WATKINS CREEK WATERSHED STUDY

The Watkins Creek Watershed Project is a collaborative watershed protection project, spearheaded by RegionWise, in cooperation with the Hazelwood School District, Intuition & Logic, Spanish Lake Community Association, and Saint Louis University. The objectives of the project are two-fold: First, to evaluate the physical stability of the Watkins Creek Watershed and identify existing problem areas affecting water quality and stream stability. Second, to identify deficiencies in existing stormwater policy that, if revised, could have dramatic effects on protecting urban streams and stormwater infrastructure.

In this report, we illustrate the existing channel stability problems, which afflict not only Watkins Creek Watershed but many degraded watersheds throughout St. Louis County. In addition, we have developed four amendments to the St. Louis County Zoning Ordinance and Metropolitan St. Louis Sewer District design standards to address existing flooding and erosion problems present in many urban watersheds, and to reduce the economic impacts associated with these problems.

An Introduction to the Watershed & Stormwater Management

Before we can begin to understand the nature of the problems existing in Watkins Creek, we must first understand some basic principles of river and stream mechanics. The three functions of a stream system are the collection of water and sediment, the transport of these materials, and deposition. Relatively undisturbed or stable streams maintain a plan, profile, and cross-section shape that efficiently transport the water and sediment supplied to them. This is because streams exist in a state of dynamic equilibrium in which the driving forces for channel form are balanced by the resisting forces. The driving forces are the quantity of water and sediment delivered through a stream, while the resisting forces are the strength and roughness of the channel materials and the channel shape. When these driving forces exceed the resisting forces, the stress applied by water or sediment exceeds the channel strength and erosion occurs. Conversely, when resisting forces exceed the driving forces, the channel may build through deposition of sediment. Thus, the stream channel is not a static form, but instead responds by altering its shape in planform, profile and cross-section to accommodate changes in flow volume and applied shear.

Perhaps the fundamental principle of stormwater management in much of the Midwest has been to concentrate and convey runoff away from populated areas. This approach made sense when urban streams were used primarily for waste disposal and viewed as little more than open sewers. As advances in sewage collection and disease control improved, urban streams no longer transported sewage, but instead became part of the vast network of municipal stormwater infrastructure. However, while it was no longer necessary to concentrate and convey for sanitation purposes, these outdated methods persisted. Today, accelerated delivery of concentrated stormwater runoff remains the primary feature of post-development hydrology. The accelerated runoff is a consequence of increased impervious surface and the simultaneous increase in drainage network density from piped stormwater systems.

Like many watersheds in the St. Louis region, the Watkins Creek Watershed experienced rapid urbanization in the 1950's, 60's, and 70's, when few stormwater management practices were in place. The changes in hydrology accompanying urbanization have provoked systemic bank erosion and mass wasting observed throughout the Watkins Creek Watershed. Streams in the watershed are now severely degraded and in a condition of physical instability, and severe erosion continues to threaten infrastructure and property.

A Changing Regulatory Climate

Whereas the degraded condition of Watkins Creek has led to an abundance of erosion-related problems, healthy stable stream systems provide a number of services and benefits, including:

- ⇒ water quality treatment
- ⇒ groundwater recharge
- ⇒ improved infiltration of rainfall
- ⇒ improved aesthetics
- ⇒ enhance adjacent property values
- ⇒ habitat for plants and wildlife
- ⇒ recreational opportunities

These benefits are valuable in-and-of themselves, but it is important to recognize from a municipal planning perspective that stable streams are a vital component of municipal stormwater infrastructure. When protected and managed properly, stable streams and their corridors can provide efficient stormwater interception, storage and transport at relatively little cost compared to conventional piped and channelized systems. In fact, the escalating capital and operating costs of conventional stormwater systems have motivated planners and policy makers alike to seek better alternatives and to revise existing policy regarding natural stream systems on a local level, throughout the Midwest, and across the nation. Here are just a handful of examples:

<u>MSD Expert System</u>

Locally, Intuition & Logic, in cooperation with the Metropolitan St. Louis Sewer District (MSD) and the University of Missouri at Rolla, has developed an Expert System to condense the advances made in stream engineering into an evaluation tool that will be readily accessible to the design engineer and plan reviewer practicing in St. Louis. Over the past thirty years, the professions of engineering of stream management have seen a convergence of disciplines including hydraulics and hydrology, fluvial geomorphology, sedimentology and soil bioengineering. This convergence has yielded significant advances in analysis and design methods, including improvements in project performance, cost, regulatory compliance and environmental quality. The MSD Expert System reduces the need for massive retraining of the engineering community, though it does encourage engineers to expand their skills.

When completed, the user-friendly system will incorporate a computer interface, which includes data queries that make sense to a user unfamiliar with the theory and practice of river science. Major data sets required to complete an assessment include critical parameters such as hydraulic geometry, channel plan and profile, boundary material characteristics as well as evaluations of riparian corridor condition.

APWA 5600

Elsewhere in the Midwest, counties and municipalities in the bi-state Kansas City metro area have recently completed a major revision to their engineering design standards. Led by the Mid-America Regional Council and the Kansas City Chapter of the American Public Works Association, the new standards address both urban water quality and quantity. An urban BMP manual addressing both structural and non-structural methods of stormwater management is coupled to rigorous design standards. Working with city and county stormwater engineers representing more than a dozen jurisdictions, Intuition & Logic developed an entirely new section of the standards addressing natural stream systems. While oriented for the civil designer, the standards are thoroughly grounded in geomorphology and account for the dynamic equilibrium that is the defining characteristic of natural streams. For the first time in the Kansas City metropolitan area, regional design standards specifically focus on the protection of natural streams. Design standards address sediment transport continuity, energy dissipation, grade stabilization, stream setbacks and pipeline, bridge and culvert crossings.

Nationwide Stormwater Design and Management Criteria

States and Counties across the nation have taken measures similar to those described above to develop policies that will effectively manage stormwater runoff to limit channel erosion, flooding, sedimentation, and pollution of their watersheds. Maryland, Massachusetts, King County, Washington, Portland and Eugene, Oregon, Kansas City, Lincoln, Nebraska, and Springfield, Missouri exemplify states, counties, and municipalities from coast to coast, which have or are currently in the process of revising stormwater standards to maintain pre-development hydrologic conditions. Many of the revised standards include stormwater management policy similar to those described below.

Revising Stormwater Policy

Based on an extensive review of existing design standards, successful stream protection ordinances, professional literature, and our knowledge of the existing condition of the Watkins Creek Watershed, we have developed four recommended revisions for St. Louis County stormwater policy, ordinances, and design standards. Each is intended to prevent the hydrologic impacts associated with new development, match post-development hydrology to the pre-development condition, and facilitate accelerated recovery of degraded streams.

I. Implement hydrology controls for channel protection. Historic changes in land use have altered the hydrology of the Watkins Creek Watershed, precipitating channel incision, subsequent widening and meander adjustment. Streams respond to changes in hydrology, specifically the post-development flow volumes, by altering their shape in cross-section, planform, and profile (Leopold, Wolmann, and Miller, 1964). Hydrology controls are intended to avoid significant changes in flow volume and timing, and will therefore reduce the likelihood of major changes in stream form.

Volume control applies specifically to stormwater detention or retention. Volume controls can be as simple as a modification or retrofit to a pond or detention feature outfall structure, or they can be integrated into the design of a new development as vegetated swales, microdetention basins, or wetlands. These strategies are capable of controlling the smaller, 1-year storm. These smaller storms are considered the “water quality” storm event for this region, and transport the greatest volume of sediment and pollutants over time.

However, controlling the water quality storm is not required by the existing design standard. Therefore, we recommend revisions to the existing stormwater detention design standards described in Section 4.080.01 (2.a) of *The Metropolitan St. Louis Sewer District Rules and Regulations and Engineering Design Requirements for Sanitary Sewage and Stormwater Drainage Facilities* (February 1997) so that the post-development flow rate shall not exceed the pre-development flow rate for the **1 year – 24hr**, 2 year – 24hr, and 100 year – 24hr storms.

In addition, timed release of stormwater for the 1yr – 24hr storm should be released at a rate such that the storm volume is released in a 48hr (minimum) to 72hr (maximum) time period following the storm event, to more closely match predevelopment hydrology.

II. <u>Manage the energy in the system.</u> Excessive erosion in a stream system indicates that kinetic energy is higher than the stream can sustain. Flooding occurs when the potential energy is higher than what neighboring residents and businesses can accept. Erosion or flooding occurs when energy is not dissipated or there is a conversion of kinetic or potential energy.

Therefore, effectively managing energy in a stream system is critical to flood and erosion prevention. We recommend revisions to the existing culverts and bridges design standards described in Sections 4.030.06 and 4.040 of *The Metropolitan St. Louis Sewer District Rules and Regulations and Engineering Design Requirements for Sanitary Sewage and Stormwater Drainage Facilities* (February 1997) so that the energy grade line upstream and downstream of any new in-stream structure, bridge, or culvert is matched. The pre- and post-project energy grade lines for the 50%, 10%, 4% and 1% flows should be plotted. The extent of the zone of influence downstream of these structures should be limited by energy dissipation and grade control.

Energy dissipation should also be required at any primary outfalls. Primary outfalls are those where the upstream channel is replaced by an enclosed system or constructed channel. Energy dissipation should be provided at the outlet to reduce velocities, and a grade control downstream of the outlet should be provided to prevent undermining of the outfall structure. Where energy dissipaters are required, they should be designed in accordance with the methods described in USBR (1974), FHWA (1983), or USACE (1987). Existing channel crossings and outfalls can be retrofitted with energy management structures, such as grade controls, stilling basins, or rock-lined plunge pools to prevent further erosion.

In addition, culverts should be designed to minimize backwater effects and maintain sediment transport competency. Culverts should be designed so that there is minimal backwater effect at all flows up to the 4% discharge. This revision is intended to maintain sediment transport and prevent sedimentation of culverts. This approach would be phased in as culverts are gradually replaced. Older culverts can be replaced with two-stage or "conservation" culverts to meet the proposed requirement.

III. Maintain stream buffer zones. Stream buffers assist in maintaining stream health and stability by providing room for planform adjustment, filtering stormwater pollutants, and alleviating bank erosion. Riparian trees and vegetation stabilize stream banks hydrologically, mechanically and hydraulically. In the Watkins Creek watershed, bank erosion is particularly severe where trees and woody vegetation have been recently removed from the top of the bank.

We recommend that the County require stream buffer zones, or wide riparian corridors densely vegetated with native trees, shrubs and grasses (not turf) along all streams and headwaters tributaries. These required setbacks should be enforced during the planning phase of land development. No construction or land disturbance of any type should be allowed in the buffer zone without permission of the County. For work on existing facilities already located closer to the stream than allowed by the stream buffer zone, the new construction should not encroach closer to the stream.

Guidance on stream protection is given in Wegner (1999), National Academy of Sciences (1999), and Heraty (1995). Natural streams should be preserved as systems and not segmented on a project-by-project basis, as the frequent intermixing of natural and man-made systems tends to degrade the function of both.

The Watkins Creek headwaters region (above left) has been ringed by roads and residential development close to the top of streambanks. In this area, creating a stream buffer zone may not be feasible. However, opportunities for buffer zones exist lower in the watershed, such as the largely undeveloped corridor between Highway 367 and Highway 270, (above right) east of Hazelwood East High School.

A buffer zone ordinance may be effectively established by revising section nine, subsection two, paragraph (b) of Chapter 1003.101 "FP" *Flood Plain District Regulations of the Zoning Ordinance of St. Louis County*. This passage should be revised to read, "**No building** shall be allowed within **(designated width)** feet of any area designated "FP" Flood Plain District." The "FP" Flood Plain District is an overlay zoning district; meaning that the "FP" Flood Plain District regulations impose certain criteria upon permitted uses underlying the "FP" Flood Plain District. Amendments to the "FP" Flood Plain District affect all permitted underlying uses.

An alternative to this approach would be to rezone all districts underlying the "FP" Flood Plain District to "PS" Park and Scenic District, which would effectively preserve a stream buffer zone as a recreational amenity. Such a regulatory change would prohibit most development in "FP" Flood Plain Districts.

IV. <u>Keep streams in their natural alignment.</u> Straight stream channels are rare in a natural setting. The near-universal tendency for stream channels to flow in a sinuous planform has been theoretically and empirically investigated for decades. It has been discovered that, like all other open systems, streams adjust their planform to minimize the expenditure of energy. The formation of pool-riffle patterns and meanders are consistent with this trend toward maintaining an equilibrium condition.

Channelization includes several types of interventions, generally designed to lower the water surface elevation for a particular flood event. For all lesser flood elevations, channelization generally increases the slope upstream of the intervention. This results in a whole host of systemic effects throughout the watershed. The increase in slope results in an increase in the quantity of sediment and an increase in the size of the mobile particles. Downstream of a channelized reach, kinetic energy is converted to work resulting in a scouring of the bed, banks or both. This was observed in the Wtakins Creek Watershed downstream of a channelized reach near Lilac Avenue and upstream of a channelized reach behind Monticello, Muriel, and June Drive.

Channelization or channel relocation should be prevented. In addition, structures such as buildings and infrastructure should be constructed far enough away from the stream to allow it to adjust its course unencumbered. While no existing county regulation or ordinance directly addresses this concern, it is possible to implement this management strategy simultaneously with a stream buffer zone ordinance.

The Cost Savings of Stormwater Best Management Practices

The policy and design standard revisions outlined above can be collectively referred to as stormwater best management practices (BMPs). They include both structural (I.E. hydrologic controls and energy management) and non-structural (I.E. buffer zones and maintaining alignment) strategies to prevent erosion, control flooding, and reduce stormwater pollution. A wealth of information has been published not only on the proven effectiveness of stormwater BMPs, but on the capital and operating cost savings they contribute to municipal or county stormwater management programs, as well (US EPA, 1995, 2000).

Capital costs can be reduced by directing flow through microdetention basins or to infiltration devices that reduce runoff rates and volumes, thereby reducing the size (and cost) of downstream conveyance and storage devices like culverts and detention basins. By controlling the full range of storm flows at detention basin outfalls upstream, peak runoff rates are reduced, thereby reducing the size (and cost) of major drainageways and storm sewers downstream. In addition, capital costs can be reduced by allowing alternative hydrologic controls, such as vegetated swales, which are less costly to install than curb and gutter or underground storm sewers.

Long-term operating cost savings are realized by the reduction in downstream sediment loads associated with controlling smaller water quality storms and preserving stream buffer zones, thereby reducing the need for sediment removal from culverts or channels. Hydrologic controls and managing stream energy also reduce shear stress on the bed and banks, minimizing downstream bank erosion and the associated repair costs of bank stabilization.

The economic benefits to builders and developers can be significant, as well. The following are examples from the USEPA's publication, *Economic Benefits of Runoff Controls* (1995):

> <u>Highland Park, Illinois</u>
> "Preservation is not a problem for developers; it's a golden opportunity," insists the president of the development company for Hybernia, a community of 122 single-family houses on a 133.5-acre site in Highland Parks, Illinois. The site, zoned for 40,000-square-foot lots, was laid out around a constructed pond/stream system and 27 acres of land approved

as a state nature preserve. The site includes 16.5 acres of ponds. Forebays at urban runoff inlets catch sediments (Tourbier and Westmacott, 1992). Hybernia is an example of ecological landscape planning. Waterfront lots, which now sell for $299,900 to $374,900, draw a 10 percent premium above those with no water view (Margolin, 1995).

Wichita, Kansas

The owner of a 72.3-acre parcel of land had plans to fill deteriorating wetlands before building a subdivision. He was persuaded to enhance them instead and now promotes enhanced and constructed wetlands as the feature selling point of The Landing. A lake with 3,750 feet of shoreline provides aesthetic and recreational value, as well as sensible detention of urban runoff. Waterfront lots currently sell for $18,000 to $40,000, a premium of up to $21,000 (150 percent) above comparable lots with no water view (Baird, 1995).

Alexandria, Virginia

Chancery on the Lake, a condominium development in Alexandria, Virginia, is a residential project with an attractive 14-acre urban runoff detention area. Realtors are currently promoting the wet pond as the development's feature selling point. The wet pond will be surrounded by a walking trail, and a gazebo and fishing pier will also be built. According to Ginger Harden, Sales Associate of Chancery Associates LP, condominiums are priced between $129,990 and $139,990. Condominiums that front the lake are selling at a $7,500 premium. For the first four buildings on the market, a $5,000 premium was charged for units fronting the lake. The lakefront units were the only units selling, and now the premium has been raised to $7,500 (Harden, 1995).

Boulder, Colorado

Built in 1993, the Sale Lake subdivision of single-family homes surrounds a 4-acre constructed wetland. Sale Lake demonstrates environmental sensitivity in suburban development. Lots located alongside the wetland sold for as much as $134,000, up to a 30 percent premium over lots with no water view (St. Germain, 1995).

Who Pays for It?

While some of the suggested revisions to policy will have little or no associated costs, other changes, particularly for hydrologic controls or buffer zone maintenance (in the event that riparian corridors are re-zoned as parkland), will require a source of private or public funding for implementation, as well as any operation and maintenance (O&M) that may be required.

Perhaps one of the more common methods of funding stormwater management programs is the reliance on general tax funds. However, general tax revenues are typically used to finance a wide range of public programs and, as a consequence, stormwater programs must compete against a wide variety of public programs for limited number of tax dollars.

As a result, effective strategies have evolved to fund municipal and county stormwater management programs.

I. One recommended method is the development of a **county-wide stormwater utility**, which would rely on user charges. Charges are usually based on an estimate of the amount of stormwater runoff contributed by a property, such as the total impervious surface area. This approach is referred to as a “percent impervious tax”, and charges are paid by individual property owners. The advantage of this system is that the charges provide a stable funding source, dedicated to stormwater management projects. Since the charges are based on individual property contributions to stormwater runoff, it is often viewed as a more equitable tax strategy. Furthermore, a percent impervious tax creates economic incentive for the implementation of on-site stormwater management, such as hydrologic controls and energy management. According to the United States Environmental Protection Agency (US EPA, 1994a), more than 100 communities across the country have already instituted stormwater utilities.

II. Another strategy relies on **inspection or permit fees** and is similar to a utility fee system. The governing body collects fees at the issuance of a building or clearing permit. A permit program based upon fees for annual inspections, such as a stormwater discharge permit, can provide an ongoing funding source. However, most permit or inspection fees tend to be one-time charges, collected when a facility is constructed. As a result, fee systems are usually not reliable sources for ongoing, or permanent, stormwater management funding.

III. In a stormwater management system that depends on **land contributions**, the land developer grants an easement on their property over which the governing body would assume control for the operation and maintenance of a stormwater BMP constructed as part of that private development. A portion of the required funding for O&M is obtained through a one-time contribution by the land developer, and the developer is often responsible for O&M during a warranty period of the first two to three years.

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