Lecture 4
Spillways and Outlet Works

Spillways and Outlet Works

Provide the capability to release an adequate rate of water from the reservoir to satisfy dam safety and water control regulation of the project.

Outlet Works – consist of a combination of structures designed to control the release of water from the reservoir as required for project purposes or operation.

Spillways – allow release of water downstream that cannot be stored or released for any of the objectives of the reservoir

Spillways

Gated (controlled) or Ungated (uncontrolled)

Ungated

- **are safer (no mechanical fixures that can fail; does not depend on operator; not likely to be obstructed by debris).**
- **need a longer length for the same maximum discharge rate;**

Gated spillways

- **provide greater control of outflow rate;**
- **initial cost is usually 25% to 30% less.**

Surface Spillways or Orifice/tunnel Spillways

Surface – discharge via weir equation (function of H^1.5)

Tunnel or Orifice – discharge via orifice equation (function of H^0.5) so need greater head. (common in deep canyons)

Types of Surface Spillways

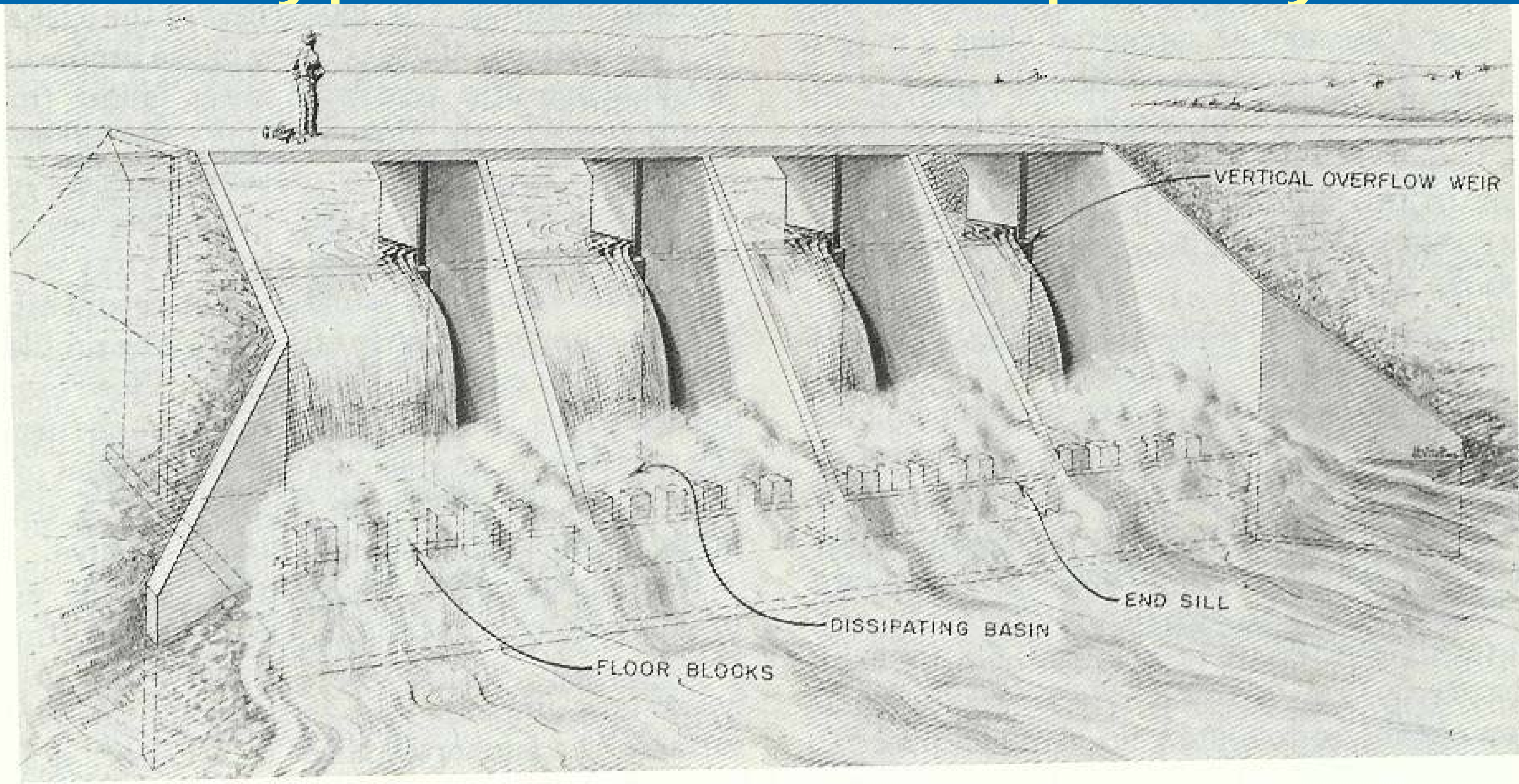


Figure 9-11.—Typical straight drop spillway installation for small heads. 288–D–2899.

Types of Surface Spillways

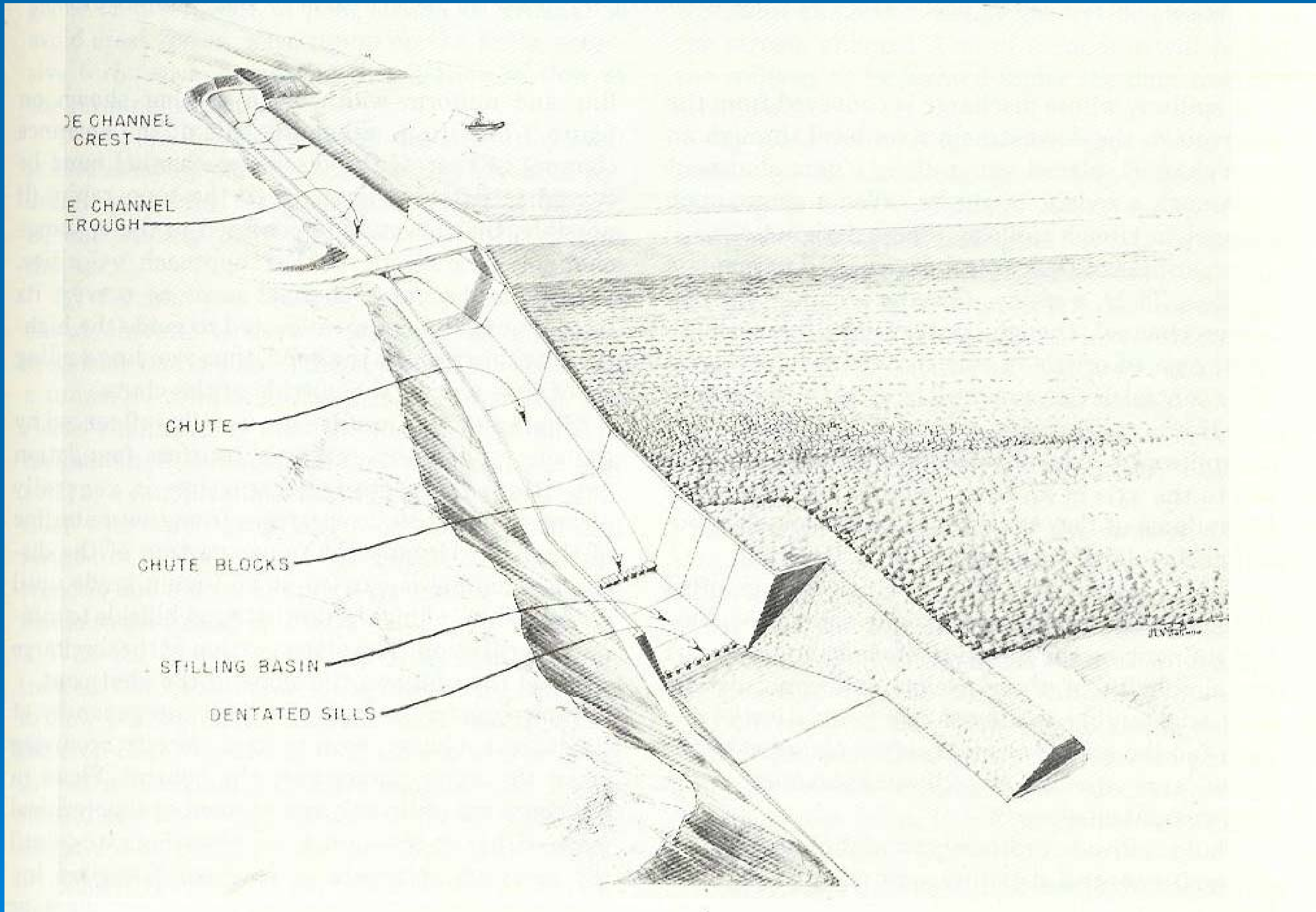


Figure 9-12.—Typical side channel and chute spillway arrangement. 288–D–2900.

Types of Surface Spillways

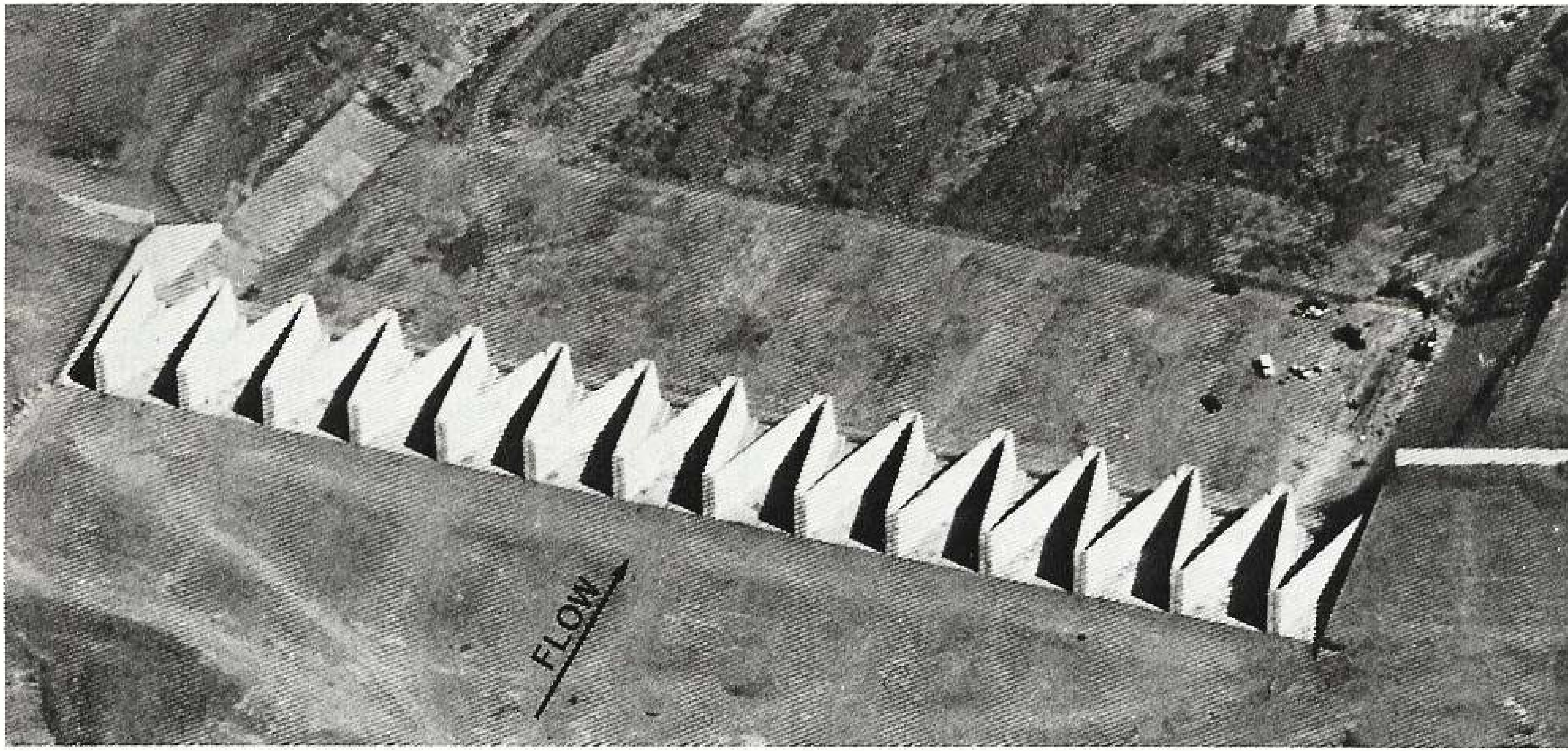
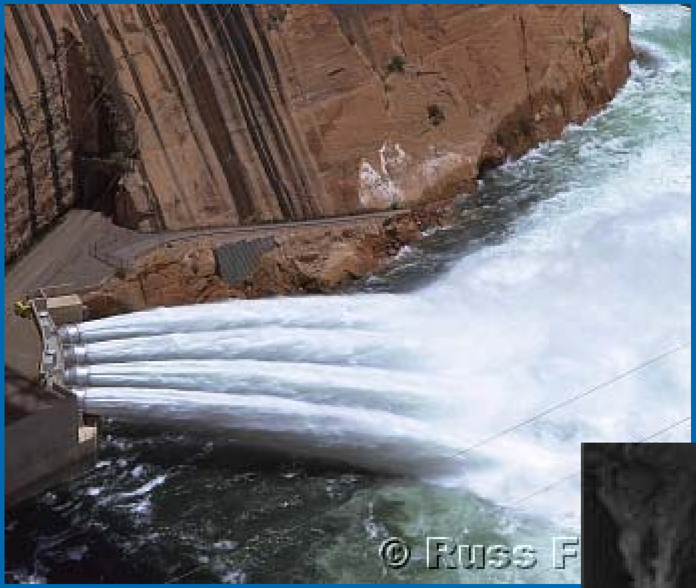


Figure 9-13.—Ute Dam 14-cycle labyrinth spillway. Total length of 3,360 feet contained in a width of 840 feet. The spillway height is 30 feet and will pass a design discharge of 590,000 ft^3/s under the design head of 19 feet. P801–D–81045.

Orifice Spillways

- Generally are construced for large flows
- Have submerged inlets
- Usually controlled with u.s. guard gates and an internal gate
- Could have uncontrolled u.s. gate
- 2 inlets should be required for each tunnel
- Trash racks required
- Aeration d.s. from inlet must be provided
- Require detail hydraulic analysis and often model studies

Tunnel Spillways at Glenn Canyon Dam

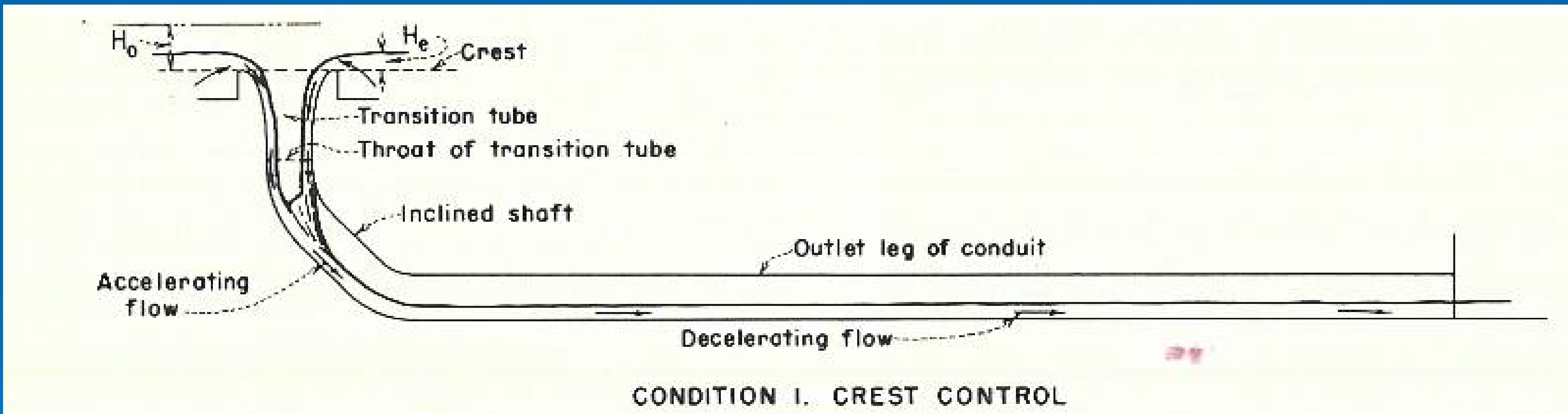


Cavitation damage below aeration slot in ’83 flood

Drop Inlet (morning glory) spillway

3 flow regimes

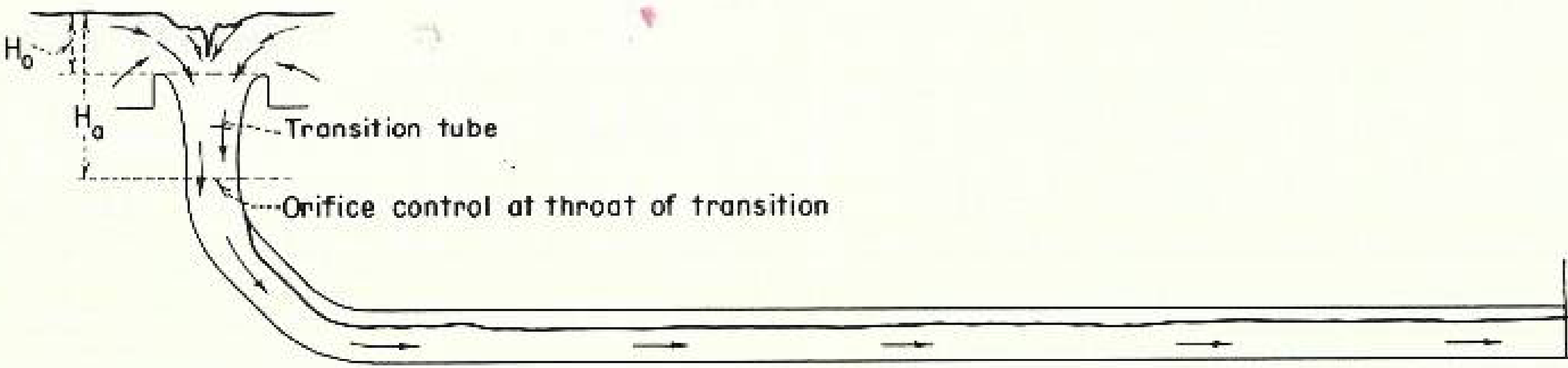
1. Crest control – weir equ; open channel flow d.s.



CONDITION I. CREST CONTROL

Drop Inlet (morning glory) spillway

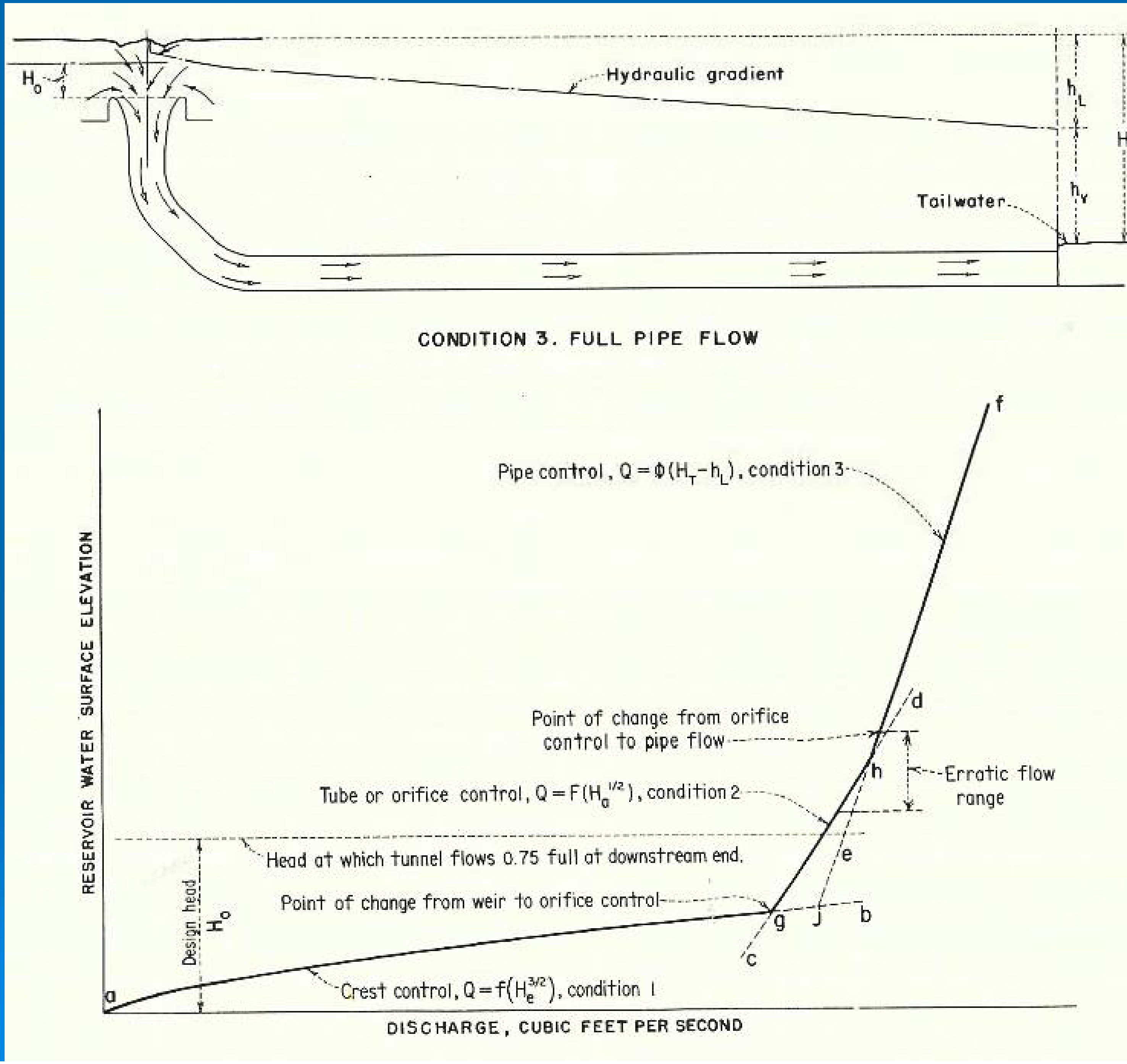
2. Tube or orifce control (medium heads)



CONDITION 2. TUBE OR ORIFICE CONTROL

Drop Inlet (morning glory) spillway

3. Full pipe flow (high heads); jet flow in orifice



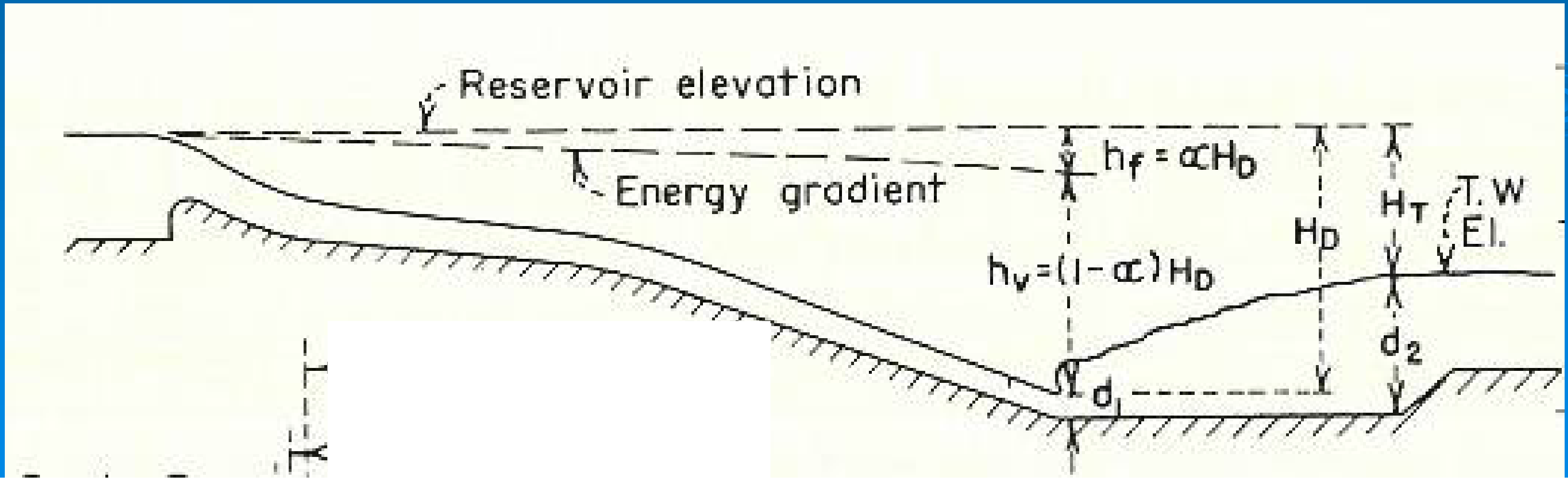
Drop Inlet (morning glory) spillway

Energy Dissipation

Commonly, a large spillway flow with even a moderate head develops high velocities, i.e., large kinetic energy. Such flow is destructive to the d.s. channel; the energy must be dissipated. Typical energy dissipation techniques include:

Stilling Basins (hydraulic jump basins)

When the approaching flow is super critical, blocks or sills are added to force the flow into the subcritical regime.



Submerged Bucket

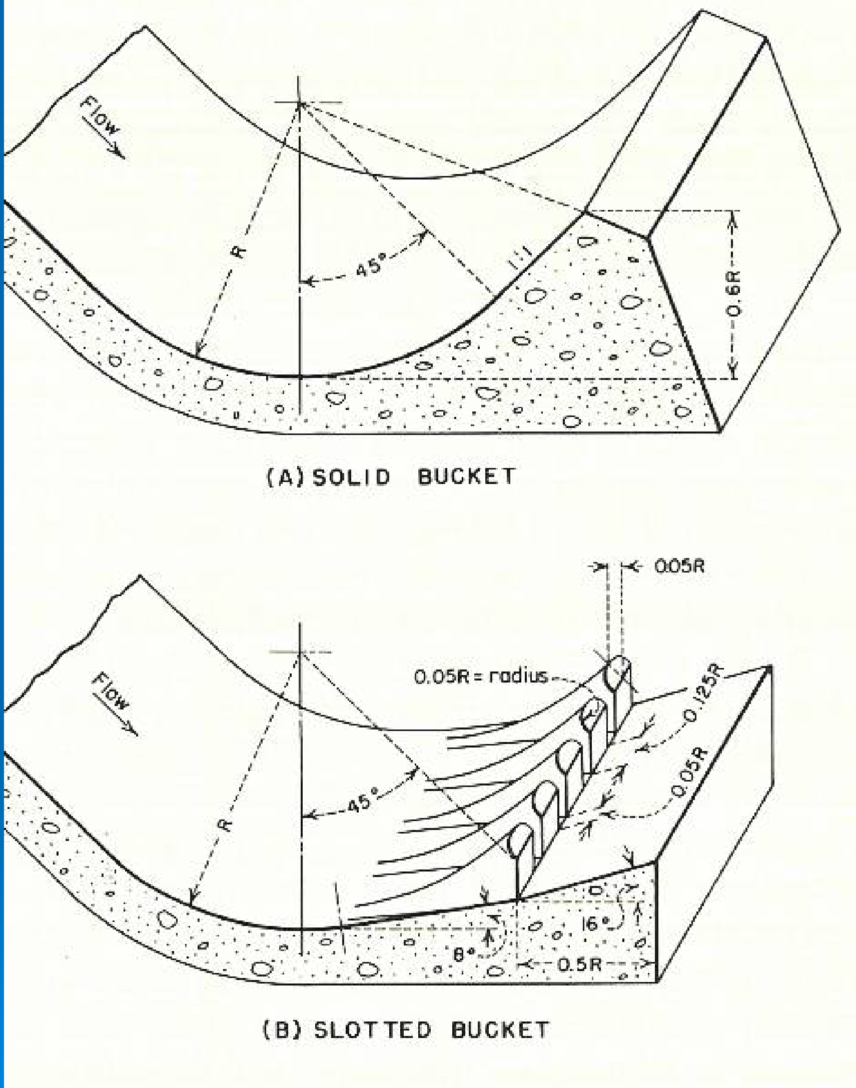


Figure 9-45.—Submerged buckets. 288-D-2430.

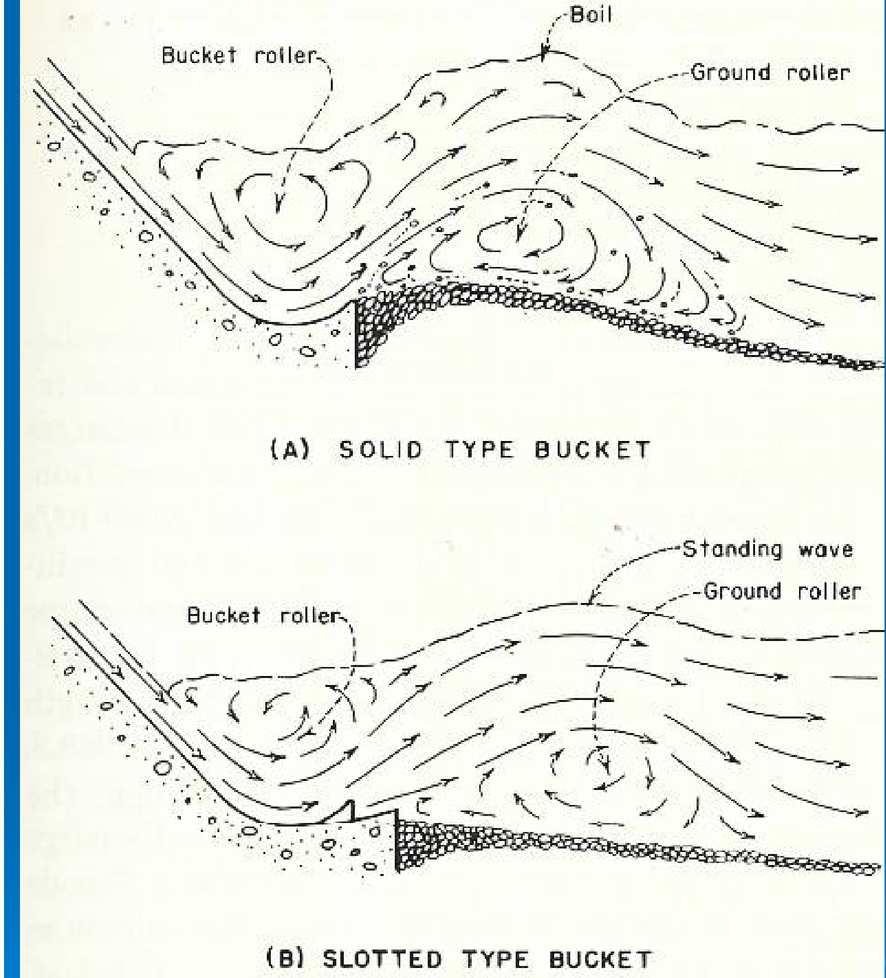


Figure 9-46.—Hydraulic action of solid and slotted buckets. 288-D-2431.

FREEBOARD

Freeboard for wave action is based on wind speed and fetch (distance from windward side of reservoir to the dam)

Table 6-7.—Wave height versus fetch and wind velocity. From [55].

Fetch, mi	Wind velocity, mi/h	Wave height, ft
1	50	2.7
1	75	3.0
2.5	50	3.2
2.5	75	3.6
2.5	100	3.9
5	50	3.7
5	75	4.3
5	100	4.8
10	50	4.5
10	75	5.4
10	100	6.1

Table 6-8.—Fetch versus recommended normal and minimum freeboard.

Fetch, mi	Normal freeboard, ft	Minimum freeboard, ft
<1	4	3
1	5	4
2.5	6	5
5	8	6
10	10	7

Source: USBR Design of Small Dams