Outlet Work:

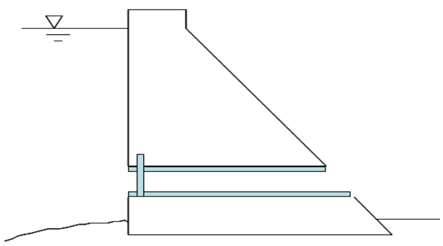
The major portion of the storage volume in most reservoirs is below the spillway crest. Outlet works must be provided in order that water can be drawn from the reservoir as needed. This water may be discharged into the channel below the dam or may be transported in pipes or canals to some distant point.

Functions of outlet works:

1. ***Flood Control***: Flood control outlets are designed for relatively large capacities where close regulation of flow is less important than are other requirements. When large discharges must he released under high heads, the design of gates, water passages, and energy dissipater should be carefully developed. Multilevel release provisions are often necessary for water quality purposes.
2. ***Navigation:*** Reservoirs that store water for subsequent release to downstream navigation usually discharge at lower capacity than flood control reservoirs, but the need for close regulation of the flow is more important. The navigation season often coincides with the season of low rainfall, and close regulation aids in the conservation of water. Outlet works that control discharges for navigation purposes are required to operate continuously over long periods of time. The designer should consider the greater operation and maintenance problems involved in continuous operation.
3. ***Irrigation***: The gates or valves for controlling irrigation flows are often basically different from those used for flood control due to the necessity for close regulation and conservation of water in arid regions. Irrigation discharge facilities are normally much smaller in size than flood regulation outlets.
4. ***Water Supply:*** Municipal water supply intakes are sometimes provided in dams built primarily for other purposes. Such problems as future water supply requirements and peak demands for a municipality or industry should be determined in cooperation with engineers representing local interests.
5. ***Power:*** For generation of hydropower, intake structures direct water from the reservoir into the penstock or power conduit. Gates or valves are used to shut off the flow of water to permit emergency unit shut-down or turbine and penstock maintenance. Racks or screens prevent trash and debris from entering the turbine units.
6. ***Low-Flow Requirements***: Continuous low-flow releases are required at some dams to satisfy environmental objectives, water supply, downstream water rights, etc. To meet these requirements multilevel intakes, skimmer weirs, or other provisions must be incorporated separately or in combination with other functions of the outlet works facility.
7. ***Diversion***: Flood control outlets may be used for total or partial diversion of the stream from its natural channel during construction of the dam. Such use is especially adaptable for earth dams.
8. ***Drawdown***: Requirements for low-level discharge facilities for drawdown of impoundments may also provide flexibility in future project operation for anticipated needs, such as major repairs of the structure, environmental controls, or changes in reservoir regulation.

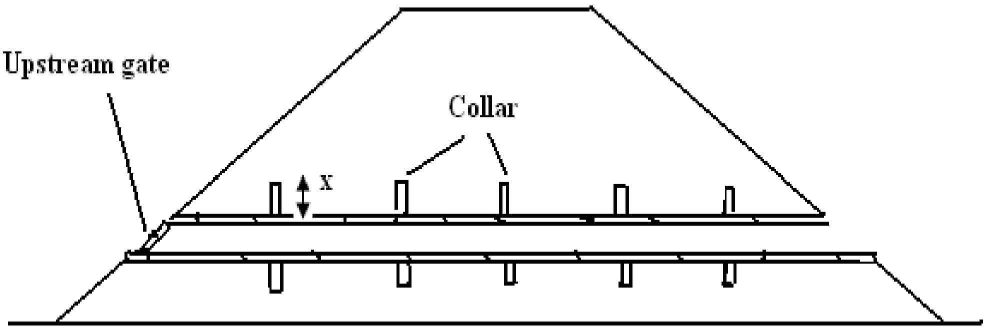
1. Sluiceways:

It is a pipe or tunnel that passes through a dam or the hillside at one end of the dam and discharges into the stream below.
Sluiceway for ***concrete dams*** generally passes through the dam.



Sluiceway for a gravity concrete dam

Sluiceways for earth or rock dams are preferably placed outside the limits of the embankment. If a sluiceway must pass through an earth dam, projecting collars should be provided to reduce seepage along outside of the conduit.



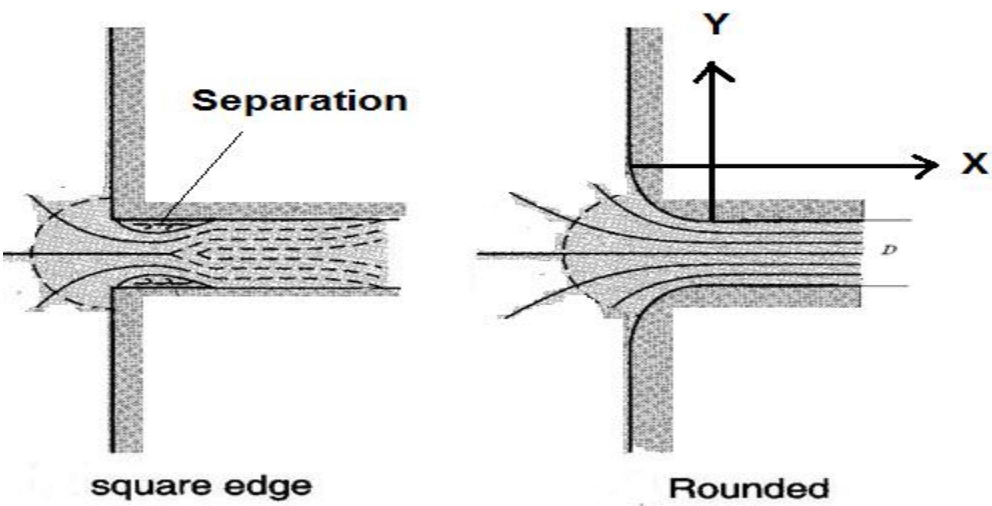
For design purpose:

$$2Nx > 0.25L$$

Where N is the number of collars, and x is the projection of the collars.

Example: determine the height of collars for an earth dam if the length of seepage path is 100m, (assume the available distance between two adjacent collars is 10m?
Sol:
N=(100/10)-1=9
X=(0.25*100)/(2*9)
=1.38m ≈ 1.5m
2(9*1.5) =27> (0.25*100) O.K.

- The outlets of most dams consist of one or more sluiceways with their inlets at about minimum reservoir level.
- Large dams may have sluiceways at various levels.
- In most cases a single large-capacity sluiceway may be structurally unsatisfactory, why?
- Sluiceways may be circular or rectangular,
- The interior should be smooth and without projections or cavities which might induce separation of flow boundary of the conduit and cause negative pressure and cavitation's.



The equation for circular conduits is:

$$4x^2 + 44.4y^2 = D^2$$

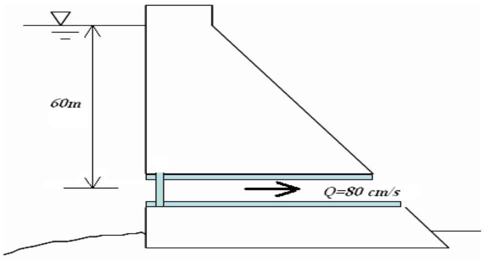
For rectangular conduits is:

$$x^2 + 10.4y^2 = D^2$$

D is the diameter of a circular conduit or the width or height of a rectangular conduit, depending on whether the side or top and bottom curves are being considered.

<u>Example:</u> the sluiceway for a dam discharge 80m^3/s, if the coefficient of discharge from sluiceway is 0.9, and the head above the entrance is 60m, determine the profile of the entrance if:

1. **Circular conduit was used,**
2. **Rectangular conduit was used.**



<u>Sol:</u>

$$Q = C_d A(2gh)^{0.5} \Rightarrow 80 = 0.9 * A * (19.62 * 60)$$

$$A = \frac{80}{1059.48} = 0.076 m^2$$

1- Circular conduit:

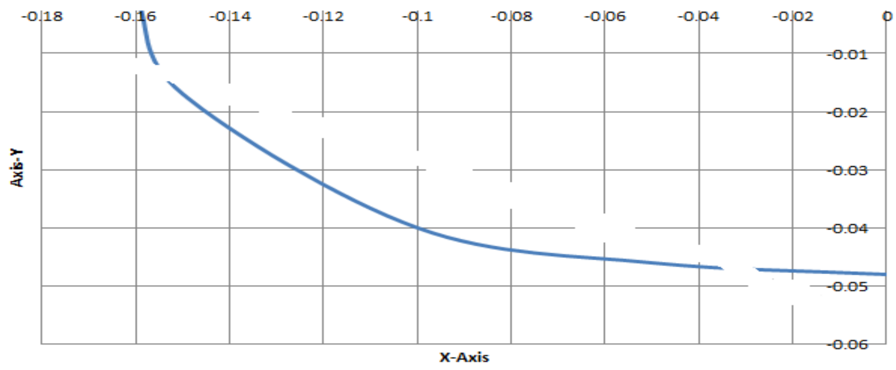
$$0.076 = \frac{d^2}{4}\pi \Rightarrow d = 0.31m \approx 0.32m$$

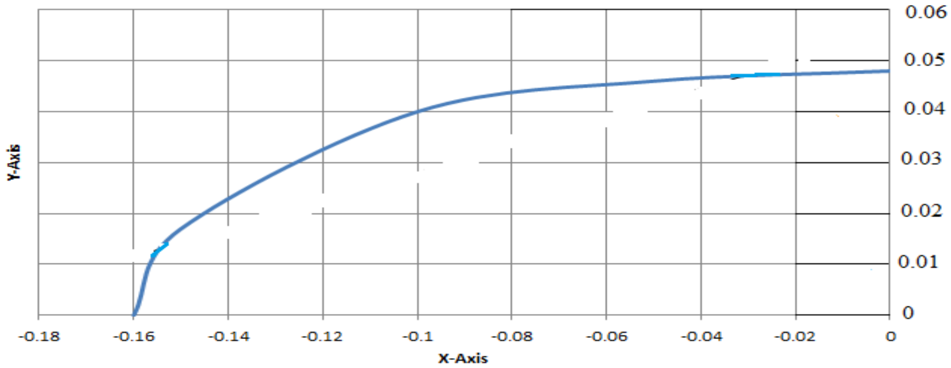
Use the following equation

$$4x^2 + 44.4y^2 = D^2$$

X	Y
0	**0.048**
0.05	**0.046**
0.10	**0.040**
0.15	**0.017**
0.16	**0**

X	Y
0	**-0.048**
-0.05	**-0.046**
-0.10	**-0.040**
-0.15	**-0.017**
-0.16	**0**





Hydraulics of Outlet Works:

- **The outlet works of a dam must be designed to discharge water at rates dictated by the purposes of the dam,**
- **Head losses encountered in outlet conduits include those caused by the trash rack, conduit entrance, friction, gates, valves, and bends,**
- **Trash rack losses are low, approximately as indicated in table,**

Velocity through rack (m/s)	Head losses (m)
0.2	0.01
0.4	0.05
0.5	0.09
0.6	0.13

- **Head losses at entrance to a conduit depends on the shape of the entrance and varies from** $0.04h_v$ **for a bell mouth entrance to** $0.5h_v$ **for a square-edged opining, where hv is the velocity head in the conduit just downstream from the entrance,**
- **Head losses caused by conduit friction may be calculated by standard pipe-friction formulas,**

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

- **The discharge formula is,**

$$Q = C_d A (2gh)^{0.5}$$

h=the total head at the valve.

Exercise: Find the discharge through a valve whose outlet diameter is 2m if the pressure just upstream of the valve is 200 kN/m^2 and Cd=0.68?