# THE JANAKPUR ZONE AGRICULTURE DEVELOPMENT PROJECT IN THE KINGDOM OF NEPAL



# DESIGN NOTE ON THE DETAILED DESIGN FOR IRRIGATED MODEL FARM SCHEME, SHALLOW TUBE-WELL PROGRAMME

DECEMBER 1980



JAPAN INTERNATIONAL COOPERATION AGENCY

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ATTACHED TABLE AND FIGURE

## I. GENERAL

This note presents design calculations made in the detailed designs for Irrigated Model Farm Scheme. The note is to be read in conjunction with Report on Implementation and Design for Shallow Tubewell Programme, Design Drawings and Tender Document.

## II. HYDRAULIC CALCULATION

### 2.1 Irrigation Canals

#### 2.1.1 Hydraulic Formula

For the hydraulic calculations of irrigation canals, Manning formula is employed as shown below:

$$Q = A \times V$$

$$V = \frac{1}{n} \times R^{2/3} \times I^{1/2}$$

where, Q : Discharge ($m^3/s$)
A : Cross sectional area ($m^2$)
V : Mean velocity (m/s)
R : Hydraulic radius (m)
I : Hydraulic gradient
n : Coefficient of roughness

#### 2.1.2 Coefficient of Roughness

Coefficient of roughnesses applied to Manning formula are as follows:

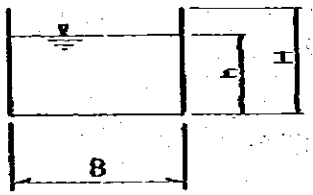
| | | |
|---|---|---|
| Brick lined canal | : | 0.020 |
| Earth canal | : | 0.030 |
| Precast concrete pipe | : | 0.015 |

### 2.1.3 Type of Canal

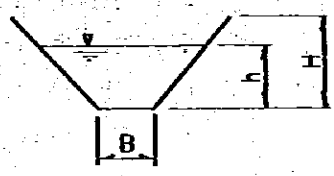
Irrigation canal consists of main and branch canals. The main canal is brick-lined rectangular open channel and the branch canal is earthern trapezoidal open channel with a side slope of 1:1.

The irrigation canals are classified into five according to the discharge, hydraulic gradient and shape as shown below:

| Type of canal | B (m) | H (m) | h (m) | I | V (m/s) | Q ($m^3$/s) |
|---|---|---|---|---|---|---|
| **Shallow tubewell areas** | | | | | | |
| Main canal A-1 | 0.30 | 0.21 | 0.11 | 1/500 | 0.36 | 0.012 |
| Main canal A-2 | 0.30 | 0.21 | 0.14 | 1/1,000 | 0.28 | 0.012 |
| Branch canal B | 0.30 | 0.30 | 0.11 - 0.16 | 1/500 - 1/2,000 | 0.16 - 0.27 | 0.012 |
| **Deep tubewell area** | | | | | | |
| Main canal C | 0.40 | 0.44 | 0.34 | 1/2,000 | 0.29 | 0.042 |
| Main canal D-1 | 0.40 | 0.28 | 0.21 | 1/500 | 0.49 | 0.042 |
| Main canal D-2 | 0.40 | 0.35 | 0.28 | 1/1,000 | 0.38 | 0.042 |




Main Canal




Branch Canal

### 2.1.4 Hydraulic Calculations

Hydraulic calculations of the main canals are shown in attached Table-1.

## 2.2 V-notch

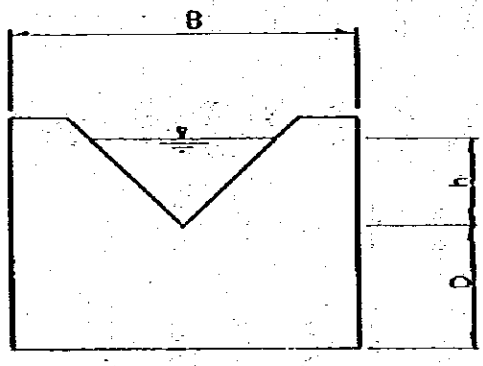
### 2.2.1 Hydraulic Formula

To measure a discharge of the flow, a V-notch is so designed as to be installed at the baffle tank. The following formula is employed for the hydraulic calculations:

$$Q = C \cdot h^{\frac{5}{2}}$$

$$C = 1.354 + \frac{0.004}{h} + (0.14 + \frac{0.2}{\sqrt{D}}) \times (\frac{h}{B} - 0.09)^2$$

where, Q : Discharge ($m^3/s$)
h : Overfloving water depth (m)
C : Coefficient of discharge




### 2.2.2 Hydraulic Calculations

Overfloving water depth (h) is calculated as shown below by using the above formula:

| Area | Q ($m^3/s$) | B (m) | D (m) | h (m) |
|---|---|---|---|---|
| Shallow tubewell | 0.012 | 0.70 | 0.70 | 0.15 |
| Deep tubewell | 0.042 | 1.00 | 0.80 | 0.25 |

# Table-1 Hydraulic Properties of Main Canals

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Base EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INVARIGUR AREA MC-1 Main Canal (Canal Length = 1175 m) | | | | | | | | | | | | | |
| No.0 | | | 0.00 | | | | 10.70 | 0.36 | 0.01 | 10.69 | 0.11 | 10.58 | BP of MC-1 |
| | 0.012 | 0.25 | | Canal type A-1 | 1/500 | 0.01 | | | | | | | |
| No.0+0.25 | | | 0.25 | | | | 10.69 | 0.36 | 0.01 | 10.68 | 0.11 | 10.57 | |
| | | | | No.1, 2 OL | | 0.02 | | | | | | | No.1 OL (L, BC-1), No.2 OL (R, BC-2) |
| No.0+0.25 | | | 0.25 | | | | 10.67 | 0.36 | 0.01 | 10.66 | 0.11 | 10.55 | |
| | 0.012 | 42.75 | | Canal type A-1 | 1/500 | 0.09 | | | | | | | |
| No.0+43.00 | | | 43.00 | | | | 10.58 | 0.36 | 0.01 | 10.57 | 0.11 | 10.46 | |
| | | | | No.1 DR | | 0.40 | | | | | | | D = 0.4 m |
| No.0+43.00 | | | 43.00 | | | | 10.18 | 0.36 | 0.01 | 10.17 | 0.11 | 10.06 | |
| | 0.012 | 53.00 | | Canal type A-1 | 1/500 | 0.11 | | | | | | | |
| No.1+46.00 | | | 96.00 | | | | 10.07 | 0.36 | 0.01 | 10.06 | 0.11 | 9.95 | |
| | | | | No.1 AB | | 0.02 | | | | | | | |
| No.1+46.00 | | | 96.00 | | | | 10.05 | 0.36 | 0.01 | 10.04 | 0.11 | 9.93 | |
| | 0.012 | 39.00 | | Canal type A-1 | 1/500 | 0.08 | | | | | | | |
| No.2+35.00 | | | 135.00 | | | | 9.97 | 0.36 | 0.01 | 9.96 | 0.11 | 9.85 | |
| | | | | No.3, 4 OL | | | | | | | | | No.3 OL (L, BC-4), No.4 OL (R, BC-3) |
| No.2+35.00 | | | 135.00 | | | | | | | | | | EP of MC-1 |
| OONMALA AREA MC-1 Main Canal (Canal Length = 142 m) | | | | | | | | | | | | | |
| No.0 | | | 0.00 | | | | 9.51 | 0.28 | 0.01 | 9.50 | 0.14 | 9.36 | BP of MC-1 |
| | 0.012 | 2.60 | | Canal type A-2 | 1/1,000 | 0.00 | | | | | | | |
| No.0+2.60 | | | 2.60 | | | | 9.51 | 0.28 | 0.01 | 9.50 | 0.14 | 9.36 | |
| | | | | No.1, 2 OL | | 0.20 | | | | | | | No.1 OL (L, BC-1), No.2 OL (R, BC-2) |
| No.0+2.60 | | | 2.60 | | | | 9.31 | 0.28 | 0.01 | 9.30 | 0.14 | 9.16 | |
| | 0.012 | 63.40 | | Canal type A-2 | 1/1,000 | 0.06 | | | | | | | |
| No.1+16.00 | | | 66.00 | | | | 9.25 | 0.28 | 0.01 | 9.24 | 0.14 | 9.10 | |
| | | | | No.3, 4 OL | | 0.20 | | | | | | | No.3 OL (L, BC-3), No.4 OL (R, BC-4) |
| No.1+16.00 | | | 66.00 | | | | 9.05 | 0.28 | 0.01 | 9.04 | 0.14 | 8.90 | |
| | 0.012 | 76.00 | | Canal type A-2 | 1/1,000 | 0.08 | | | | | | | |

- to be continued -

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Base EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.2+42.00 | | | 142.00 | | | | 8.97 | 0.28 | 0.01 | 8.96 | 0.14 | 8.82 | |
| | | | | No.5, 6 OL | | | | | | | | | No.5 OL (S, BC-5), No.6 OL (R, BC-6) |
| No.2+42.00 | | | 142.00 | | | | | | | | | | EP of MC-1 |
| NAPHY AREA MC-1 Main Canal (Canal Length = 67 m) | | | | | | | | | | | | | |
| No.0 | | | 0.00 | | | | 9.18 | 0.28 | 0.01 | 9.17 | 0.14 | 9.03 | BP of MC-1 |
| | 0.012 | 67.00 | | Canal type A-2 | 1/1,000 | 0.07 | | | | | | | |
| No.1+17.00 | | | 67.00 | | | | 9.11 | 0.28 | 0.01 | 9.10 | 0.14 | 8.96 | |
| | | | | No.1, 2 OL | | | | | | | | | No.1 OL (L, BC-3), No.2 OL (S, BC-2) |
| No.1+17.00 | | | 67.00 | | | | | | | | | | EP of MC-1 |
| NAPHY AREA MC-2 Main Canal (Canal Length = 182 m) | | | | | | | | | | | | | |
| No.0 | | | 0.00 | | | | 9.53 | 0.28 | 0.01 | 9.52 | 0.14 | 9.38 | BP of MC-1 |
| | 0.012 | 3.40 | | Canal type A-2 | 1/1,000 | 0.00 | | | | | | | |
| No.0+3.40 | | | 3.40 | | | | 9.53 | 0.28 | 0.01 | 9.52 | 0.14 | 9.38 | |
| | | | | No.1 AB | | 0.02 | | | | | | | No.1 AB (L, BC-1) |
| No.0+3.40 | | | 3.40 | | | | 9.51 | 0.28 | 0.01 | 9.50 | 0.14 | 9.36 | |
| | 0.012 | 49.60 | | Canal type A-2 | 1/1,000 | 0.05 | | | | | | | |
| No.1+3.00 | | | 53.00 | | | | 9.46 | 0.28 | 0.01 | 9.45 | 0.14 | 9.31 | |
| | | | | No.1 OL | | 0.02 | | | | | | | No.1 OL (R, BC-4) |
| No.1+3.00 | | | 53.00 | | | | 9.44 | 0.28 | 0.01 | 9.43 | 0.14 | 9.29 | |
| | 0.012 | 61.00 | | Canal type A-2 | 1/1,000 | 0.06 | | | | | | | |
| No.2+14.00 | | | 114.00 | | | | 9.38 | 0.28 | 0.01 | 9.37 | 0.14 | 9.23 | |
| | | | | No.2 AB | | 0.02 | | | | | | | |
| No.2+14.00 | | | 114.00 | | | | 9.36 | 0.28 | 0.01 | 9.35 | 0.14 | 9.21 | |
| | 0.012 | 7.00 | | Canal type A-2 | 1/1,000 | 0.01 | | | | | | | |
| No.2+21.00 | | | 121.00 | | | | 9.35 | 0.28 | 0.01 | 9.34 | 0.14 | 9.20 | |
| | | | | No.2, 3 OL | | 0.20 | | | | | | | No.2 OL (L, BC-5), No.3 OL (R, OL only) |
| No.2+21.00 | | | 121.00 | | | | 9.15 | 0.28 | 0.01 | 9.14 | 0.14 | 9.00 | |
| | 0.012 | 61.00 | | Canal type A-2 | 1/1,000 | 0.06 | | | | | | | |
| No.3+32.00 | | | 182.00 | | | | 9.09 | 0.28 | 0.01 | 9.08 | 0.14 | 8.94 | |
| | | | | No.4 OL | | | | | | | | | No.4 OL (S, BC-6) |
| No.3+32.00 | | | 182.00 | | | | | | | | | | EP of MC-2 |

- to be continued -

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL. (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Base EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAKHUWA AREA MC-1 Main Canal (Canal Length = 210 m) | | | | | | | | | | | | | |
| No.0 | | | 0.00 | | | | 10.26 | 0.36 | 0.01 | 10.25 | 0.11 | 10.14 | BP of MC-1 |
| | 0.012 | 4.00 | | Canal type A-1 | 1/500 | 0.01 | | | | | | | |
| No.0+4.00 | | | 4.00 | | | | 10.25 | 0.36 | 0.01 | 10.24 | 0.11 | 10.13 | |
| | | | | No.3, 4 OL | | 0.30 | | | | | | | No.3 OL (L), No.4 OL (R) |
| No.0+4.00 | | | 4.00 | | | | 9.95 | 0.36 | 0.01 | 9.94 | 0.11 | 9.83 | |
| | 0.012 | 78.00 | | Canal type A-1 | 1/500 | 0.17 | | | | | | | |
| No.1+82.00 | | | 82.00 | | | | 9.78 | 0.36 | 0.01 | 9.77 | 0.11 | 9.66 | |
| | | | | No.1 DR | | 0.40 | | | | | | | D = 0.4 m |
| No.1+82.00 | | | 82.00 | | | | 9.38 | 0.36 | 0.01 | 9.37 | 0.11 | 9.26 | |
| | 0.012 | 39.00 | | Canal type A-1 | 1/500 | 0.08 | | | | | | | |
| No.2+21.00 | | | 121.00 | | | | 9.30 | 0.36 | 0.01 | 9.29 | 0.11 | 9.18 | BP of No.1 SY |
| | 0.042 | 11.30 | | No.1 SY | | 0.19 | | | | | | | |
| No.2+32.30 | | | 132.30 | | | | 9.11 | 0.36 | 0.01 | 9.10 | 0.11 | 8.99 | EP of No 1 SY |
| | 0.012 | 2.00 | | Canal type A-1 | 1/500 | 0.00 | | | | | | | |
| No.2+34.30 | | | 134.30 | | | | 9.11 | 0.36 | 0.01 | 9.10 | 0.11 | 8.99 | |
| | | | | No.5, 6 OL | | 0.02 | | | | | | | No.5 OL (L), No.6 OL (R) |
| No.2+34.30 | | | 134.30 | | | | 9.09 | 0.36 | 0.01 | 9.08 | 0.11 | 8.97 | |
| | 0.012 | 35.70 | | Canal type A-1 | 1/500 | 0.07 | | | | | | | |
| No.3+20.00 | | | 170.00 | | | | 9.02 | 0.36 | 0.01 | 9.01 | 0.11 | 8.90 | |
| | | | | No.2 DR | | 0.30 | | | | | | | D = 0.3 m |
| No.3+20.00 | | | 170.00 | | | | 8.72 | 0.36 | 0.01 | 8.71 | 0.11 | 8.60 | |
| | 0.012 | 40.00 | | Canal type A-1 | 1/500 | 0.08 | | | | | | | |
| No.4+10.00 | | | 210.00 | | | | 8.64 | 0.36 | 0.01 | 8.63 | 0.11 | 8.53 | |
| | | | | No.7, 8 OL | | | | | | | | | No.7 OL (L), No.8 OL (S) |
| No.4+10.00 | | | 210.00 | | | | | | | | | | EP of MC-1 |
| IAP AREA MC-5-2 Main Canal (Canal Length = 700 m) | | | | | | | | | | | | | |
| No.40 | | | 0.00 | | | | 96.98 | 0.38 | 0.01 | 96.97 | 0.28 | 96.69 | BP of MC-5-2 |
| | 0.042 | 2.00 | | Canal type D-2 | 1/1,000 | 0.00 | | | | | | | |
| No.40+2.00 | | | 2.00 | | | | 96.98 | 0.38 | 0.01 | 96.97 | 0.28 | 96.69 | |
| | | | | No.1, 2 OL | | 0.02 | | | | | | | No.1 OL (L), No.2 OL (R) |

- to be continued -

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL. (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Bank EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.40+2.00 | | | 2.00 | | | | 96.96 | 0.38 | 0.01 | 96.95 | 0.28 | 96.67 | |
| | 0.042 | 98.00 | | Canal type D=2 | 1/1,000 | 0.10 | | | | | | | |
| No.41 | | | 100.00 | | | | 96.86 | 0.38 | 0.01 | 96.85 | 0.28 | 96.57 | |
| | | | | No.3, 4 OL | | 0.02 | | | | | | | No.3 OL (L), No.4 OL (R) |
| No.41 | | | 100.00 | | | | 96.84 | 0.49 | 0.01 | 96.83 | 0.21 | 96.62 | |
| | 0.042 | 7.80 | | Canal type D=1 | 1/500 | 0.02 | | | | | | | |
| No.41+7.80 | | | 107.80 | | | | 96.82 | 0.49 | 0.01 | 96.81 | 0.21 | 96.60 | |
| | | | | No.1 DR | | 0.40 | | | | | | | D = 0.4 m |
| No.41+7.80 | | | 107.80 | | | | 96.42 | 0.49 | 0.01 | 96.41 | 0.21 | 96.20 | |
| | 0.042 | 92.20 | | Canal type D=1 | 1/500 | 0.18 | | | | | | | |
| No.42 | | | 200.00 | | | | 96.24 | 0.49 | 0.01 | 96.23 | 0.21 | 96.02 | |
| | | | | No.5, 6 OL | | 0.02 | | | | | | | No.5 OL (L), No.6 OL (R) |
| No.42 | | | 200.00 | | | | 96.22 | 0.49 | 0.01 | 96.21 | 0.21 | 96.00 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |
| No.43 | | | 300.00 | | | | 96.02 | 0.49 | 0.01 | 96.01 | 0.21 | 95.80 | |
| | | | | No.7, 8 OL | | 0.02 | | | | | | | No.7 OL (L), No.8 OL (R) |
| No.43 | | | 300.00 | | | | 96.00 | 0.49 | 0.01 | 95.99 | 0.21 | 95.78 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |
| No.44 | | | 400.00 | | | | 95.80 | 0.49 | 0.01 | 95.79 | 0.21 | 95.58 | |
| | | | | No.9, 10 OL | | 0.20 | | | | | | | No.9 OL (L), No.10 OL (R) |
| No.44 | | | 400.00 | | | | 95.60 | 0.38 | 0.01 | 95.59 | 0.28 | 95.31 | |
| | 0.042 | 100.00 | | Canal type D=2 | 1/1,000 | 0.10 | | | | | | | |
| No.45 | | | 500.00 | | | | 95.50 | 0.38 | 0.01 | 95.49 | 0.28 | 95.21 | |
| | | | | No.11, 12 OL | | 0.02 | | | | | | | No.11 OL (L), No.12 OL (R) |
| No.45 | | | 500.00 | | | | 95.48 | 0.38 | 0.01 | 95.47 | 0.28 | 95.19 | |
| | 0.042 | 100.00 | | Canal type D=2 | 1/1,000 | 0.10 | | | | | | | |
| No.46 | | | 600.00 | | | | 95.38 | 0.38 | 0.01 | 95.37 | 0.28 | 95.09 | |
| | | | | No.13, 14 OL | | 0.20 | | | | | | | No.13 OL (L), No.14 OL (R) |
| No.46 | | | 600.00 | | | | 95.18 | 0.38 | 0.01 | 95.17 | 0.28 | 94.89 | |
| | 0.042 | 100.00 | | Canal type D=2 | 1/1,000 | 0.10 | | | | | | | |
| No.47 | | | 700.00 | | | | 95.08 | 0.38 | 0.01 | 95.07 | 0.28 | 94.79 | |
| | | | | No.15, 16 OL | | | | | | | | | No.15 OL (L), No.16 OL (R) |
| No.47 | | | 700.00 | | | | | | | | | | EP of MC-3-2 |

- to be continued -

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL. (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Base EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAI ANUA MC-5-3 Main Canal (Canal Length = 700 m) | | | | | | | | | | | | | |
| No.50 | | | 0.00 | | | | 96.85 | 0.49 | 0.01 | 96.84 | 0.21 | 96.63 | BP of MC-5-3 |
| | 0.042 | 2.00 | | Canal type D=1 | 1/500 | 0.00 | | | | | | | |
| No.50+2.00 | | | 2.00 | | | | 96.85 | 0.49 | 0.01 | 96.84 | 0.21 | 96.63 | |
| | | | | No.1, 2 OL | | 0.02 | | | | | | | No.1 OL (L), No.2 OL (R) |
| No.50+2.00 | | | 2.00 | | | | 96.83 | 0.49 | 0.01 | 96.82 | 0.21 | 96.61 | |
| | 0.042 | 11.1 | | Canal type D=1 | 1/500 | 0.02 | | | | | | | |
| No.50+13.10 | | | 13.10 | | | | 96.81 | 0.49 | 0.01 | 96.80 | 0.21 | 96.59 | |
| | | | | No.1 DR | | 0.30 | | | | | | | D = 0.3 m |
| No.50+13.10 | | | 13.10 | | | | 96.51 | 0.49 | 0.01 | 96.50 | 0.21 | 96.29 | |
| | 0.042 | 33.10 | | Canal type D=1 | 1/500 | 0.07 | | | | | | | |
| No.50+46.20 | | | 46.20 | | | | 96.44 | 0.49 | 0.01 | 96.43 | 0.21 | 96.22 | |
| | | | | No.2 DR | | 0.20 | | | | | | | D = 0.2 m |
| No.50+46.20 | | | 46.20 | | | | 96.24 | 0.49 | 0.01 | 96.23 | 0.21 | 96.02 | |
| | 0.042 | 53.80 | | Canal type D=1 | 1/500 | 0.11 | | | | | | | |
| No.51 | | | 100.00 | | | | 96.13 | 0.49 | 0.01 | 96.12 | 0.21 | 95.91 | |
| | | | | No.3, 4 OL | | 0.02 | | | | | | | No.3 OL (L), No.4 OL (R) |
| No.51 | | | 100.00 | | | | 96.11 | 0.49 | 0.01 | 96.10 | 0.21 | 95.89 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |
| No.52 | | | 200.00 | | | | 95.91 | 0.49 | 0.01 | 95.90 | 0.21 | 95.69 | |
| | | | | No.5, 6 OL | | 0.02 | | | | | | | No.5 OL (L), No.6 OL (R) |
| No.52 | | | 200.00 | | | | 95.89 | 0.49 | 0.01 | 95.88 | 0.21 | 95.67 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |
| No.53 | | | 300.00 | | | | 95.69 | 0.49 | 0.01 | 95.68 | 0.21 | 95.47 | |
| | | | | No.7, 8 OL | | 0.02 | | | | | | | No.7 OL (L), No. 8 OL (R) |
| No.53 | | | 300.00 | | | | 95.67 | 0.49 | 0.01 | 95.66 | 0.21 | 95.45 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |
| No.54 | | | 400.00 | | | | 95.47 | 0.49 | 0.01 | 95.46 | 0.21 | 95.25 | |
| | | | | No.9, 10 OL | | 0.20 | | | | | | | No.9 OL (L), No.10 OL (R) |
| No.54 | | | 400.00 | | | | 95.27 | 0.49 | 0.01 | 95.26 | 0.21 | 95.05 | |
| | 0.042 | 100.00 | | Canal type D=1 | 1/500 | 0.20 | | | | | | | |

- to be continued -

| Station No. | Discharge ($m^3/s$) | Distance (m) | Reduced Distance (m) | Works | Energy Gradient | Energy Loss (m) | Energy Line EL (m) | Velocity (m/s) | Velocity Head (m) | Water Level (m) | Water Depth (m) | Canal Base EL. (m) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.55 | | | 500.00 | | | | 95.07 | 0.49 | 0.01 | 95.06 | 0.21 | 94.85 | |
| | | | | No.11, 12 OL | | 0.02 | | | | | | | No.11 OL (L), No.12 OL (R) |
| No.55 | | | 500.00 | | | | 95.05 | 0.49 | 0.01 | 95.04 | 0.21 | 94.83 | |
| | 0.042 | 100.00 | | Canal type D-1 | 1/500 | 0.20 | | | | | | | |
| No.56 | | | 600.00 | | | | 94.85 | 0.49 | 0.01 | 94.84 | 0.21 | 94.63 | |
| | | | | No.13, 14 OL | | 0.02 | | | | | | | No.13 OL (L), No. 14 OL (R) |
| No.56 | | | 600.00 | | | | 94.83 | 0.38 | 0.01 | 94.82 | 0.28 | 94.54 | |
| | 0.042 | 100.00 | | Canal type D-2 | 1/1,000 | 0.10 | | | | | | | |
| No.57 | | | 700.00 | | | | 94.73 | 0.38 | 0.01 | 94.72 | 0.28 | 94.44 | |
| | | | | No.15, 16 OL | | | | | | | | | No.15 OL (L), No.16 OL (R) |
| No.57 | | | 700.00 | | | | | | | | | | EP of MC-5-3 |

Notes
- BP: Beginning Point
- EP: Ending Point
- MC: Main Canal
- BC: Branch Canal
- DR: Drop Structure
- OL (L): Outlet Structure on the Left Bank
- OL (R): Outlet Structure on the Right Bank
- AB : Angle Box Structure

## III. PUMPING EQUIPMENT

### 3.1 Shallow Tubewell Areas

#### 3.1.1 Pumps and Engines

Specifications of pumps and engines to be installed at four shallow tubewell areas are as follows:

Discharge capacity : 1.2 $m^3$/min

Total head : 9 m

Type : Horizontal shaft, centrifugal and self-priming

Driving method : Driven by horizontal, single cylindered, water-cooled and tropicallized diesel engine

Diameter of pipe : 4 inches

#### 3.1.2 Accessories and Materials

Accessories and materials required for four sets of pump and engine are as follows:

(1) Steel common base (4 nos.)

(2) Standard tool kit for maintenance (4 sets)

(3) Starting handle (4 nos.)

(4) Materials listed below

| Name of parts | Material | Remarks | Q'ty |
|---|---|---|---|
| Piping | 5 kg/$cm^2$ carbon steel pipe | $\phi$ 4" | 16 m |
| Sleeve pipe | - ditto - | $\phi$ 6" | 1.0 m |
| Pipe fitting | steel butt-welding pipe fitting | $\phi$ 4" 90° elbow | 12 pcs |
| Flange | 5 kg/$cm^2$ steel pipe flange | $\phi$ 4" | 44 pcs |
| Suction unit | steel section | L60 x 60 x 5 | 10.8 m |
| - ditto - | steel plate | 400 x 400 x 9 | 4 pcs |

| Name of parts | Material | Remarks | Q'ty |
|---|---|---|---|
| Pipe support | - ditto - | 200 x 255 x 6 | 4 pcs |
| - ditto - | - ditto - | 190 x 90 x 6 | 4 pcs |
| End plate | - ditto - | $\phi$ 200 x 6 | 4 pcs |
| Anchor bolts & nuts | | M16 x 200L | 24 sets |
| Bolts & nuts | | M16 x 30L | 32 sets |
| - ditto - | | M16 x 55L | 224 sets |
| U bolts & nuts | | M10 x 165L | 4 sets |
| Sluice valve | 5 kg/cm$^2$ cast iron flanged gate valve | $\phi$ 4" | 4 sets |

3.2 Deep Tubewell Area

3.2.1 Pump

Specification of pump and engine to be installed at Irrigation Water Block No.5 in IAP area is as follows:

Discharge capacity : 2.52 m$^3$/min

Total head : 9 m

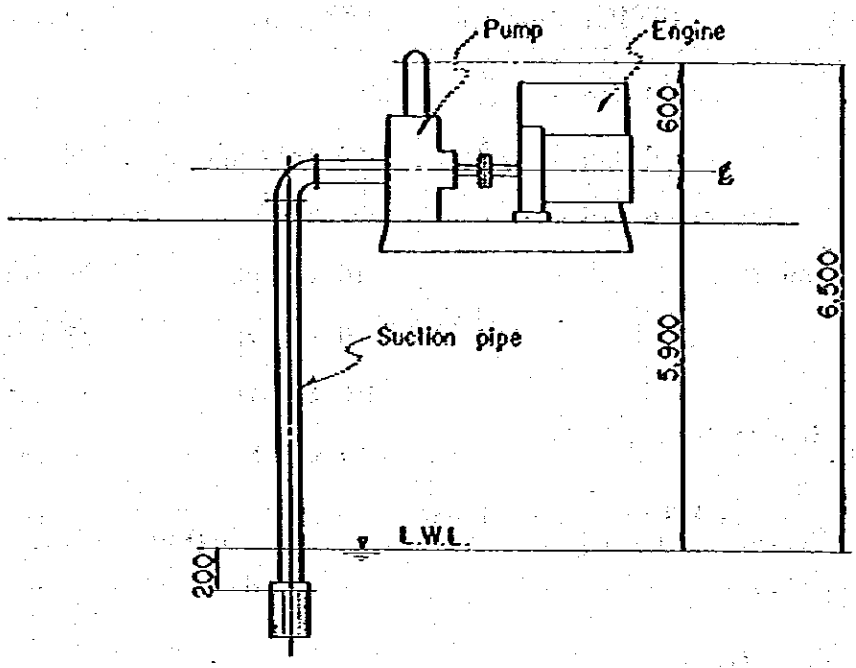
Type : Horizontal shaft and centrifugal

Driving method : Driven by diesel engine

Diameter of pipe : 6 inches

3.2.2 Engine

The engine to be used as prime mover is specified to be a horizontal, single cylindered, water-cooled and tropicallized. The required horse-power is estimated at eleven as follows:




$$H = Ha + Hb$$

$$Hb = h_f + h_v$$

$$h_f = \lambda \times \frac{L}{D} \times \frac{V^2}{2g}$$

$$h_v = \Sigma \zeta \times \frac{V^2}{2g}$$

where, H : Total head (m)

Ha : Actual head (6.5 m)

Hb : Loss of head (m)

$h_f$ : Friction loss of head (m)

$h_v$ : Loss of head due to bend etc. (m)

L : Pipe length (14 m)

D : Diameter of pipe (0.15 m)

V : Velocity (2.377 m/s)

$\lambda$ : Coefficient of friction loss of head (0.03)

$\zeta$ : Coefficient of loss of head due to bend etc.

Then, $h_f$ and $h_v$ become 0.807 m and 0.676 m, respectively as shown below:

$$h_f = 0.03 \times \frac{14}{0.15} \times \frac{2.377^2}{2 \times 9.8} = 0.807 \text{ (m)}$$

| Pipe | $\xi$ | $V^2/2g$ (m) | $h_f$ (m) |
|---|---|---|---|
| inflow | 0.3 x 1 | 0.288 | 0.086 |
| bend | 0.15 x 5 | 0.288 | 0.216 |
| valve | 0.15 x 2 | 0.288 | 0.086 |
| outflow | 1 | 0.288 | 0.288 |
| Total | | | $h_v$ = 0.676 |

Therefore, H and Hb become as follows:

$$Hb = h_f + h_v = 0.807 + 0.676 \doteq 1.5 \text{ (m)}$$

$$H = Ha + Hb = 6.5 + 1.5 = 8 \text{ (m)} \longrightarrow 9 \text{ (m)}$$

The required horsepower is estimated by using following formula:

$$P = \frac{0.222 \times \gamma \times H \times Q}{\eta} \times (1 + \alpha)$$

where, P : Required horsepower (pH)
$\gamma$ : Specific gravity of water (1.0)
H : Total head (9 m)
Q : Discharge (2.52 $m^3$/min)
$\eta$ : Pump efficiency (0.6)
$\alpha$ : Allowance (0.30)

$$P = \frac{0.222 \times 1 \times 9 \times 2.52}{0.6} \times (1 + 0.3) \doteq 10.91$$

say 11.0

### 3.2.3 Accessories and Materials

Accessories and materials required for the pump and engine described above are as follows:

(1) Steel common base and anchor bolts (1 no.)

(2) Standard tool kit for maintenance (1 set)

(3) Starting handle (1 no.)

(4) Materials listed below

| Name of part | Material | Remarks | Q'ty |
|---|---|---|---|
| Sluice Valve | 50 kg/cm$^2$ cast iron flanged gate valve | $\phi$ 6" | 3 sets |
| Piping | 5 kg/cm$^2$ carbon steel pipe | $\phi$ 6" | 12 m |
| Pipe fitting | steel butt-welding pipe fitting | $\phi$ 6" 90$^\circ$ elbow | 6 pcs. |
| Flange | 5 kg/cm$^2$ steel pipe flange | $\phi$ 6" | 22 pcs. |
| Sleeve pipe | 5 kg/cm$^2$ carbon steel pipe | $\phi$ 8" | 350 mm |
| Bolts & nuts | | M 16 x 60 L | 104 sets |
| Anchor bolts & nuts | | M 16 x 200 L | 6 sets |
| U bolts & nuts | | M 10 x 200 L | 2 sets |
| Suction unit | steel plate | $\phi$ 480 x 22 | 1 pc. |
| Stiffer plate for by-pass pipe | - ditto - | 280 x 240 x 9 | 1 pc. |
| Air vent cock | $\phi$ 3/8" screwed plug cock and pipe | | 1 pc. |
| - ditto - | screwed cock | | 1 pc. |
| Bolts & nuts | | M 20 x 65 L | 12 sets |
| Support - I | steel plate<br>- ditto - | 100 x 320 x 6<br>50 x 650 x 3.2 | 1 pc.<br>1 pc. |
| Support - II | steel section | L 60 x 60 x 5 | 4 m |

| Name of part | Material | Remarks | Q'ty |
|---|---|---|---|
| Steady blade | steel plate | 67 x 110 x 6 | 6 pcs. |
| End plate | - ditto - | ϕ 280 x 9 | 1 pc. |

## IV. LAND IMPROVEMENT

### 4.1 Earth Volume Calculation

Land improvement work which consists of levelling work and construction work of farm ridges, will be carried out in Sakhuva area of 5 ha. The area will be divided into 30 plots with the standard size of 50 m x 40 m by the land improvement work. To determine appropriate field elevation of each plot, earth volume calculation for the land improvement work is made based on the following conditions:

i) Cutting and filling earth volumes should be balanced.

ii) Earth works considered in the calculation are main canal, farm roads, farm ridges and levelling work.

iii) Hauling earth volume and distance should be as little as possible.

iv) Conversion factor of cutting into filling is 0.9.

The calculation is made in the following procedures:

i) Calculate filling earth volume for the canal and farm roads by using their profiles.

ii) Calculate filling earth volume for the farm ridges.

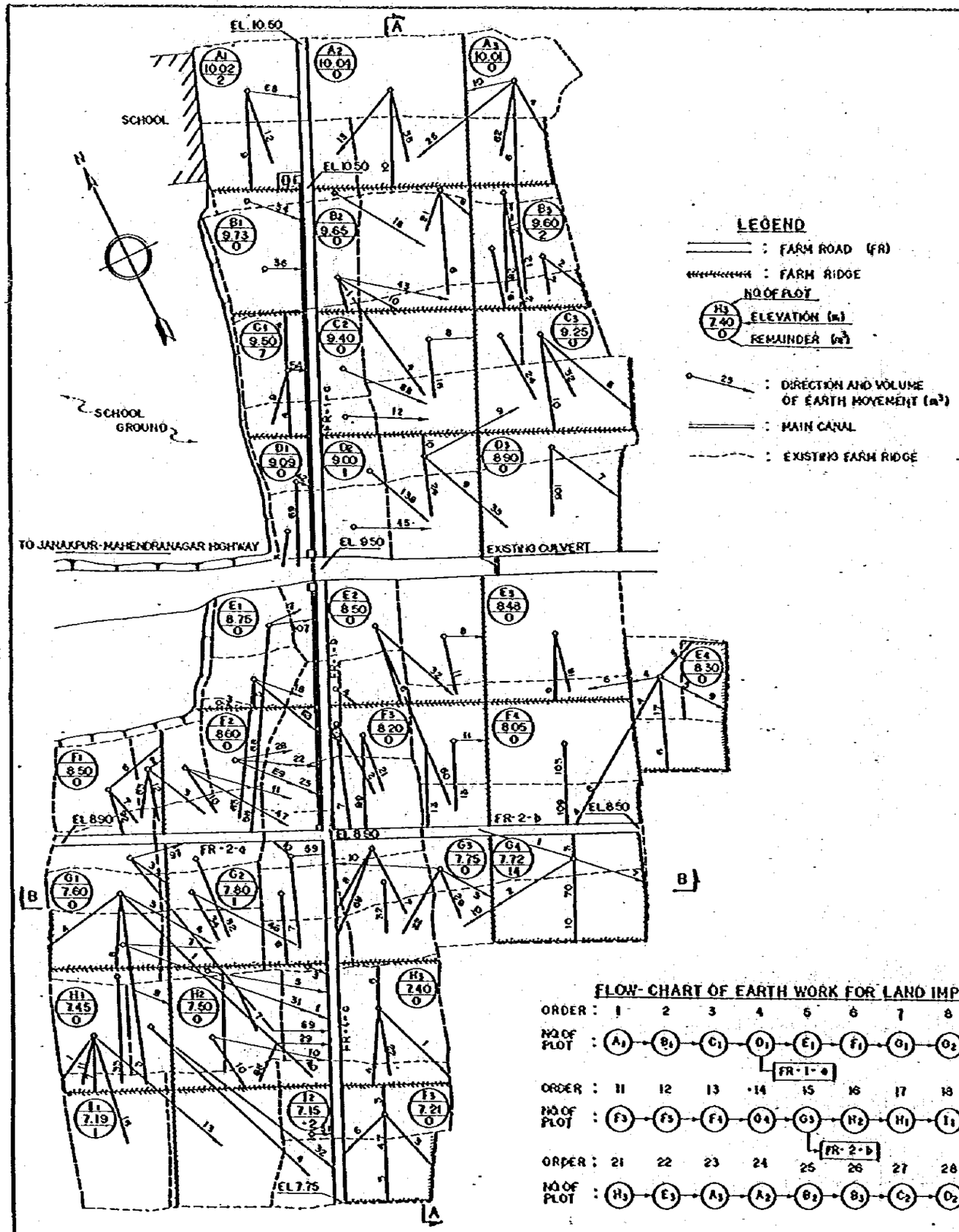
iii) Assume field elevation of each plot.

iv) Calculate filling and cutting earth volumes for the levelling work.

v) Repeat the assumption of the field elevations until total filling earth volume for the canal, farm roads, farm ridges and levelling work is equal to total cutting earth volume for the levelling work. (Final field elevations are shown in attached Fig. - 1.)

## 4.2 Earth Work Schedule

The land improvement work is scheduled to be carried out in parallel with construction works of the canal and farm roads. Levelling work of the land improvement work will be carried out on force account basis. The construction works of the canal, farm roads and farm ridges will be carried out on contract basis. Taking into account difference of contract base and order of works, earth work schedule for the land improvement work is established as shown in attached Fig. - 1.




## LEGEND

- : FARM ROAD (FR)
- : FARM RIDGE
- H3 / 7.40 / 0 : NO OF PLOT / ELEVATION (m) / REMAINDER (m³)
- 23 : DIRECTION AND VOLUME OF EARTH MOVEMENT (m³)
- : MAIN CANAL
- : EXISTING FARM RIDGE

## EARTH WORK FOR LAND IMPROVEMENT

| PLOT NO | AREA (m²) | GROUND EL (m) | CUT FIELD (m³) | FILL FIELD (m³) | FILL ROAD (m³) | FILL RIDGE (m³) | FILL TOTAL (m³) | f | REVISED (m³) | BALANCE + (m³) | BALANCE − (m³) | TO OR FROM (+) (−) | DISPOSAL (m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A 1 | 1,300 | 10.02 | 88 | 10 | 61 | 6 | 77 | 0.9 | 86 | 2 | | | 2 |
| A 2 | 2,400 | 10.04 | 78 | 84 | 0 | 9 | 93 | 0.9 | 103 | | 25 | + 126(A3) | 0 |
| A 3 | 1,300 | 10.01 | 128 | 65 | 0 | 19 | 74 | 0.9 | 82 | 46 | | - 25(A2)<br>- 21(B3) | 0 |
| B 1 | 1,100 | 9.73 | 90 | 0 | 81 | 0 | 81 | 0.9 | 90 | 0 | 0 | | 0 |
| B 2 | 2,000 | 9.65 | 111 | 79 | 0 | 17 | 96 | 0.9 | 107 | 4 | | - 4(C2) | 0 |
| B 3 | 1,250 | 9.60 | 60 | 62 | 0 | 9 | 71 | 0.9 | 79 | | 19 | + 121(A3) | 2 |
| C 1 | 800 | 9.60 | 72 | 2 | 48 | 8 | 58 | 0.9 | 65 | 7 | | | 7 |
| C 2 | 2,000 | 9.40 | 124 | 108 | 0 | 7 | 115 | 0.9 | 128 | | 4 | + 4(B2) | 0 |
| C 3 | 1,800 | 9.25 | 92 | 77 | 0 | 14 | 91 | 0.9 | 101 | | 9 | + 9(D2) | 0 |
| D 1 | 650 | 9.09 | 114 | 0 | 102 | 0 | 102 | 0.9 | 114 | 0 | 0 | | 0 |
| D 2 | 2,000 | 9.00 | 271 | 187 | 0 | 16 | 203 | 0.9 | 226 | 45 | | - 96(C3)<br>- 36(D3) | 1 |
| D 3 | 1,600 | 8.90 | 112 | 126 | 0 | 6 | 132 | 0.9 | 147 | | 35 | + 35(D2) | 0 |
| E 1 | 1,300 | 8.75 | 412 | 23 | 96 | 7 | 126 | 0.9 | 140 | 272 | | - 272(F2) | 0 |
| E 2 | 2,000 | 8.50 | 134 | 39 | 0 | 16 | 55 | 0.9 | 61 | 73 | | - 73(F3) | 0 |
| E 3 | 1,600 | 8.48 | 90 | 78 | 0 | 8 | 86 | 0.9 | 96 | | 6 | + 6(E4) | 0 |
| E 4 | 1,300 | 8.30 | 64 | 19 | 0 | 24 | 43 | 0.9 | 48 | 16 | | - 6(E3)<br>- 10(F4) | 0 |
| F 1 | 1,050 | 8.50 | 181 | 65 | 87 | 6 | 158 | 0.9 | 176 | 5 | | - 5(F2) | 0 |
| F 2 | 1,850 | 8.60 | 212 | 294 | 242 | 0 | 536 | 0.9 | 596 | | 384 | + 272(E1) + 97(G1)<br>+ 5(F1) + 10(G2) | 0 |
| F 3 | 2,000 | 8.20 | 164 | 86 | 118 | 10 | 214 | 0.9 | 238 | | 74 | + 1(G4)<br>+ 73(E2) | 0 |
| F 4 | 1,900 | 8.05 | 213 | 98 | 105 | 0 | 203 | 0.9 | 226 | | 13 | + 10(E4) + 3(G4) | 0 |
| G 1 | 1,500 | 7.60 | 426 | 0 | 0 | 18 | 18 | 0.9 | 20 | 405 | | - 12(G2)<br>- 393(H1) - 97(F2) - 10(F2) | 0 |
| G 2 | 2,000 | 7.80 | 248 | 162 | 124 | 9 | 295 | 0.9 | 328 | | 80 | + 12(G1) + 79(G3) | 1 |
| G 3 | 1,900 | 7.75 | 182 | 97 | 0 | 5 | 102 | 0.9 | 113 | 69 | | + 78(G2)<br>- 10(G4) | 0 |
| G 4 | 1,700 | 7.72 | 117 | 63 | 0 | 17 | 80 | 0.9 | 89 | 28 | | - 1(F3) - 10(G3)<br>- 3(F4) | 114 |
| H 1 | 1,400 | 7.40 | 118 | 42 | 0 | 16 | 58 | 0.9 | 64 | 54 | | + 11(G1) - 16(I1)<br>- 49(I2) | 0 |
| H 2 | 2,000 | 7.60 | 29 | 150 | 123 | 9 | 282 | 0.9 | 314 | | 285 | + 285(G1) | 0 |
| H 3 | 1,350 | 7.40 | 33 | 20 | 0 | 10 | 30 | 0.9 | 33 | 0 | 0 | | 0 |
| I 1 | 1,250 | 7.18 | 0 | 13 | 0 | 0 | 13 | 0.9 | 15 | | 15 | + 16(H1) | 1 |
| I 2 | 1,900 | 7.15 | 51 | 16 | 80 | 0 | 98 | 0.9 | 107 | | 56 | + 5(I3)<br>+ 49(H1) | -2 |
| I 3 | 1,200 | 7.21 | 66 | 42 | 0 | 13 | 55 | 0.9 | 61 | 5 | 0 | - 5(I2) | 0 |
| Total | 47,700 | | 4,079 | 2,097 | 1,267 | 279 | 3,643 | | 4,053 | 1,031 | 1,006 | | 26 |

NOTES
1. Elevation of BH-3 is tentatively assumed at 10.000 meters.
2. Units of elevations and lengths are shown in meters.
3. Land improvement except construction of farm ridges will be carried out on force account basis.
4. Construction of farm ridges will be carried out under this contract.

## FLOW-CHART OF EARTH WORK FOR LAND IMPROVEMENT

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ORDER : | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| NO OF PLOT : | A1 | B1 | C1 | D1 | E1 | F1 | G1 | G2 | F2 | E2 | F3 |
| | | | | FR-1-a | | | | | FR-2-a | | FR-1-b |
| ORDER : | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| NO OF PLOT : | F3 | F4 | F1 | G4 | G3 | H2 | H1 | I1 | I2 | I3 | H3 |
| | | | | | FR-2-b | | | | | FR-1-c | |
| ORDER : | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | |
| NO OF PLOT : | H3 | E3 | A3 | A2 | B2 | B3 | C2 | D2 | D3 | C3 | |

SCALE 0 — 50 (Meter)

Figure - 1

Earth Work Schedule for Land Improvement