PLANNING AND DESIGN PARAMETERS-IRRIGATION

1.2 Data Necessary In The Design Of An Irrigation System

1.2.1 Investigation and Survey

Investigation and survey is the gathering of data and other information necessary in the determination of the feasibility, planning and design of proposed irrigation projects. With that effect, careful investigation and survey will minimize construction and future operation and maintenance cost of the irrigation system.

1. **Reconnaissance Survey With the aid of an appropriate map, reconnaissance survey is to be undertaken in order to locate the best diversion site by considering the following:**
    a. The dam site must be located in a long, uniform and straight reach of river;
    b. The soil foundation must be sufficiently stable to sustain the weight of the dam and nearly impervious;
    c. The site must preferably be the narrowest part of the river but it should be of sufficient width such that after the construction of the dam it will have the capacity of discharging the maximum allowable flood concentration depending on the character of the foundation;
    d. The riverbanks must be firm and stable to provide good anchorage of the dam abutments and they must be high enough to allow free board for the maximum afflux elevations;
    e. There must be no possibility that the river might change its course;
    f. The site must have adequate watershed area so that the average stream flow during the dry season can irrigate the potential irrigable area;
    g. The diversion canal is short and minimizing the need of costly structures, funnels, or deep cuts;
    h. The source of construction materials like sand, gavel, boulders and rocks must be abundant;
    i. No considerable damage due to inundation of public and private properties and facilities upstream, will result after the dam is constructed;
    j. The value of necessary land and right of way is cheap;
    k. The site is accessible to transportation.
    l. No water rights grantee is adversely affected;
    m. No factory or mining activity upstream of the dam site must be present as mill and mine tailings will pollute the good quality of the irrigation water;
    n. The requirement as to cofferdam, pumping or other provisions for dewatering the site is at a minimum.

A relatively small study with the data gathered in the reconnaissance survey will usually result in the elimination of undesirable sites and narrow the decisions to cover a few sites only.

2. **Gathering of Planning Data**

Below are the steps and procedures in the gathering of date for planning and feasibility studies:

a. Make a sketch map indicating the diversion point, limits of irrigable area, source of water supply, major structures, and location of canals.
b. Determine the dependable water supply during the wet and dry cropping seasons by taking discharge measurement and from information of the inhabitants who knew about the behaviour of the river flow.
c. Determine the approximate distance of the dam site to the head of irrigable area and the average cut of the diversion canal.
d. Take the approximate cross section of the river indicating the maximum flood level and minimum water surface, ordinary water surface during the dry and wet seasons, recommended height of operating level above the river bed, and description of river bed and bank materials.

3. **Gathering of Economic Data**

a. Production cost/ha for dry and wet season
b. Area planted in hectares for different kind of crops
c. Yield/ha., for dry and wet season
d. Socio-economic condition of the locality
e. Market value of crops

1.2.2 Design Data For An Irrigation Project

After all the necessary data have been gathered and evaluated, the following are to be conducted:

1. **Topographic survey** of the irrigable area for the preparation of a topographic map with one-meter contour interval of true elevation above mean sea level.

2. **Final investigation of diversion site.** Once the feasible site has been selected, the final and more extensive investigation of the said site follows. The site survey and the resulting topographic maps should be sufficiently accurate and precise to serve all the purposes of construction. In order to have a good design of the dam, the following design data and useful information should be obtained:

a. Topographic map of the site covering an area of at least ten (10) hectares with ½ meter contour interval of true elevations and scale of 1:500 to 1:1,000. The topographic map must also show the location of boreholes.
b. Rectified aerial photographs of the area, if readily and economically available.
c. Cross-section of the proposed dam axis and at least four (4) cross-sections more, two (2) to be taken upstream at points along the river spaced 200 meters apart and the other two (2) at the downstream side of the dam line similarly spaced. Each cross-section must show the character of the river bed, the nature and kind of vegetation on the banks and flood plains, the water surface elevation at the time the survey was made, and the maximum flood level elevation as obtained by repeated inquiries from old folks residing in the vicinity. The ordinary water surface should also be indicated in the cross-section, which is usually drawn at a scale of 1:100. Where applicable, in cases where the maximum flood overtops the river bank the cross-section should extend beyond both banks up to the point where the maximum flood meets the natural ground surface.

d. The profile of the riverbed following the centre of the waterway should be obtained. Said profile should extend at least one kilometre upstream and downstream of the dam axis. The profile must also show the water surface line at the time of the survey and the maximum flood line. Profiles are normally plotted at a scale of 1:1,000 horizontal to 1:100 vertical.

e. Photographs to show the kinds of vegetation along the river banks and flood plains would be most helpful in determining the coefficient of roughness to be used in estimating the flood flows by the slope-area method.

f. Boring logs of subsurface exploration must be shown with the cross-section of the dam axis. Other logs not taken along the dam axis should also be studied.

g. The cores of the boring must be preserved for further evaluation and interpretation by the designing engineer and also for use as information to bidders.

h. Stream flow measurement and more comprehensive study of hydrologic data obtained from the Hydrology Division of DPWH[1], NIA[2], PAGASA[3], or other line agencies.

3. **Profiling** of the proposed main canal and laterals showing the following features, information and requirements.

   a. Scale – 1:400 Horizontal; 1:100 Vertical
   b. Location of roads, railroads, trails, rivers, waterways. etc.
   c. Indicate vegetation, land use, type of soils along profile.
   d. Cross-sections of natural drainage or waterways crossing the canal line with scale 1:100 vertical and 1:400 horizontal, indicating the maximum flood elevations and river bank and bed characteristics.

[1] Department of Public Works and Highways

[2] National Irrigation Administration

[3] Philippine Atmospheric, Geographical and Astronomical Services Administration

1.3 Design and Planning Of An Irrigation System

1.3.1 Layout of Irrigation Canals

After an inventory of all data and the availability of water resources, the canal network plan is prepared based on the field data obtained. A thorough study of the topographic map of the project area should be made before deciding on the scheme to be adopted. A good canal layout is one of the first requirements in an efficient operation of an irrigation system, as a maximum area within the system should be benefited at least cost.

Irrigation canals and farm ditches of various grades, as a rule, should be located along the highest points of the proposed service area and should be as straight as is practicable to minimize their length, unless such a layout involves excessive banking on heavy cutting or other engineering and agricultural difficulties. However, it is sometimes unavoidable that the irrigation system is laid out along property lines, when the land acquisition is extremely difficult.

The layout of the canal system is usually determined on a topographic map. Several alternative locations may be taken into consideration. The final decision will be made on the actual field survey, the demand for integrated water management and the proposed cropping patterns. The density of canals should be considered quite seriously, as irrigation water cannot be evenly distributed throughout a field if the farm ditches in one portion are inadequate which will not have enough water and another portion may be over irrigated, wasting a considerable amount of water.

1.3.2 Required Data In Layout Preparation

1. **Topographic map of the irrigable area showing:**
   a. source of water supply;
   b. natural features such as rivers, creeks and waterways; likewise manmade features such towns, barangays, railroads and roads, etc.

2. **Profile and cross section of the river at proposed diversion and also at points 200 meters above and below showing;**
   a. maximum and minimum water surface elevations, and
   b. character of riverbed and bank.

3. **Discharge of river or creek at proposed diversion site in order to determine the maximum area to be irrigated.**

1.3.2.1 Factors To Be Considered In The Layout Preparation

a. A tentative operating level at diversion site is considered in such a way that it can serve the upper most limit of the irrigable area.

b. Main canal must be located in places, which have full command of the adjoining area. It may cut contours or skirt along foothills whichever is advantageous depending on local topographic conditions.

c. Branch and lateral canals may cut contours thus, is the recipient of many loops but it is shorter than the main canal and this may be designed for a steeper slope.

d. Canal locations should follow roads or property borders where possible.
e. Designer should see to it that a minimum number of creeks, rivers, or other waterways should be crossed; but this should not prejudice the objective of securing the maximum possible area.
f. The maximum angle of curvature of canal lines should be such to prevent excessive scouring at the concave side of the canal.
g. Intersections with roads should preferably be at right angles; skew crossings are longer and more expensive.
h. Natural drainage channels may be utilized to form part of the supply canal if it is advantageous. However, provisions should be made for handling effectively and economically the drainage water and possible silt, sand or gravel deposits.
i. As many laterals as the topography and irrigable area will require should be plotted on the map and its distance shall be more or less one (1) kilometre apart.
j. Canals must end in a drainage system.

In planning a canal system for a proposed irrigation project, approximate locations of principal canals are made in the office on topographic maps. Final locations are then made in the field, where the engineer can give more adequate consideration to local requirements.

1.3.2.2 Canal Capacities

Capacities for which canals must be designed should be based upon the consumptive–use requirements of the crops anticipated after implementation of the irrigation system in the area. This quantity of water should then be increased because of inefficiencies in the conveyance system and the application of the water to the land. Conveyance losses can be attributed to seepage, operational losses, and evaporation. The losses in this category represent losses in the distribution system up to farm delivery. Farm application efficiency is a measure of the ability to store in the root zone the crop's water demand. The shape and slope of the farm unit, method of application, and type of soil are all factors, which affect this efficiency. The **duty of water**, in other words the amount of water required for every hectare/second, is determined from the soil requirements. One litre per second per hectare (1.00 l/sec/ha.) is the minimum duty and 3.00 l/sec/ha. is the maximum. For clay loam, the most predominant type of soil in Philippine farms, the duty being used is 1.50 l/sec/ha. The minimum duty is sufficient for clay and the maximum is used for sandy soil. The carrying capacity of the main canal is equal to the gross area times the water duty.

1.3.2.3 General Design Considerations

1. **Section** The cross section of unlined canals in earth material, generally trapezoidal, is usually determined by practical requirements rather than by the criterion of maximum hydraulic efficiency. Topography usually controls the canal grade and depth of excavation; materials encountered determine the mean velocity of flow and the canal shape. The geologic formations below canal beds may influence bottom grade and canal depth. The ratio of canal bottom width to water depth varies from 1:2 to 1:4 for small canals and from 1:4 to 1:8 for large canals.

2. **Side Slope** The side slope depends on the properties of materials in which they are constructed. The side slope for unlined canal are suggested as follows:

Material	**Side Slope (Horizontal / Vertical)**
Firm rock	**1½: 1**
Fissured rock, more or less disintegrated rock, tough hard pan	**1½: 1**
Cemented gravel, stiff clay soils, ordinary hard pan	**¾: 1**
Firm, gravely, clay soil, or for side-hill cross section in average loam	**1: 1**
Fills in average loam or gravely loam	**1½: 1**
Fills in loose sandy loam	**2: 1**
Fills in very sandy soil	**2: 1**

Below are tabulations of allowable velocities for lined and unlined canals:

i. Concrete lined canal 1.00 mps - 2.50 mps

ii. Earth or earth-lined canal 0.30 mps - 1.20 mps

iii. Buried membrane-lined canal 0.30 mps - 1.20 mps

iv. Small drainage channels in earth:
- Stiff clay 1.20 mps (max.)
- Sandy loam 0.75 mps
- Light sandy 0.50 mps

Maximum permissible velocities, in meters per second, recommended by Fortier and Scoby for essentially straight canals, are shown below:

Materials	**Value of Manning's "n"**	**Clear Water, metre/sec.**	**Water Transporting Colloidal Silts, metre/sec**
Fine sand colloidal	0.020	0.45	0.75
Sandy loam, non-colloidal	0.020	0.50	0.75
Silt loam, non-colloidal	0.020	0.60	0.90
Alluvial silts, non-colloidal	0.020	0.60	1.00
Ordinary firm loam	0.020	0.75	1.00
Stiff clay, very colloidal	0.025	1.10	1.50
Alluvial silts, colloidal	0.025	1.10	1.50
Shales and hard pan	0.025	1.80	1.80
Fine Gravel	0.020	0.75	1.50
Graded loam to cobbles when non-colloidal	0.030	1.10	1.50
Graded silts to cobbles When colloidal	0.030	1.20	1.70
Coarse gravel, non-colloidal	0.025	1.20	1.80
Cobbles and Shingles	0.035	1.50	1.70

1.3.3 Design Procedures For Canal Section And Considerations

In the design of canals, use as much as possible the available slope of the ground surface without introducing drops:

1. **Determine the service area of the canal in hectares and the water duty (use W.D. during the dry season cropping):**

   $$Q = A \times W.D.$$

2. **From the profile of the ground surface, draw the appropriate grade line to get the value of the friction slope "S". The flattest being 0.0002 for main supply canal with Q = 10 cu.m./sec.**

3. **Determine the value of side slope "SS", this is usually**

   1½: 1., for canals of Q = 50 litres/sec or less.

4. **Determine the value of Kutter's coefficient or roughness "n". This is usually 0.025 for earth canal and 0.015 for lined. See Table above.**

5. **After determining the above values, assume trial value for canal base width "b" and depth of water "d". The usual ratio of "b" to "d" is 2.5. Then compute for velocity using open channels formulae:**

   (a) by Manning's, $V = 1/n \; R^{2/3} \, S^{1/2}$

   (b) **Check section by Chezy's and Kutter's formula:** $V = C \quad RS$

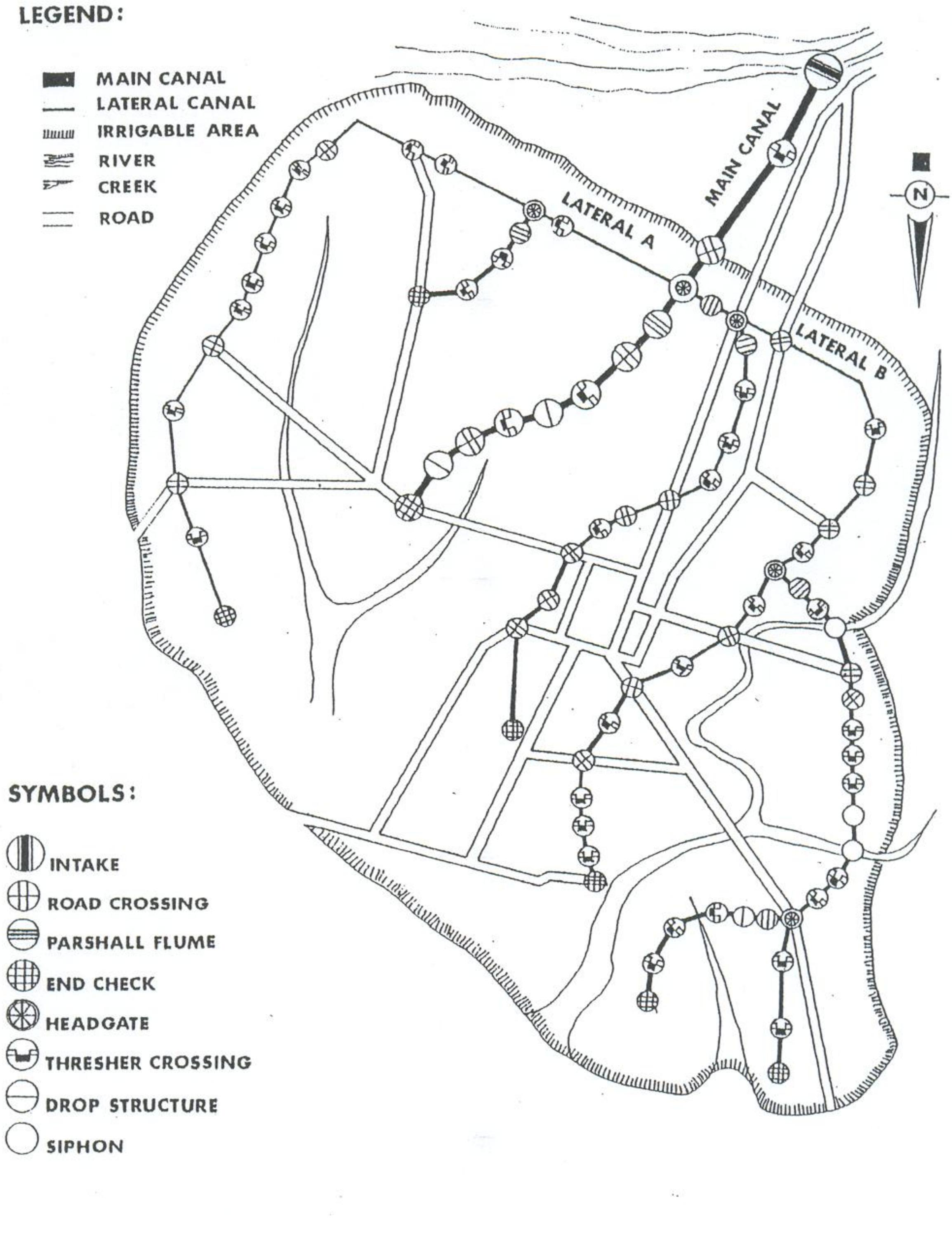
   Where C = Kutter's coefficient

   n = Roughness factor

   R = Hydraulic radius

   S = Slope of canal

The following illustrations / photos are typical structures for communal irrigation system projects.



TYPICAL LAYOUT OF A COMMUNAL IRRIGATION SYSTEM