This document was prepared before the project was completed in order to communicate the scope of the project to all parties involved.

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Big Hollow Road Workshop Demonstration Project
College Township, Centre County
August 2009

The demonstration site is located on 575’ long stretch of Big Hollow Road in northwestern College Township and is approximately ¼ mile northeast of the intersection with Fox Hollow Road. The project begins at the crest of the first hill past the PSU Deer Pens access road on the left and follows the road corridor northeast to a point at the bottom of the down-hill grade. The property adjacent to the road right-of-way is owned by Penn State University and managed by Penn State’s Forestland Management Office in the School of Forest Resources, which has granted permission to do off right-of-way road maintenance work.

The focus of this demonstration site is to highlight the use of surface drainage features (Broad-Based Dips and Grade Breaks) on unpaved municipal roads that have low ADT volumes. In addition, the project will feature the installation of a Through-Pipe to address a concentrated off right-of-way flow that enters the upslope ditch, and will compare a Through-the-Bank Pipe ditch outlet with a traditional Turn-Out on an entrenched road. The Grade Break will serve as both a surface drainage feature and as pipe cover for the Through-Pipe. Driving Surface Aggregate will be used to construct all of the project structures. The structures in the project stretch will then be monitored over time to gauge the durability of the DSA as compared to the existing 2A surface, and to determine the suitability of a targeted use of DSA to reduce the adverse impact of winter maintenance on surface drainage structures and high wear areas.

With the rare hydrologic and geologic features of Big Hollow, any reduction in sediment delivery to the stream channel resulting from the planned drainage improvements will positively impact both surface and ground water in the watershed.
**Project Stationing**

00+00 – **Begin Project** at the location of installed grade stake on left road bank at the approximate crest of the hill.

00+54 – Location of up-slope end of BBD channel. **Install Broad-Based Dip** angled downslope from left to right.

00+67 – Location of down-slope end of BBD channel on right.

00+67 (inlet on right) – **Install Through-the-Bank Pipe** in same alignment as BBD. Outlet Through-the-Bank Pipe at marked location on right.

01+58 - Location of up-slope end of BBD channel. **Install Broad-Based Dip** angled downslope from left to right.

01+69 - Location of down-slope end of BBD channel on right. **Grade and re-profile Turn-Out** on right to outlet flow from BBD. Use existing spoils from previous maintenance activities to **build a berm and plug the right ditch below Turn-Out** to keep water from returning to the road.

03 + 77 (inlet on left) – **Install Shallow Through-Pipe** (Crosspipe) angled downslope from left to right with inlet at location of trail/water channel and outlet at marked location on right. **Install associated Grade Break** over pipe with a minimum of 12" of pipe cover. Build Headwall at pipe inlet to accept both off right-of-way flow and flow from the left road ditch.

03+85 - **Grade and re-profile Turn-Out** on right to outlet flow from right road ditch. Use existing spoils or imported aggregate to gain sufficient pipe cover over the portion of pipe that is outside of the cartway. Construct the Grade Break and use pipe cover to effectively plug both road ditches and create a berm to ensure that flow from the Turn-Out does not return to the road.

04+03 - Approximate outlet of Through-Pipe on right at far side of spoil pile.

05+20 – Existing low spot on road surface where water crosses the road from left to right. **Reprofile low spot to form a Broad-Based Dip** with effective fall from left to right.

05+20 to 05+75 – **Elevate road** with two loads of 2A at this location to form the downslope reverse grade and ramp portion of the Broad-Based Dip. Grade the material into the left bank to **plug the left ditch** and taper into existing road surface at approx. 05+75.

05+75 – **End Project**.
So where is the water? This project is located in BIG HOLLOW. A surface and subsurface tributary to Spring Creek. Big Hollow flows largely underground through sinkholes, faults, and caves to emerge as various springs to "SPRING" creek. "Big Spring" in Bellefonte, at 10-20 Million Gallons per day, it is the second largest spring in PA. The complete flow pathways under Big Hollow are complicated and still not fully mapped.

The Spring Creek Watershed is Defined by Both Ground-Water and Surface-Water Boundaries

The area of the Spring Creek Watershed is 146 square miles when the surface-water boundary is used to define the watershed. The surface-water boundary is the location where a drop of rain falling onto the ground surface splits, and one-half flows overland and through tributary stream channels to Spring Creek, and one-half of the raindrop flows overland (in the opposite direction) to a stream in an adjacent watershed such as Bald Eagle Creek watershed.

The area of the Spring Creek Watershed as defined by its ground-water boundary is 175 square miles, which is 20 percent larger than the surface-water watershed area of 146 square miles. A ground-water boundary is similar in concept to a surface-water boundary, except it is the location on the water-table surface where a drop of water (which has infiltrated into the subsurface) splits when it reaches the water-table surface, and one-half of the drop flows (as ground water) to a stream bed or spring which flows into Spring Creek, and one-half of the drop of ground-water recharge flows in the opposite direction to a stream bed or spring in an adjacent watershed such as Spruce Creek. Watershed boundaries are also called drainage divides, because they are the location where surface-water or ground-water flow divides and flows in opposite directions. The ground-water and the surface-water boundaries of the Spring Creek Watershed are shown on the map below:
On the mountain ridges the surface-water and ground-water drainage divides are coincident, because ground water flows in the same direction as the surface water. On the floor of Nittany Valley and Penn’s Valley, where the underlying bedrock is limestone, ground-water flow is controlled by caverns in the bedrock. The southwestern ground-water divide boundary of Spring Creek Watershed is located several miles beyond the surface-water divide, because subsurface caverns and solution openings in the limestone bedrock drain the ground water in this area to the northeast. Ground-water recharge that occurs throughout several square miles of the adjacent Spruce Creek Surface-Water Watershed flows underground to the northeast through the caverns and conduits developed along a fault zone and discharges at Big Spring. Thus the headwaters of Big Spring are located beneath the area of State Game Lands 176 in Halfmoon and Ferguson Townships. The limestone and dolomite areas of the valley floor are shown on the geologic map of the Spring Creek Watershed below:

In Penn’s Valley, subsurface caverns in the limestone bedrock drain some of the ground-water recharge within the Spring Creek Watershed surface-water drainage basin into Sinking Creek, in the adjacent Penn’s Creek Watershed. Therefore the area of Spring Creek Watershed is reduced in the vicinity of Old Fort and Tusseyville due to the subsurface drainage of ground-water to Sinking Creek.

Throughout the entire Spring Creek Watershed, ground water seeps into the beds of streams and flows from the many springs. This is how ground-water becomes surface water flowing in the stream channels. The tributary streams feed into Spring Creek, which flows out of the watershed at the McCoy Dam near Milesburg. Approximately 86 percent of the total annual flow of Spring Creek is ground water before it becomes surface water. This very high percentage of former ground water in our streams illustrates the important role of ground water in the Spring Creek Watershed and in the flow of Spring Creek.
State College Rainfall Event 7/31/09
Total Storm = 1.45 inches

Dry 7/30/09
7/31/09  10:30am
7/31/09  3:00 pm
Bottom of hill

7/31/09  3:00 pm
Big Hollow Road

State College Rainfall Event 7/31/09
Total Storm = 1.45 inches

7/31/09  10:30am
7/31/09  3:00 pm

Bottom half of project site looking downhill.

7/31/09  3:00 pm

Bottom of hill

7/31/09  10:30am

Bottom half of project site looking downhill.
“THROUGH-THE-BANK” PIPE – A pipe placed in the down-slope road bank to carry ditch drainage through the bank and away from the road.

PURPOSE - “Through-the-bank” pipes provide additional outlets for ditch drainage that would otherwise be confined to the road corridor by the road bank on the downhill side of the road. On an entrenched road (a road that is sunken below the surrounding terrain), bank pipes can be used in conjunction with traditional culverts to provide additional outlets for road drainage. Through-the-bank pipes capture ditch flow and direct it away from the road to a point of lower elevation. The water is outletted at the natural ground elevation where it can flow away from the roadway. (Fig B)

BENEFITS

- Provides additional outlets for road drainage that would otherwise be trapped in the road corridor.
- Reduces length of flow of road drainage, which reduces the water velocity and erosion potential to the ditch, road bank, and road shoulder.
- Good alternative to “turnout trenches” that disturb the bank and require constant maintenance.

WHERE TO USE

- Any time a traditional “turn out” would disturb a large area of road bank.
- On entrenched roads (roads lower than the surrounding terrain) where drainage is funneled into the roadway without any opportunity for outlet.
- On entrenched roads where raising the road profile to a level above the surrounding roadbanks is impractical due to cost, absence of suitable fill material, or other limitations.
- On roads where water is trapped on the roadway because maintenance practices have created artificial roadside banks or berms that are difficult to remove on the down slope side of the road.
- Where an appropriate drainage area exists but is obscured by a down slope road bank.
IMPORTANT CONSIDERATIONS

EQUIPMENT
- A backhoe can typically be used to excavate the pipe trench from the roadway. Bank pipes can be installed with minimal off right-of-way impacts.

SITE SELECTION
- A leveling tool is recommended when locating and installing these pipes. Proper fall of the pipe into an appropriate drainage area is required for through-the-bank pipes to function correctly. Maintain at least a 1% fall in the pipe as with all crosspipes.
- Pipes should be outletted at the elevation of existing terrain to avoid the need for an outlet trench. Be sure that outlet water will flow away from the road!
- Vegetation may be affected by the excavation of the pipe trench. Look for areas to place the pipe trench that will minimize impacts on existing vegetation.

PIPE INSTALLATION
- Excavate pipe trench through the bank so that the inlet of the pipe lays on the bottom of the existing ditch. (Photo 2)
- “Through-the-Bank” pipes do not need the same amount of cover that cross pipes require since traffic is not crossing them. Excavated material from the pipe trench can be re-used as cover over the pipes. This will also help with vegetation re-establishment.
- Seeding and mulching of the disturbed soil is important. Native vegetation should be used whenever possible, as these plants are adapted to the site and will provide erosion protection. Non-native plants should be avoided.
- Outlet the bank pipe on the existing ground elevation to minimize disturbed area and to provide a stable outlet site. Native stone headwalls and endwalls are recommended to reduce erosion around the pipe.

Figure A shows how a “through-the-bank” pipe can be used to “punch a hole” in an immovable bank or berm to get water off the road.
Figure B shows a less obvious scenario where the “through-the-bank” is installed on an entrenched road. Using a level is important in these situations because the pipe may actually appear to run uphill with the naked eye, especially on steeper roads!

Photo 2. This is the inlet of the same “through-the-bank” pipe shown in Photo 1. The pipe has just been placed and is about to be covered.
**Shallow Crosspipes**: A drainage culvert (not stream pipe) that is installed so the pipe outlet discharges at natural ground elevation, avoiding the need for outlet trenches or “tail-ditches.”

Please see the Center’s related technical bulletins for general pipe information or crosspipe installation procedures.

The key to shallow crosspipes is to allow the “Natural Ground Elevation” at the pipe outlet determine the crosspipe elevation. Natural Ground Elevation simply refers to the height of the existing land at the pipe outlet. Typical deep crosspipes, illustrated on the left below, use the road elevation to determine pipe installation depth. This often results in excessively deep pipes because the required pipe cover is achieved by digging deeper below the road. The associated “outlet trenches”, or “tail-ditches” are a constant source of maintenance and erosion. When installing a shallow crosspipe, the pipe is placed at an elevation where it drains to natural ground. Necessary pipe cover is obtained by importing fill over the pipe, not by digging deeper into the road base. The best way to understand a shallow pipe is to compare it to a traditional deep pipe as shown below.

**Deep Pipe**

**Shallow Pipe**

Side View, looking through crosspipe from outlet, comparing deep and shallow pipe placements. Note the green “natural ground elevation” line. Deep pipes dig down to obtain pipe cover. Shallow pipe placements are based off the natural ground elevation, and use fill to achieve pipe cover.

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Problems associated with traditional “Deep Pipes”:
When a pipe outlet is placed below the surface of the ground, it creates the need for continual maintenance of a “tail-ditch” to keep water flowing away from the road (illustrated in bottom left photo on page 1).
- Constant “cleaning” of tail-ditches costs money and generates large amounts of sediment.
- Unmaintained tail-ditches often clog, resulting in standing water at the outlet that can breed mosquitoes, saturate the road base, and lead to clogged pipes.
- Tail-ditches channel carry drainage far from the road, making stream and wetland pollution more likely.

Benefits of Shallow Crosspipes:
- **Less Maintenance:** No tail-ditch to maintain will save time and money.
- **Less Problems:** No tail-ditch means no standing water to saturate road or breed mosquitoes.
- **Less Pollution:** Outletting drainage quickly on natural ground gives maximum opportunity for infiltration.
- **Shallower inlet:** A shallower pipe means a shallower inlet that is less likely to plug or need maintenance.
- **Potential “grade break”**: The material imported to cover a shallow crosspipe can sometimes be used to create a grade break. These structures are designed to prevent water from flowing down the road by forcing it into road ditches. More info on grade breaks at [www.dirtandgravelroads.org](http://www.dirtandgravelroads.org): resources: tech bulletins

Installing a Shallow Crosspipe:
1. **Determine proper outlet elevation:** Ideally, bottom of pipe outlet should rest on natural ground as pictured above.
2. **Dig pipe trench:** Pipe trench should be excavated based on outlet elevation. Ideally, pipe inlet should be placed in existing ditch line. Insure minimum ¼ inch per foot fall across trench.
3. **Install pipe:** Separate bulletin about proper crosspipe installation available at: [www.dirtandgravelroads.org](http://www.dirtandgravelroads.org): resources: tech bulletins.
4. **Cover pipe:** Shallow pipe installations typically require 30 to 60 tons of fill to obtain necessary pipe cover. Proper compaction is critical to avoid settling and pipe strain. Pipes should be covered with a minimum of 12 inches of compacted material (not including surface aggregate) before allowing traffic on the road. The fill should be tapered into the existing road elevation on either side of the pipe. The amount of fill needed and length of fill taper will depend on site conditions such as road slope and pipe depth. Transitions should be sufficiently long to accommodate expected traffic. In some cases, a grade break can be created with fill that forces water off the road and into the ditches and pipe.

“Crosspipe elevation should be determined by the elevation of the existing ground at the pipe outlet, not of the elevation of the road surface”
**Broad Based Dip:** An intentional watercourse and associated high spot created across a roadway that conveys water from the uphill ditch over the road surface to a discharge area.

**Purpose:**
The main function of a *broad based dip* is to collect flowing water from the road surface and ditches, directing it across the road to a stable outlet. *Broad based dips* can be used in place of crosspipes in certain situations to outlet water from the uphill ditch across the road. *Broad based dips* also act as gradebreaks or water bars to prevent drainage from flowing down the wheel tracks on the road surface.

**Benefits:**
- Prevents erosion caused by water flowing down road.
- Acts as a crosspipe to outlet drainage from the uphill side of the road, reducing potential for erosion and stream pollution from long ditch runs.
- Cheap, easy, and effective on low volume roads.

**Considerations:**
- Use discretion when considering *broad based dips*. They are only appropriate for use on low traffic roads. Roads with high vehicle traffic and oversized loads may not be appropriate for *broad based dips*.
- *Broad based dips* should not be used on roads with a slope of greater than 10%.
- A *broad based dip* is designed to carry runoff across the surface of the road. It may be necessary to reinforce the bottom of the dip and dip outlet to prevent erosion, depending on site conditions.
- *Broad based dips* are not designed to accommodate continually flowing water such as springs or streams.

This *broad based dip* in Huntingdon County is located on an access road that is only open to the public for hunting season. This low-use road is ideal for *broad based dips* instead of crosspipes to reduce long term maintenance. The dip pictured here collects road and ditch water and directs it from left to right across the road.

Water is allowed to run down the roadway and ditch. This builds volume and velocity which can erode the road area and deliver sediment to streams.

The *Broad Based Dip* forces water flowing on the roadway and in the ditches to a stable outlet area to reduce erosion. Reinforcement of the outlet area may be needed, depending on site conditions.
Construction Considerations:

- **SPACING:** Multiple *broad based dips* can be used in sequence, similar to crosspipes, to drain a long stretch of road. Spacing for *broad based dips* depends on a variety of site-specific conditions including road slope, native soils, and hydrologic conditions.

- **SIZE & SHAPE:** Sizing for *broad based dips* will vary widely depending mostly on road slope and anticipated traffic. Dips constructed on flat roads may be relatively small (fill transitions as short as 12 feet and as low as 6 inches). Dips installed on steeper sections of road will require more “approach fill” to ease the transition into and out of the structure (fill transitions over 100 feet long and up to 18 inches deep). Be sure to take anticipated traffic into account. The dip pictured on the front of this document is on a gated access road and is much more abrupt. The dip pictured above has much smoother transitions to accommodate cars and log trucks. A relatively wide dip bottom is recommended to accommodate water and ease vehicle transitions. The upslope end of the dip should be tied into the uphill bank to insure water does not bypass the structure and continue flowing down the ditch.

- **ANGLE:** *Broad based dips* should be angled across the road at approximately 20-40 degrees, not placed at 90 degrees perpendicular to the road like a speed bump. The angle will facilitate the flow of water across the road. A dip placed straight across the road will be much more likely to fail because it forces water to turn at a right angle to flow across the roadway.

- **SLOPE:** Similar to crosspipes, the bottom of a *broad based dip* should have an elevation drop towards the outlet end. A 3% slope is recommended across the bottom of the dip.

- **DIP REINFORCEMENT:** Because a *broad based dip* is designed to carry concentrated flow on the surface of the road, reinforcement of the dip bottom is recommended. Hard stone and even geo-synthetic materials can be used to reinforce the bottom of the dip to resist erosion.

- **OUTLET REINFORCEMENT:** Because a *broad based dip* outlets water similar to a crosspipe, similar outlet stability concerns apply. When possible, outlet dips into a vegetated buffer area. Depending on the amount of water and slope of the land, additional outlet stabilization with stone may be required.

- **MAINTENANCE:** A properly constructed *broad based dip* will function for years with minimal maintenance. Care must be taken not to remove the dip during any future maintenance activity.

*Broad based dips* are a cheap and effective means of drainage control on low volume roads. Farm lanes, camp roads, gated access roads, and other low use roads are ideal candidates for these structures. Always try to discharge dips to a stable outlet away from streams.

*A Gradebreak is a related surface drainage structure designed to divert water off the road surface, but not to carry flowing water across the road. For details about gradebreaks, see the Center’s related technical bulletin at www.dirtandgravelroads.org.*