Definition and Purpose

A Key is a structure made of stone, wood, plants, or a combination of such material that connects bank stabilization works, or a river training structure, to the riverbank, reducing the chance of the stream to bypass, or "flank" the project works. A trench is dug into the bank of a river or stream (potentially up to top bank and into the overbank), with adventitious live poles placed on one or both sides of the trench. Soil is placed to cover the basal ends of the poles, and the trench is then filled to within 1 foot of the surrounding soil with a well-graded, self-adjusting, self-filtering stone. The stone is then choked with a cobble-gravel-sand mix (possibly obtained from the stream bed), backfilled with soil, and overfilled with 1.5 feet of additional soil for settling.

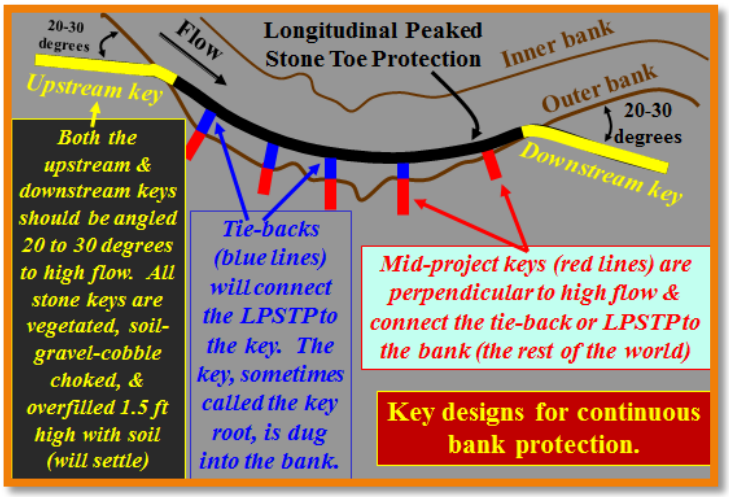

Figure 1: Key installation connected to Longitudinal Peaked Stone Toe Protection (LPSTP). Derrick.

Keys are cheap and easy insurance for any stream or river project. They serve to connect a project's structures to the river bank, reducing the chance of the river flanking the project.

Image 1: A flanked grade control structure. Derrick

The biggest key to stability in a stream project is the Key! A Key needs to go up the bank and tie into roughness. If roughness is not available, it should be planted. The picture on the left is what happens to a project with either short or improperly installed Keys. If they are built of large blocky stone, water tends to flow through the voids between stones. When stream forces interact with the Key, the stone will not self-adjust. It's important when using stone that it has the ability to "launch," or self-adjust, when the Key is undercut. Because of this, Keys are the cheapest and easiest project insurance to include in development and planning. Keys can be used to protect bank protection, grade control, river training structures, plants, and more.

Practice Applicability

The Key itself should be heavily vegetated so as to slow flow velocities over it. Slower water on the bank and overbank means less chance of flanking. Vegetation is designed to act like a Living Dike (closely spaced adventitious rooting poles, and/or rooted stock plants, and/or container plants). In some cases the length of the Key can be extended with vegetation alone, or other materials like buried anchored logs (with vegetation), or a poorer quality stone with vegetation installed.

Image 2: Locked Log selection at Camp Miakonda in Sylvania, OH. Kyle Spicer

Willow and dogwood poles are the easiest and most successful plants to use for this purpose. The poles can be harvested with long-handled loppers, or a small chainsaw, and then stripped of excess leaves or extraneous branches (leaving some is appropriate). The poles can be bundled and then soaked up to two weeks before their installation. Studies have shown that Black Willow soaked for 10 days can put out up to 2,600% more roots!

If funding is scarce, put money into the upstream Key (extend and reinforce it). If the upstream Key gets flanked, the entire project will be compromised.

Image 3: Thalweg displacement by Locked Log in Ottawa River at Camp Miakonda, Sylvania, OH. Kyle Spicer

Keys have been implemented all over the U.S.A. Several restoration projects in the Maumee Area of Concern (AOC) are among those success stories. The Ottawa River bordering Camp Miakonda in Sylvania, Ohio, has multiple Keys securing LPSTP, Bendway Weirs, Single Stone Bendway Weirs, Bioengineering, and Grade Control. By protecting the investment in project structures, the quality and amount of in-stream habitat has increased, erosion to the bank was minimized, and the stream thalweg has been realigned, all while being safely insured that the river and surrounding tributaries do not bypass the projects. Other local restoration projects with Keys include the Ottawa River on the University of Toledo campus, Secor Dam decommissioning, and Hill Ditch within Toledo Botanical Gardens.

Methods typically combined with, or connected to, Keys:

- Longitudinal Peaked Stone Toe Protection (LPSTP)
- Bendway Weirs
- Grade Control
- Project Vegetation

IMPROVING THE PLANET...ONE STREAM AT A TIME
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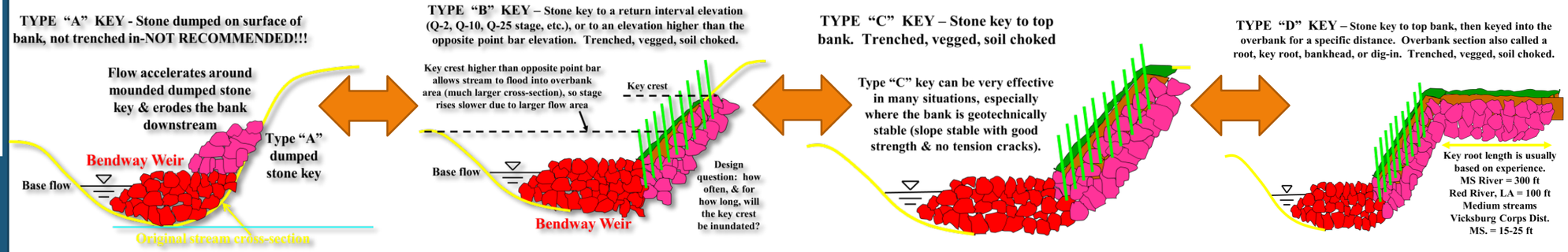
Preparing for Keys

Keys are best built of self-adjusting (well-graded), preferably self-filtering stone. If you cannot locate self-filtering stone, a granular filter might be needed. Stone used in the Key can be the same used as bank paving, Bendway Weirs, or Longitudinal Peaked Stone Toe Protection (LPSTP).The amount of stone in a Key should equal or exceed the amount of stone used per lineal foot in the bank protection or river training structure. The design for Keys must factor in soil type, bank competence (tension cracks or visible failure planes), active failure areas, vegetation (or lack thereof), and height of bank. Stream or river size, flow velocities, flood crests, durations, and recurrence intervals must be factored in as well. There are no rules of thumb for all of this.

There are four different Key Variations:



Limitations

- If a Key cannot be dug into the bank, i.e. bank is too tall to excavate, there exist environmental or land ownership issues, or an archeological site is present, etc., then a portion of the bank will have to be paved to provide protection from flanking.
    - Rule-of-thumb for downstream paved distance from a dike is three times the sum of the maximum bank height and maximum scour depth. Upstream paving from dike equals the sum of the maximum bank height and maximum scour depth.
- Bendway Weir (BW) Keys are the most difficult to build. Since the crest (top) of the BW is only 1 ft above the water, the location where the BW ties into the river end of the Key (toe of the bank) is mostly underwater. It's hard to dig out and maintain the required continuous section (thickness) of the Key in non-cohesive bank materials.
    - In this case, it might be wise to double the volume of the Key in this critical area to over-compensate for the possibility that the original Key cross-section was not completely excavated.

General Guidelines for Construction

- Keys should go up bank and far enough back into the overbank so river migration will not flank the Key. Analyze the meander belt width of the stream or river to determine if the Key can get flanked.
- Minimum Key width should be two times the D-100 of the stone used.
- Any continuous bank protection method, (LPSTP, bank paving, LFSTP) must be deeply keyed into the bank at both the upstream and downstream ends, as well as at regular intervals along its entire length. A spacing rule-of-thumb for Keys in flat-sloped sand bed water bodies:
    - 50 to 100 foot intervals on smaller streams, one to two bank-full channel widths on larger waterways.
- Keys at the upstream and downstream ends of LPSTP should not be at a 90 degree angle to the LPSTP structure, but at 20 to 30 degrees to high flow (or the bank), then curved away from the stream (greater angle) further from the stream (see Figure 1).
- Volume of material per foot of Key should equal or exceed the volume of material per foot in the LPSTP or river training structure.
- Keys should be vegetated to slow flow velocities over the Key. Slower water on the bank and overbank means less chance of flanking. Key length can be extended with vegetation alone in some cases.

Example Construction Sequence

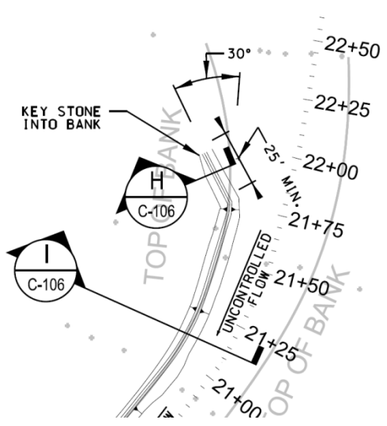
After calculating the appropriate size and direction, and before the LPSTP installation, a trench is dug for the Key.

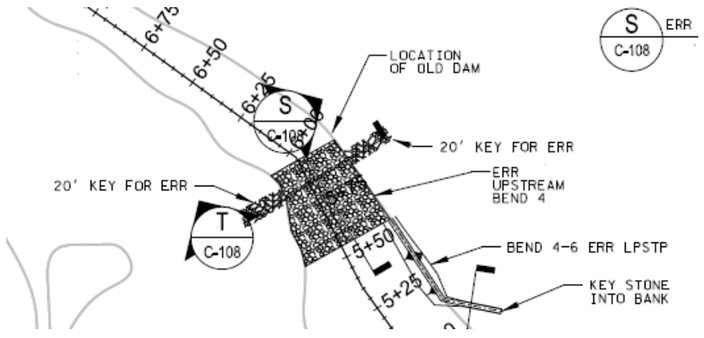
Willow and/or dogwood poles are then placed within the trench, against one or both sides. Make sure the ends of the poles are in the water table, or the capillary zone.

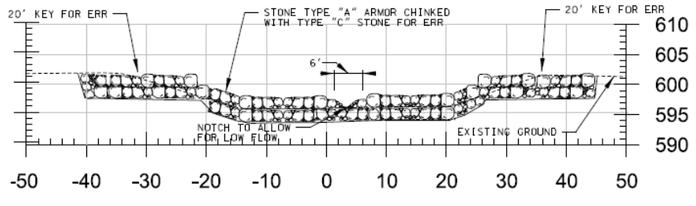
Self-filtering stone is then placed within the trench, taking care to not disturb the recently installed poles. If not able to use self-filtering stone, a granular filter is put down first.

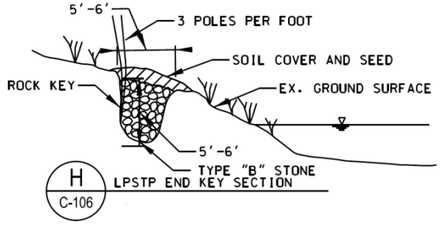
The stone is then backfilled and overfilled with native soils to compensate for any potential settling. The soil is <u>not</u> compacted. Seed heartily and generously!

Example Plan Drawings









Estimating Time and Materials

Incorporating Keys and understanding their necessity when it comes to river and stream projects is important, as catastrophic failure can occur, rendering the project useless! When viewed as “extensions” for structures like Bendway Weirs (BW) and Longitudinal Peaked Stone Toe Protection (LPSTP), it’s easier to understand the amount and size of stone required to secure your initial investment. Keys also take little time to complete, depending on the recommended type for your project. In many cases stone for the key can be dumped directly into the key trench from an articulating front end loader, not bucket-at-a-time from the track hoe.

Maintenance and Monitoring

Keys require little maintenance; however it is important to monitor their condition within a year after implementation, especially during and after high flow events. Monitor vegetation in Key for condition, growth, and debris accumulation. If the vegetation is laid over, in what direction (upstream or downstream) is it pointed? When possible, if there is any damaged or missing vegetation, replant it. Dead vegetation still fulfills the need for roughness, and oftentimes creates more roughness than living plants, however if the project is in its early stages of recovery, it’s recommended that replanting occurs when possible. Deposition or local scour on the bank or overbank may occur, while in-channel scour or deposition near the toe of the Key and area where the Key connects to the structure can also be of concern.