**Article 150**

*Technical Note #50 from Watershed Protection Techniques. 1(4): 198-202*

# Parallel Pipe Systems As a Stream Protection Technique

Blown-out streams, channelization, rip rap, eroded streambanks are all familiar conditions within the urban stream network. Recent stream enhancement activities have concentrated on bioengineering and instream habitat structures to correct past abuses and preserve existing conditions.

An alternative approach for some small headwater streams involves employing a parallel pipe storm drainage system (parallel to the natural stream channel), that conveys frequent storm flows past the existing natural channel, eventually discharging to a more stable downstream location. Parallel pipe systems are designed to maintain low flows within the existing stream channel, bypass the frequent erosive storms around sensitive portions of a stream, and allow large, less frequent storm events to remain within the stream channel or its floodplain.

This concept recognizes that urban streams are subject to flow events equaling bank-full conditions as often as three to five times per year or more, whereas undeveloped natural streams may be subjected to bank-full flows once every other year or so (Hollis, 1975). These smaller, more frequent storms are thought to cause much of the stream channel erosion since high velocity flows are working on the entire channel cross-section. In non-urbanized channels, more extreme storm events (i.e., greater than the 1.5- to two-year storm) spill over the banks and into the adjacent floodplain and are less erosive.

Parallel pipe systems have been installed for many reasons. For example, they can protect sensitive portions of natural stream channels, or convey urban runoff to downstream stormwater management facilities, or aid in stabilizing the hydraulic regime to existing "blown-out" channels as part of stream protection efforts. Parallel pipe systems are appropriate for highly urbanized stream systems where biological stabilization techniques are not likely to withstand excessive erosive velocities, upstream stormwater management facilities are not feasible or practical, and structural

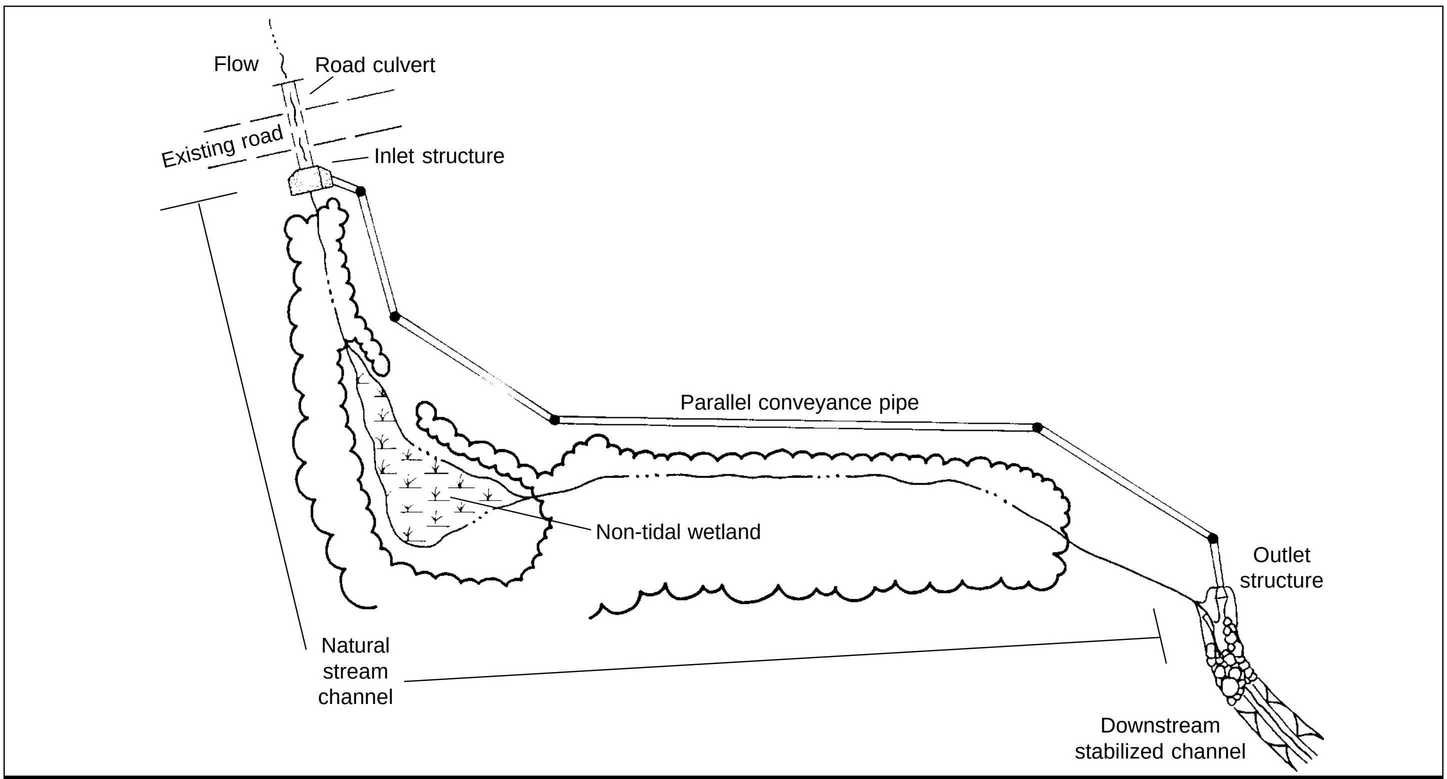



**Figure 1: Parallel Pipe System Components**

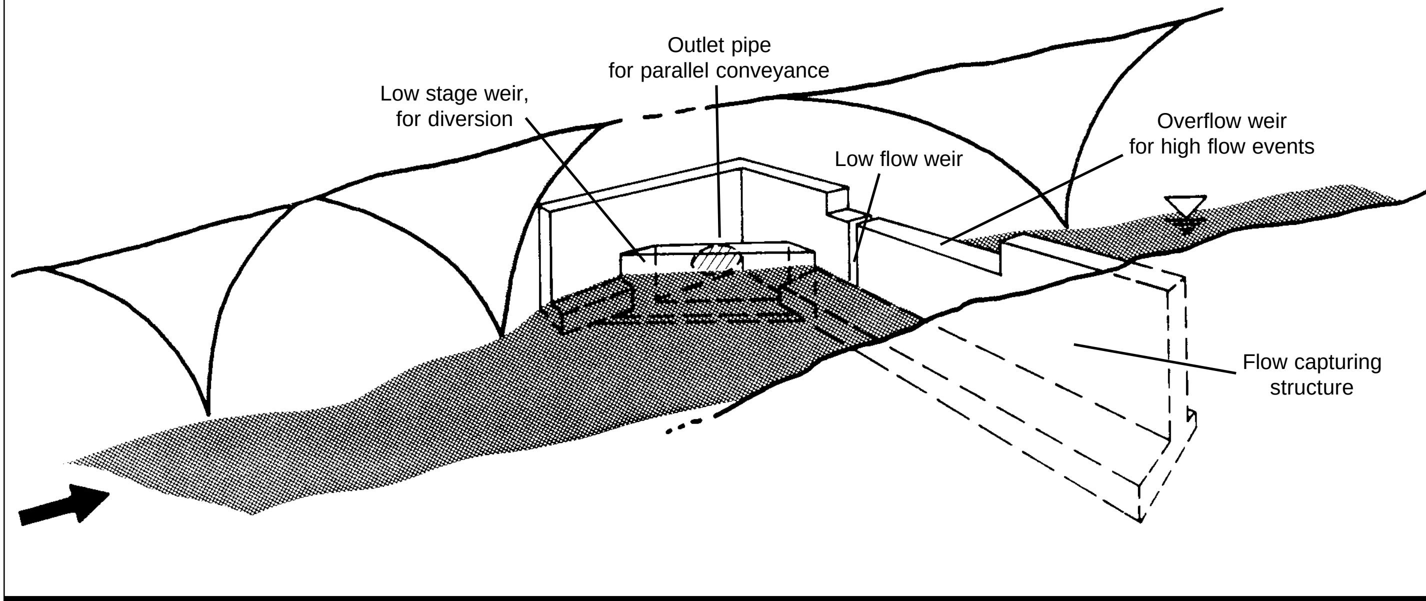



**Figure 2: Parallel Pipe System Typical Inlet Structure**

**Table 1: Parallel Pipe Design Approach**

1. Identify the stream reach to be protected
2. Field locate the control structure (detailed topography necessary)
3. Compute peak discharges for storm events
   - Design discharge for diversion (use storm for which 85% of all annual events are equal to or less than, i.e., 1.05" rainfall)*
   - Large storm(s) for overflow weir (e.g., 10 to 100 year frequency event)
4. Field measure or compute baseflow discharge (1 cfs per square mile)**
5. Calculate hydraulic characteristics of control structure
   - Use weir flow/orifice flow equations for baseflow
   - Use Federal Highway Administration culvert charts or computer model, for parallel pipe inlet flow condition
   - Use weir flow equation for high stage overflow
   - Use hydraulic model (e.g., HEC-2) for downstream tailwater analysis
   - Designer must recognize hydraulic losses at control structure intake
6. Compute required pipe size for parallel pipe system to pass design storm (use open channel flow equations, e.g., Manning's.)
7. Check hydraulic gradient for parallel pipe system under high flow conditions (usually 10 to 100 year storm)
8. Compute required outlet channel size (length and geometry)

* Washington DC metropolitan area (50 year analysis at Washington National Airport)

** Rule of thumb for Mid-Atlantic region

stabilization with rip rap is not desired. In addition, parallel pipe system construction is often less disruptive than rechannelization and instream construction techniques. It is important to recognize that parallel pipe systems are most appropriate for small headwater streams where the small frequent storms can be adequately conveyed with reasonable pipe sizes and control structures are reasonably small in scale.

A parallel pipe system incorporates an inlet structure (flow splitter), a conveyance pipe or open channel, and an outlet or discharge structure (Figure 1). The inlet or control structure (usually cast-in-place concrete) is located at an upstream control point. It consists of a flow-capturing structure, a low-flow orifice or weir, a low stage weir for diversion of design flow rates, an outlet pipe for the parallel conveyance system, and an overflow weir for high-flow events discharging back into the natural channel (Figure 2). Large rip rap is usually required to guard against erosion at the control structure. The actual "parallel pipe" consists of a reinforced concrete pipe. The outlet channel or stilling basin should be stabilized and designed to conform to the natural channel geometry. Large rip rap or other suitable energy dissipation technique should be employed immediately below the outlet, but should be as short as possible and designed to return to the natural conditions quickly.

Table 1 outlines a general approach that can be used to design most parallel pipe applications. This approach is based on capturing a given frequency storm event for parallel conveyance. Further monitoring may suggest that an alternative storm frequency may be more appropriate for stream protection. Table 2 presents some key design tips that are often employed in

parallel pipe projects. Designers must also assess the potential costs of installing a parallel pipe system as opposed to alternative stream protection measures. As the drainage area increases, it becomes increasingly expensive to employ the parallel pipe application. Table 3 gives a sample drainage area versus cost comparison for moderately developed single family residential land use in the Mid-Atlantic region of the United States.

Parallel pipe systems can be installed in several locations within the urban drainage network (Figure 3). Common locations are:

- Existing or planned conventional storm drainage outfalls
- Within an existing or planned conventional storm drain manhole
- Immediately downstream of a road culvert
- Within the natural stream channel itself

**Table 2: Some Key Design Issues for Parallel Pipes**

- Keep parallel pipe out of forested stream buffer, where possible
- Locate mature trees prior to laying out parallel pipe alignment
- Locate control structure to minimize secondary environmental impacts
- Reforest parallel pipe right-of-way after construction
- Use appropriate trash rack (or no trash rack) depending on litter/ debris supply of watershed
- Consider fish migration barrier potential for spawning headwater streams
- Often requires a waterway construction permit or 404 non-tidal wetlands permit

**Table 3: Parallel Pipe Construction Cost Data**

| Pipe size (RCP) | Maximum drainage area (acres) | Capacity (cfs) | Construction costs ($/linear foot) |
|---|---|---|---|
| 24" | 40 | 22.6 | $40 |
| 36" | 130 | 66.7 | $75 |
| 48" | 300 | 143.6 | $105 |
| 60" | 570 | 260.4 | $150 |
| 72" | 1,000 | 423.4 | $235 |

Assumptions: Standard pipe sizes for reinforced concrete, maximum drainage area is based on single family residential land use (i.e., one-half acre lots), capacity is based on Manning's equation for reinforced concrete pipe at a 1.0% slope or steeper, construction cost includes installation, exclusive of control structure costs, and is based on approximate average installation costs for the Mid-Atlantic region from 1990 to 1994.

### Flora Lane - A Case Study

A parallel pipe system was constructed in 1993 adjacent to Flora Lane in Montgomery County, Maryland. The Flora Lane tributary to Sligo Creek drains a moderately developed area of approximately 235 acres. The parallel pipe system was constructed as part of the overall Sligo Creek restoration effort (see article 144), and was specifically targeted to protect approximately 750 linear feet of natural channel. The system consists of up two upstream control points to collect stormwater from small storm events, a parallel pipe, and an outfall.

One method to assess the success of the project is through an ongoing physical, biological and chemical monitoring program. Biological monitoring was conducted for fish and macroinvertebrates prior to implementation of the project to help establish baseline conditions. Macroinvertebrate abundance was moderate to very low and only three native fish species were present (Stribling *et al.*, 1993). Nine native fish species were reintroduced into the stream in the spring of 1994, and, according to preliminary monitoring results, at least seven species were still present in the fall of 1994 (Galli, 1995).

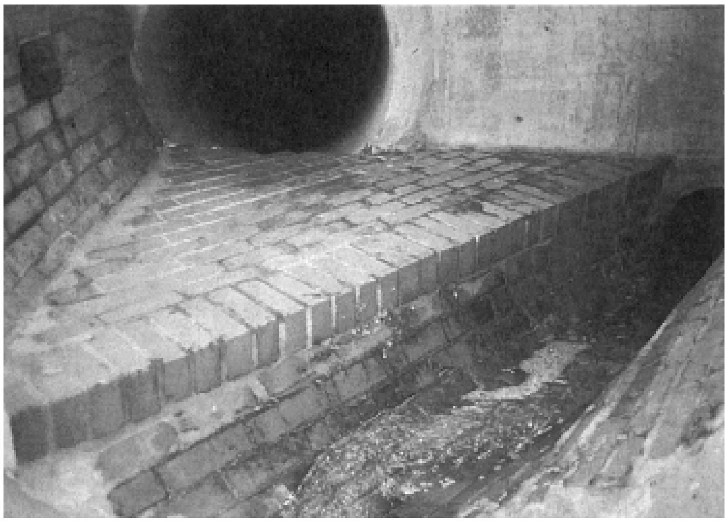
It is probably too soon to assess the overall success of this project since far more monitoring needs to be performed, and it remains to be seen whether or not transplanted fish are reproducing on their own, but all preliminary indications point to parallel pipe systems as a viable though limited tool for stream restoration.

### Construction Elements

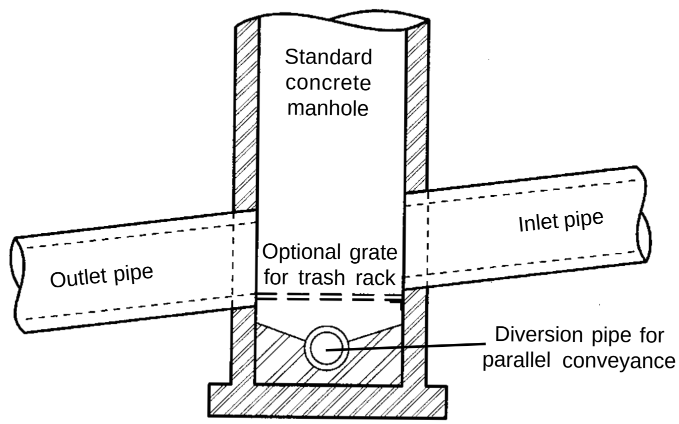
Construction of parallel pipe systems are not significantly different from construction of conventional storm drain systems. However, extra attention must be given to the temporary diversion of flows (both baseflow and storm flows) during construction of the control structure. It is also extremely important to have good quality control in constructing the weir and orifice elevations for any type of flow splitting device, as the slightest error can divert substantial amounts of water to the wrong location. A pre-construction meeting is imperative, and frequent inspections by the design engineer should be incorporated into the bidding specifications. The control structure formwork should be field surveyed prior to pouring concrete to ensure that the proper elevations and lengths have been achieved.

**Figure 3: Common Applications for Control Structure Location**

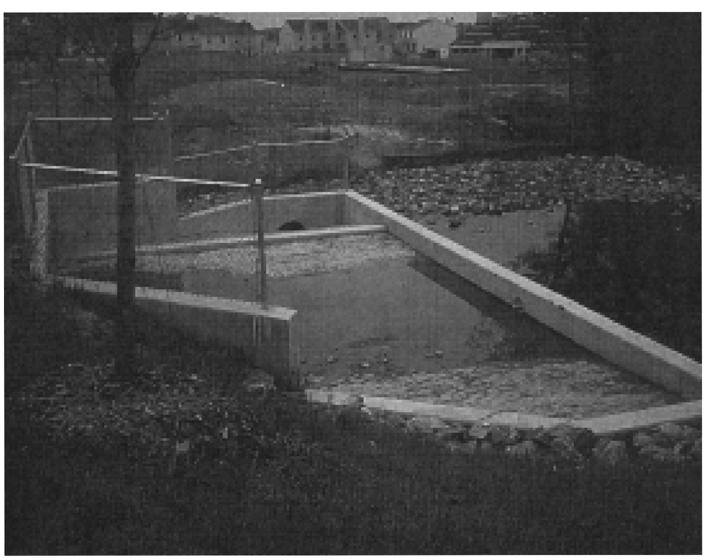
**A. Storm drain outfall**



**B. Storm drain manhole *(adapted from Loiederman Assoc., Inc.)***




**C. Downstream from road culvert**



**D. Within natural stream channel**

**Clogging, Maintenance, Longevity and Safety**

One of the primary concerns about parallel pipe systems is the susceptibility of the inlet structure to clogging. Accumulated trash, woody debris or sediment can potentially clog low flow openings and thus deprive the stream of necessary baseflows. A good solution is to provide a stilling basin immediately upstream of the control structure, and employ a hooded low flow orifice with a minimum diameter of three inches. The intake and outlet structures should be inspected at least twice a year and after major rainfall events to check for clogging. Trash racks and hooded openings may require cleaning on a more frequent basis. Based on local experience modest drainage areas, stilling basins may require dredging every two to three years. The actual pipe system requires little maintenance as long as the intake does not clog and the system was initially constructed on a stable subgrade and backfilled properly.

Care should be employed to locate structures in areas where children are not likely to congregate. Trash racks and concrete structures can be an inviting play area to younger children. Fences are not desirable, since high flows are likely to wash them out. Warning signs might be considered where appropriate. Perhaps the best approach is to assume that children will be present, and use common sense in the design of reinforcing bars and concrete walls.

Parallel pipe systems can provide a cost-effective alternative to structural stabilization of small natural channels for urban areas. However, once the drainage area becomes reasonably large, and pipe sizes increase much above 54 inches, structural stabilization may be more cost effective (Table 3). Furthermore, it is important to realize that parallel pipes are not water quality treatment practices and do not attenuate stormwater runoff. If these systems are poorly designed, many of the problems they are designed to correct are simply moved downstream.

Parallel pipe systems have been used extensively in suburban Montgomery County, Maryland since 1987 and informal inspections indicate that they are protecting small stream channels. More formal monitoring reports indicate that urban streams protected by parallel pipes show minimal signs of continued channel erosion (Galli, 1995). Perceptions regarding clogging potential and maintenance appear to be the principal impediment to more widespread implementation. Some systems that have been in place for more than five years show signs of persistent clogging. Continued monitoring and review of design criteria are necessary to ensure that the practice is a reliable, long term stream protection measure. Additionally, research is needed to evaluate parallel pipe system design criteria to help define and establish the appropriate protection for small headwater streams.

***—RAC***

**References**

Galli, J. 1995. Personal communication. Department of Environmental Programs. Metropolitan Washington Council of Governments. Washington, DC.

Hollis, G.E. 1975. "The Effect of Urbanization on Floods of Different Recurrence Interval." *Water Resour. Res.* Vol. 11, No. 3.

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