	Drainage Modulus		Runoff
Tr, yrs	m (mm/d)	m(in/d)	Q (m^3/s)
5	131.5	5.2	8.2
10	161.7	6.4	10.1
15	181.0	7.1	11.3
20	195.6	7.7	12.2
30	217.5	8.6	13.6
50	247.5	9.7	15.5

Table 5 – Lot 3 Drainage Modulus

The drainage pumps were both installed in 1924 and decades of land use changes resulted in the pumps being incapable of handling the drainage load. However, the National Drainage and Irrigation Authority (NDIA) has indicated their intentions to install two 100 cubic feet per sec pumps providing a total of 200 cubic feet per second for Lot 2 – Buxton. Likewise pumps of similar capacity should be installed for Lot 3 – Triumph.

3. Canals Hydraulic Design

The designs encompassed for the main, secondary and tertiary canals system were based on the conveyance requirements to meet the crop water requirements at the field level. The total freshwater volume supplied was founded on the premise of the maximum water demand over the growth stages of the crops being considered. The canals conveyance system was then designed to satisfy the total freshwater volume from the source to the field.

The crops considered during this assessment are presented in Table 6 along with their basic physical description. The Chapter that follows elaborates on the design procedure involved towards the quantification of the gross irrigation requirements. Design Module 2 (DM2) presents the canal system design concept along with the hydraulic design requirements.

4. Crop Water Requirement

Crop water requirement is defined as "the depth of water needed to meet the water loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields under non-restricting soil conditions including soil water and fertility and achieving full production potential under the given growing environment” (Source: FAO ISSN 0254-5284). Considering all other conditions being equal, this depth is dependent on the type of crop and the prevailing environmental demand.

Evapotranspiration (ET)

Evaporation is the process whereby water in its liquid form is converted to its gaseous form (water vapor) and removed from the evaporating surface. Water evaporates from a variety of surfaces, such as lakes, rivers, pavements, soils and wet vegetation.

Transpiration consists of the vaporization of water in its liquid form contained in plant tissues and the vapor being transpired into the atmosphere in its gaseous form. Crops predominately lose their water through stomata. These are small openings on the plant leaf through which gases and water vapor pass. Evaporation and transpiration occur simultaneously and there is no easy way of distinguishing between the two processes. Apart from the water availability in the topsoil, the evaporation from a cropped soil is mainly determined by the fraction of the solar radiation reaching the soil surface. This fraction decreases over the growing period as the crop develops and the crop canopy shades more and more of the ground area. When the crop is small, water is predominately lost by soil evaporation, but once the crop is well developed and completely covers the soil, transpiration becomes the main process.

For this project Evapotranspiration was calculated using the pan evaporation method then verified by the Penman-Montieth method through manual calculations. The assessment was also supplemented by modeling using CROPWAT. The subchapters which follow elaborates on the methods employed to quantify the total irrigation requirement for the RAID Projects areas.

Pan Evaporation Method

The Pan Evaporation method is a simple and efficient method of calculating evapotranspiration. In the absence of rain, the amount of water evaporated during a period (mm/day) corresponds with the decrease in water depth in that period. Pans provide a measurement of the integrated effect of radiation, wind, temperature, and humidity on the evaporation from an open water surface. Although the pan responds in a similar fashion to the same climatic factors affecting crop transpiration, several factors produce significant differences in loss of water from a water surface and from a cropped surface such as refraction, storage of heat within the pan, etc.

Notwithstanding the difference between pan-evaporation and the evapotranspiration of cropped surfaces, the use of pans to predict ET_o for periods of 10 days or longer may be warranted. The pan evaporation is related to the reference evapotranspiration by an empirically derived pan coefficient:

$ET_o = K_p E_{pan}$

where

ET_o reference evapotranspiration [mm/day]
K_p pan coefficient [-]
E_{pan} pan evaporation [mm/day]

Penman-Monteith Method

In 1948, Penman combined the energy balance with the mass transfer method and derived an equation to compute the evaporation from an open water surface from standard climatological records of sunshine, temperature, humidity and wind speed. This so-called combination method was further developed by many researchers and extended to cropped surfaces by introducing resistance factors.

The resistance nomenclature distinguishes between aerodynamic resistance and surface resistance factors. The surface resistance parameters are often combined into one parameter, the 'bulk' surface resistance parameter which operates in series with the aerodynamic resistance. The surface resistance, r_s, describes the resistance of vapor flow through stomata openings, total leaf area, and soil surface. The aerodynamic resistance, r_a, describes the resistance from the vegetation upward and involves friction from air flowing over vegetative surfaces. Although the exchange process in a vegetation layer is too complex to be fully described by the two resistance factors, good correlations can be obtained between measured and calculated evapotranspiration rates, especially for a uniform grass reference surface (Source FAO website).

The Penman-Monteith approach as formulated above includes all parameters that govern energy exchange and corresponding latent heat flux (evapotranspiration) from uniform expanses of vegetation. Most of the parameters are measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration as the surface and aerodynamic resistances are crop specific.

A consultation of experts and researchers was organized by FAO in May 1990, in collaboration with the International Commission for Irrigation and Drainage and with the World Meteorological Organization, to review the FAO methodologies on crop water requirements and to advise on the revision and update of procedures.

The panel of experts recommended the adoption of the Penman-Monteith combination method as a new standard for reference evapotranspiration and advised on procedures for calculation of the various parameters. By defining the reference crop as a hypothetical crop with an assumed height of 0.12 m having a surface resistance of 70 s m^{-1} and an albedo of 0.23, closely resembling the evaporation of an extension surface of green grass of uniform height, actively growing and adequately watered, the FAO Penman-Monteith method was developed. The method overcomes shortcomings of the previous FAO Penman method and provides values more consistent with actual crop water use data worldwide.

From the original Penman-Monteith equation and the equations of the aerodynamic and surface resistance, the FAO Penman-Monteith method to estimate ET_o can be derived:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)}$$

where

ET_o reference evapotranspiration [mm day^{-1}]
R_n net radiation at the crop surface [MJ m^{-2} day^{-1}]
G soil heat flux density [MJ m^{-2} day^{-1}]
T mean daily air temperature at 2 m height [°C]
u_2 wind speed at 2 m height [m s^{-1}]
e_s saturation vapor pressure [kPa]
e_a actual vapor pressure [kPa]
e_s - e_a saturation vapour pressure deficit [kPa]
D slope vapour pressure curve [kPa $°C^{-1}$]
g psychrometric constant [kPa $°C^{-1}$]

CropWat

CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. All calculation procedures used are based on the two FAO publications of the Irrigation and Drainage Series, namely, No. 56 "Crop Evapotranspiration - Guidelines for computing crop water requirements” and No. 33 titled "Yield response to water".

Crops proposed for cultivation

The following is the recommended list of crops that were proposed for cultivation as part of the RAID project areas. This list was provided by the Ministry of Agriculture through careful consideration of its economic value and possible sustainability in the respective areas.

Group No.	Common Name of Commodity	Scientific Name of Commodity	Classification (Rotation)	Number of Crops/year	Annual Volume of Production (Yield)	Rooting Depth (cm)
1	Plantain	Musa. Paradisiaca	Fruit crop	One (Annual)	One (Annual)	50
	Banana	Musa. Acuminata	Fruit crop	One (Annual)	One (Annual)	50
	Coconut	Cocos nucifera	Fruit crop	One (Annual)	One (Annual)	100
	Mango	Mangifera indica	Fruit crop	One (Annual)	One (Annual)	100
2	Cabbage	Brassica oleracea	Leafy Vegetable	Two (Biannual)	Two (Biannual)	50
	Broccoli	Brassica oleracea italica	Leafy Vegetable	Two (Biannual)	Two (Biannual)	40
3	Cassava	Manihot esculenta	Root crop	One (Annual)	One (Annual)	60
	Sweet Potatoes	Ipomoea batatas	Root crop	Three (Perennial)	Three (Perennial)	100
	Ginger	Zingiber officinale	Root crop	One (Annual)	One (Annual)	
4	Beans	Vigna unguiculata	Legume	Three (Perennial)	Three (Perennial)	60
	Pigeon Peas	Cajanus cajan	Legume	One /three Perennial)	One /three Perennial)	60
	Sweet corn	Zea mays	Legume	Two (Biannual)	Two (Biannual)	90

Table 6 - Crops proposed for cultivation

Design Summary

Of the crops proposed for cultivation, Sweet Potatoes and Pigeon Peas were determined to have the highest crop evapotranspiration (ETcrop) since they have the highest crop coefficients. The critical ETcrop was the same for each crop since they both have the same critical crop coefficient.
The ETcrop was computed using each of the aforementioned methods and a summary of the maximum values (ETcropmax) was summarized in the following table.

Method	$ET_{cropmax}$ (mm/d)
Pan Evaporation Method	6.1
Penman-Monteith Method (Manual Calculations)	9.04
Cropwat	5.71

Table 7 - Summary of Results obtained for ETcropmax

The method with the highest ETcropmax value was the Penman-Monteith method. However, these computations needed data that was not locally available and were done using generic values. The results were not found to be reliable and therefore were not used for this project. The Pan Evaporation Method provided the second highest ETcropmax value of 6.1 mm/d. This was considered reliable since it includes the effect of radiation, wind, temperature, and humidity and was therefore endorsed for this project. Irrigation efficiencies of 60% field application, 70% field canal and 85% conveyance were subsequently applied giving a combined system efficiency of 35.7%. This resulted in a total of 17.1mm/d requirement and was used to calculate a total discharge for each individual lot as, refer to Table 8.

Lot	Area (km2)	Total Discharge (m3/s)
1: Ithaca	3.6	0.71
2: Buxton	6.3	1.25
3: Triumph	3.6	0.71

Table 8 - Summary of Crop Water Requirement

5. Hydraulic Design Summary

In an attempt to present a simplistic overview of the designs proposed in its entirety for the respective lots this chapter seeks to tabulate and group these designs accordingly. The works are classified as either new or existing drains and canals, irrigation and drainage structures, and access dams. The respective lengths of the channels are provided and the executing agency presented. However, the agencies responsible for the execution of the works both fall under the purview of the Ministry of Agriculture. As such this may be subject to change at the direction of the client.

Lot 1 – Ithaca

Item No.	Description of Works	Length (m)	Executing Agency
1.0	**Grading and Shaping of Existing Drains**		
1.1	MD1 – Main Drain 1	10,020	ASDU
	Section 2 of MD2 – Main Drain 2	2,320	ASDU
2.0	**Construction of New Drains**		
2.1	Section 1 of MD2 – Main Drain 2	2,600	ASDU
2.2	SD1 – Secondary Drain 1	820	NDIA
2.3	TD1 – Tertiary Drain 1	400	NDIA
3.0	**Construction of New Canals**		
3.1	MC1 – Main Canal 1	5,100	ASDU
3.2	MC2 – Main Canal 2	3,420	ASDU
3.3	SC1 – Secondary Canal 1	1,320	NDIA
3.4	SC2 – Secondary Canal 2	760	NDIA
4.0	**Construction of Irrigation Structures**		
4.1	IS_1 – Intake Structure 1 on SC1		NDIA
4.2	IS_2 – Intake Structure 2 on SC2		NDIA
4.3	C_2 – Culvert 2 on MC2		ASDU
5.0	**Construction of Drainage Structures**		
5.1	C_1 – Culvert 1		ASDU
5.2	C_3 – Culvert 3 on TD1		NDIA
5.3	C_4 – Culvert 4 on SD1		NDIA
5.4	TR_1 – Tail Regulator 1 on MD1		NDIA
5.5	TR_2 – Tail Regulator 2 on MC1		NDIA
5.6	TR_3 – Tail Regulator 3 on MC2		NDIA
5.7	Outfall Sluice		NDIA
6.0	**Rehabilitation/Provision of Main Access Dams**		
6.1	Access Dam North of MD1 from Evan's Canal to "New Crown Dam"	4,520	ASDU
6.2	Ithaca/Zorg en Hoop Sideline dam from residential street to "New Crown Dam"	3,460	ASDU
6.3	Access Dam to plots 2ac_2 to 2ac_7 (South of MD2)	540	ASDU
6.4	Access Dam to plots 1ac_1 to 2_ac1 (North of MD1)	260	ASDU
6.5	Access Dams north and south of Section 1 MD2	5,200	NDIA
6.6	Access Dam east of SD1	820	NDIA
7.0	**Construction of Structures for Access**		
7.1	TB1 – Timber Bridge 1		ASDU

7.2	TB2 – Timber Bridge 2		ASDU
7.3	TB3 – Timber Bridge 3		NDIA

Table 9 – Lot 1 Design Summary

Lot 2 – Buxton

Item No.	Description of Works	Length (m)	Executing Agency
1.0	**Grading and Shaping of Existing Drains**		
1.1	BX-MD1 – Buxton Main Drain No. 1	10,200	ASDU
1.2	BX-MD2 – Buxton Main Drain No. 2	10,460	ASDU
1.3	FS-MD1 – Friendship Main Drain No. 1	10,500	ASDU
1.4	FS-MD2 – Friendship Main Drain No. 2	10,200	ASDU
2.0	**Grading and Shaping of Existing Canals**		
2.1	FS-MC1 – Friendship Main Canal No. 1	8,300	ASDU
2.2	BX-MC1 – Buxton Main Canal No. 1	8,340	ASDU
2.3	BX_FS-MC1 – Buxton Friendship Main Canal No. 1	12,250	ASDU
3.0	**Construction of Irrigation Structures**		
3.1	BX-IS1 – Buxton Intake Structure No. 1		ASDU
3.2	FS-IS1 – Friendship Intake Structure No. 1		ASDU
3.3	BX_FS-CS1 – Buxton Friendship Control Structure No. 1		ASDU
4.0	**Construction of Drainage Structures**		
4.1	BX-PStn – Buxton Pump Station		NDIA
5.0	**Rehabilitation/Provision of Main Access Dams**		
5.1	Buxton-Annandale Sideline (West of BX-MD2)	8,460	NDIA
5.2	Company Path (East of BX-MD1)	10,250	NDIA
5.3	Brush Dam (East of FS-MD1)	8,300	NDIA
6.0	**Desilting of Storage/Holding Area to the North of Buxton Pump Station**		NDIA

Table 10 – Lot 2 Design Summary

Note:

- The approved excavated material from the existing drains shall be placed to one side of the embankment at a maximum height of 1m to dry out in anticipation to be used for the rehabilitation/provision of the Main Access Dams

- The Main Access Dams along Buxton-Annandale Sideline and Brush Dam, at the intersection with the CNC, shall see the CNC being filled with approved earthen material to maintain continuity for the main access dams.

Lot 3 – Triumph

Item No.	Description of Works	Length (m)	Executing Agency
1.0	**Grading and Shaping of Existing Drains**		
1.1	TRI-MD1 – Triumph Main Drain No. 1	8,000	NDIA
1.2	TRI-MD2 – Triumph Main Drain No. 2	8,060	NDIA
1.3	BV-MD1 – Beterverwagting Main Drain No. 1	8,140	NDIA
1.4	BV-MD2 – Beterverwagting Main Drain No. 2	1,820	NDIA
1.5	PR-MD1 – Public Road Main Drain No. 1	700	NDIA
2.0	**Grading and Shaping of Existing Canals**		
2.1	TRI-MC1 – Triumph Main Canal No. 1	6,580	ASDU
2.2	BV-MC1 – Beterverwagting Main Canal No. 1	6,360	ASDU
2.3	CNC-MC1 – CNC Main Canal No. 1	580	ASDU
3.0	**Construction of Irrigation Structures**		
3.1	IS_01 – Intake Structure No. 1 along BV-MC1		ASDU
3.2	IS_02 – Intake Structure No. 2 along TRI-MC1		ASDU
3.3	SPW-01 – Spillweir No. 1 at Eastern end of CNC		ASDU
3.4	SPW-02 – Spillweir No. 2 at Western end of CNC		ASDU
4.0	**Construction of Drainage Structures**		
4.1	TR_01 – Tail Regulator No. 1 at end of BV-MC1		ASDU*
4.2	TR_02 – Tail Regulator No. 2 at end of TRI_MC1		ASDU*
4.3	C1 – Culvert No. 1 along BV-MD2		ASDU
4.4	TR_03 – Tail Regulator No. 3 on BV-MD2 at Railway		NDIA
4.5	TRI-PStn – Triumph Pump Station		NDIA
5.0	**Rehabilitation/Provision of Main Access Dams**		
5.1	Agriculture Road from Duck Pond to CNC	3,000	NDIA
5.2	Republic Drive from the end of A.C. Road to CNC	6,500	NDIA

Table 11 – Lot 3 Design Summary

*Note:

- Due to budgetary constraints tail regulators, TR_01 and TR_02 shall be implemented as a simple earthen dam with HDPE pipes. However, it should be noted that the design calls for a reinforced concrete structure with a vertical lift gate to provide the needed control.