Notch Flow, Pipe Flow And Hydraulic Jumps

Flow through a notch
Most of our grade reducing and gully head structures have a notch to concentrate and direct the water through the structure.

The amount of water that can flow through a notch is governed by its:

- Dimensions
- Shape
- Thickness
- Approach
- Downstream conditions

Most of our structures have rectangular or trapezoidal shaped notch with the flow being approximated by the formula 1.7 x length x height $^{3/2}$

Pipe flow
Flow through a pipe is affected by the size and type of pipe, the head of water, height of tailwater and inlet and outlet conditions.

Flow rates through the same sized pipe can vary significantly depending on whether the hydraulic conditions result in the pipe having "inlet control" or "outlet control"

Most of our pipe structures operate under "inlet control" conditions.

Hydraulic jump
A hydraulic jump is a natural energy absorbing process most often observed in rapids or at the base of a waterfall or immediately downstream of an obstruction such as a log. It occurs when shallow high speed flows meet deeper slow moving flows and appears as a wave downstream of the obstruction. Significant turbulence occurs in the area of the jump with potential to create significant erosion problems.

Hydraulic jumps are used in erosion control structures as a way of dissipating excess energy. The location of the jump is critical to the success of the structure.

Designing A Rock Chute

A rock chute is a short steep section of the bed of a channel which has armoured with rock. It is used to stabilise an active gully head either at the top of the gully or in the floor. It can also be used to reduce the grade of a channel by forming a low weir to protect an upstream asset.

A well design rock chute, with an appropriate floor grade, rock size and apron will withstand flows well in excess of designed flood events.

Well-graded rock down the face of a rock chute protects the underlying channel from erosion and absorbs stream energy. Most of the energy absorbed on a rock chute occurs as a result of a designed "hydraulic jump". Keeping the hydraulic jump on the chute prevents turbulence and undermining of the downstream channel. Rock chutes work by safely transferring water from a high level to a low level and absorbing the energy on the face of the chute and in the hydraulic jump.

Like other grade reducing structures rock chutes only reduce the channel grade under certain flow conditions. Under high flows (drowned out) they have little impact on controlling bed erosion other than acting a sediment trap to encourage vegetation.

Hydraulic conditions on a rock chute are quite complex and unpredictable. For example the size of rock required under high flow conditions may be smaller than for certain low flows conditions. For this reason it is very important to test out the rock chute design for a large range of flow conditions.

Free software now makes this process relatively quick and easy.

A Well Designed Rock Chute Will:

- Give long term protection both upstream and downstream
- Will have a width, length, grade and range of rock size to ensure stability under all flow conditions
- Will be suitably located and have appropriate abutment protection to prevent outflanking
- Have suitable bypass facilities (gully head structure)

Siting Rock Chutes

Rock chutes should be sited on a reasonably straight alignment of the stream at a site that minimises excessive excavation or extra rock filling. Rock chutes must be built on parent material not on filling. Avoid very narrow sections of the gully as this tends to restrict design options.
Inlet and outlet levels should be established by determining the stable grade of the upstream and downstream channel. Like with other grade control structures, the rock chute capacity mustn't exceed the capacity of the upstream channel. Overbank flows are likely to result in this scenario.

Other Design And Construction Details

The angle of repose for rock ranges from about 35° for rounded rock to about 42°for more angular rock. Rock density varies from 2.0 for sandstone to about to 3.0 for basalt.
The D50 is the median rock size required for a certain design. It basically means that 50% of the rock by weight is larger than the specified size and 50% by weight is smaller than the specified size. Ideally the grading will range from D50/3 to 2D50. The best rock to use in a rock chute is angular, resistant to weathering and is tough and durable. The factor of safety 1.0 – 1.3 for low risk work should be set somewhere in the range 1.0 to 1.3. It is vital that all rock chutes have a crest either fixed or made from a fold in filter cloth. They also require a cutoff 1 to 2 metres deep. The cutoff can consist of filter cloth and rock or impermeable material such as concrete.